APPENDIX A
Design Specifications (See Volume II)

APPENDIX B
Soil Cover Data

EROSION CONTROL CALCULATION

PEMACO SUPERFUND SITE

Purpose

The following calculation determines the average annual erosion of the vegetated soil layer of the final closure cover at the site. In addition, the calculation determines the number of years which would be required to fully erode the vegetated soil layer if no cap maintenance was provided.

Procedure

The average soil loss per year was estimated using the Universal Soil Loss Equation (USLE), an empirical equation developed by the U.S. Department of Agriculture for use in determining soil loss at both agricultural and construction sites. The parameters of this equation were determined by referencing the manual "Predicting Rainfall Erosion Losses," by the U.S. Department of Agriculture, published in 1978 as discussed below.

The universal soil loss equation is:

$$A=RKLSCP$$

Where:

- **A** is the average annual soil loss per unit area, expressed in units of tons per acre per year.
- **R** is the rainfall and runoff factor, which is based upon the number of rainfall erosion index units, plus a factor for runoff from snowmelt or applied water where such a runoff is significant. The erosion index factor is defined as the product of the storm energy and the maximum thirty minute storm intensity for a particular storm event. An R-value of 50 was used for Los Angeles, California as determined from Figure 1 of the USDA manual "Predicting Rainfall Erosion Losses."
- **K** is the soil erodibility factor which is the soil loss rate per erosion index unit for a specified soil as measured on a unit plot, which is defined as a 72.6-foot length of uniform 9 percent slope continuously in clean-tilled fallow. A K-value of 0.48 was used for the Pemaco Site. This value was based on the assumption that a silt-loam, or equivalent soil, will be used for the topsoil in the final cover at the site. Because the source of the final soil cover has not yet been determined, the greatest K value, which was not evaluated for continuous fallow was used in the calculation to provide a conservative estimate of overall erosion.
- **L** is the slope-length factor which is the ratio of soil loss from the field slope length to that from a 72.6 foot length under identical conditions. S is the slope-steepness factor, which is the ratio of soil loss from the field slope gradient to that of the 9% slope under otherwise identical conditions. The product of the slope-length and slope-steepness factors were evaluated as one factor based on data available in the USDA manual "Predicting Rainfall Erosion Losses." A slope length and steepness factor (LS) of 0.2375 was estimated based on a slope of

2% and a maximum length of 175 feet (average cross-gradient width of the Pemaco Site.)

- **C** is the cover and management factor, which is the ratio of soil loss from an area with specified cover and management to that from an identical area in tilled continuous fallow. A cover management value for pasture land was estimated as 0.003 based on the assumption that a grass cover will be maintained over 100 percent of the capping surface and no appreciable vegetative canopy will develop.
- **P** is the support practice factor, which is the ratio of soil loss with a support practice like contouring, strip cropping, or terracing to that with a straight row farm up and down. A P-value of 0.6 was estimated for the Pemaco Site based on a slope of 2% and a length of less than 400 feet.

Numerical values for each of the six factors which determine the soil loss were derived from analyses of assembled research data and from the National Weather Service precipitation records. Charts and tables for determining the value of each of the six factors were obtained from the manual "Predicting Rainfall Erosion Losses" published by the U.S. Department of Agriculture in December 1978.

Results

The average annual loss of vegetated soil from the capped site was estimated to be 0.01026 tons/acre/year (20.52 lb/acre/year). The results of the USLE were evaluated based on the number of years required to completely erode the topsoil layer from the final closure cover at the Pemaco Site. The number of years required to completely erode the 1-foot vegetated soil layer of the soil closure cover at the Pemaco Site was determined by dividing the total mass of soil in the top soil layer per acre by the average annual soil erosion. A calculated value of 220,176 years would be required to completely erode the topsoil layer at the site.

The magnitude of this estimate indicates that natural soil erosion will not be a significant maintenance concern at the site.

3904 Virginia Ave • Cincinnati, Ohio 45227 • Phone (513) 271-6000 • Fax (513) 271-4420

To: TN & Associates Inc.
March 21, 2005
Attn: Pamela
Fax: (805)585-2111
From: Chuck Fedders
Re: Comparison of US 160NW to Amoco Propex 4551

Pamela,

Here is a brief comparison between US 160NW and Amoco 4551. These values are taken from the 2004 GFR (Geotechnical Fabric Report) and / or current manufacturer data sheets, which report MARV (Minimum Average Roll Values). The US 160NW and Amoco 4551are nonwoven, needlepunched fabrics. US 160NW will satisfy the requirements of AASHTO Class 2.

Property	Test Method	160NW	4551
Tensile Strength	ASTM D-4632	160 lbs	160 lbs
Elongation @ Break	ASTM D-4632	50%	50%
Puncture Strength	ASTM D-4833	85 lbs	90 lbs
Trapezoidal Tear	ASTM D-4533	60 lbs	65 lbs
Apparent Opening Size	ASTM D-4751	80 US Sieve	70 US Sieve
Permittivity	ASTM D-4491	1.3 Sec^{-1}	1.5 Sec^{-1}
UV Resistance, % Retained	ASTM D-4355	70%	70%

As you can see, US 160NW is a functional equivalent to the specified material Amoco 4551. Additionally, US 160NW will satisfy the requirements of AASHTO M-288 00 Class 2 requirements as well as AHTD Type 8. Per this comparison we request you approve the US 160NW Nonwoven Fabric for inclusion in this project.

Please call me with any question you have.

Sincerely,

Chuck Fedders

US Fabrics INC.
3904 Virginia Ave • Cincinnati, Ohio 45227 • Phone (513) 271-6000 • Fax (513) 271-4420

To: TN & Associates Inc. March 21, 2005
Attn: Pamela
Fax: (805)585-2111
From: Chuck Fedders
Re: US 115NW Nonwoven 4.0 oz/sy Vs Amoco 4546 Nonwoven

Pamela,

Here is a brief comparison between US 115NW and Amoco 4546. These values are taken from the 2005 GFR (Geotechnical Fabric Report) and / or current manufacturer data sheets, which report MARV (Minimum Average Roll Values). The US 115NW and the Amoco 4546 are nonwoven, needlepunched fabrics. US 115NW will satisfy the requirements of AASHTO M 288-96/00 Class 3.

Property	Test Method	115NW	4546
Tensile Strength	ASTM D-4632	115 lbs	100 lbs
Elongation @ Break	ASTM D-4632	50%	50%
Puncture Strength	ASTM D-4833	65 lbs	65 lbs
Mullen Burst	ASTM D-3786	210 psi	225 psi
Trapezoidal Tear	ASTM D-4533	50 lbs	45 lbs
Apparent Opening Size	ASTM D-4751	70 US Sieve	70 US Sieve
Permittivity	ASTM D-4491	2.0 Sec^{-1}	2.0 Sec^{-1}
UV Resistance, % Retained	ASTM D-4355	70%	70%

As you can see, US 115NW is a functional equivalent to the specified material Amoco 4546. Per this comparison we request you approve the US 115NW Nonwoven Fabric for inclusion in this project.

Please call me with any question you have.

Sincerely,

Chuck Fedders

US Fabrics INC.

3904 Virginia Ave • Cincinnati, Ohio 45227 • Phone (513) 271-6000 • Fax (513) 271-4420

To: TN & Associates Inc.
Attn: Pamela
Fax: (805)585-2111
From: Chuck Fedders
Re: US 90NW Nonwoven 3.5 oz/sy Vs Amoco 4545 Nonwoven

March 21, 2005

Pamela,

Here is a brief comparison between US 90NW and Amoco 4545. These values are taken from the 2002 GFR (Geotechnical Fabric Report) and / or current manufacturer data sheets, which report MARV (Minimum Average Roll Values). The US 90NW and the Amoco 4545 are nonwoven, needlepunched fabrics. Additionally,

Property	Test Method	US 90	4545
Tensile Strength	ASTM D-4632	90 lbs	90 lbs
Elongation @ Break	ASTM D-4632	50%	50%
Puncture Strength	ASTM D-4833	55 lbs	50 lbs
Mullen Burst	ASTM D-3786	185 psi	185 psi
Trapezoidal Tear	ASTM D-4533	35 lbs	40 lbs
Apparent Opening Size	ASTM D-4751	70 US Sieve	70 US Sieve
Permittivity	ASTM D-4491	2.0 Sec^{-1}	2.10 Sec^{-1}
UV Resistance, % Retained	ASTM D-4355	70%	70%

As you can see, US 90NW is a functional equivalent to the specified materialAmoco 4545. Per this comparison we request you approve the US 90NW Nonwoven Fabric for inclusion in this project.

Please call me with any question you have.

Sincerely,

Chuck Fedders

APPENDIX C
TN&A Well Design and Installation SOP

STANDARD OPERATING PRACTICE TNFLD008D

Monitoring and Extraction Well Installation and Development

TABLE OF CONTENTS

STANDARD OPERATING PRACTICE TNFLD008D

Monitoring and Extraction Well Installation and Development

1.0 INTRODUCTION

The purpose of TNFLD008D is to describe procedural guidelines for the design, installation, and construction of groundwater monitoring and extraction wells to be completed in water-bearing geologic materials. This document also provides procedures for well development. Site-specific procedures will depend on project objectives, geologic conditions, and appropriate state and federal regulations and standards.

2.0 MONITORING AND EXTRACTION WELL INSTALLATION

2.1 OBJECTIVE

Monitoring wells are installed to provide information regarding site hydrogeology and groundwater quality. TN&A will design, install, and construct monitoring wells so they are: (1) adequately sealed to prevent surface contamination or cross contamination between aquifers; (2) capable of yielding high quality groundwater samples representative of true water quality; (3) adequately protected from vehicles or other traffic; and (4) in compliance with applicable state and federal regulations. Extraction wells at remedial sites may also be used for groundwater quality monitoring and should, therefore, be installed with the same care as monitoring wells.

The procedures set forth in this section apply to all personnel who are responsible, both directly and indirectly, for design of monitoring well systems, oversight of drilling and construction operations, and evaluation of the suitability and reliability of monitoring wells and data and measurements obtained from monitoring wells.

2.2 QUALIFICATIONS

All drilling personnel must meet all applicable Occupational Safety and Health Administration (OSHA) requirements. The supervising geologist, engineer, or hydrogeologist must be fully knowledgeable and experienced with state and federal requirements/regulations for groundwater monitoring programs.

2.3 PROCEDURES

Various drilling methods are described in TNFLD007A. Well design and construction elements are described in the project Sampling and Analysis Plan (SAP) or equivalent document. The drilling methods, well design, and well construction will adhere to the criteria and methodologies presented in the SAP. The proposed well design will be based on existing geologic and groundwater elevation data from previous investigations, if available. All equipment, well materials, and tools that will enter the borehole must be decontaminated before borehole entry and will remain clean until installed in the borehole. If needed, they will be steam-cleaned. Well materials that are cleaned and wrapped by the manufacturer do not need to be cleaned unless the factory wrap is damaged or the materials show signs of staining.

2.3.1 Well Design Specifications

Well Screen

Well screen materials for monitoring wells will be selected depending upon the known or suspected chemical contaminants at the site, and so that the completed monitoring well provides data meeting the project data quality objectives (DQOs). Extraction well screening should further meet the objective of a functional pumping well. The screen slot size will be determined to maintain compatibility with the aquifer and filter pack material. In general, the screen will be sized to retain over 90 percent of the filter pack and be either factory-slotted or continuous wrap design. Well screen materials will be of the same diameter and strength material as the well riser and will be a non-contaminating material that is compatible with the anticipated or known groundwater chemistry and/or contaminants at the well site. No glues, adhesives, lead shot, or lead wool will be used to connect the riser sections or screen. No field slotted screens will be permitted (e.g., machined in the field).

Filter Pack

Filter pack material will be clean, washed, well-rounded silica sand sized to perform as a filter between the formation material and the well screen. The filter pack gradation shall have a uniformity coefficient (C_u) of not more than 2.5 and shall be sized so that the well screen will retain 90 percent of the material. A grain size distribution curve for the filter pack materials used at each site will be included with the submittal of well construction diagrams (selected filter pack gradations for existing monitoring wells will be also taken into account).

If a pertinent grain-size distribution curve is available for a particular site or monitoring well, then the following procedure will be used to design a filter pack.

1. Multiply the D30 size (from the grain-size distribution graph) by a factor of four to nine (Pack-Aquifer ratio). A factor of four is used if the formation is fine-grained and uniform (Cu is less than 3), six if it is coarse-grained and non-uniform, and up to nine if it is highly non-uniform and contains silt. Head losses through filter packs increase as the Pack-Aquifer (P-A) ratios decrease. In order to design a fairly stable filter pack with a minimum head loss, the D30 size will be multiplied by a factor of four.

2. Plot the point from step 1 on the 30 percent abscissa of a grain-size distribution graph and draw a smooth curve with a uniformity coefficient of approximately 2.5.

3. A curve for the permissible limits of the filter pack is drawn plus or minus 8 percent of the desired curve with the C_u of less than 2.5. The appropriate-sized filter pack can then be chosen from the grain-size distribution curves of various filter packs.

4. Select the slot openings for the well screen that will retain 90 percent or more of the filter packs.

This design will be based on the gradation of the finest aquifer materials anticipated to be affected by the screened part of the monitoring wells (USEPA, 1996).

If no pertinent grain-size distributions curves are available, then 0.010-inch slotted or continuous wrapped screen will be used with appropriate sized filter pack material in accordance with the following table adapted from ASTM D 5092-90 (ASTM, 1990).

Size of Screen opening, mm (in.)	**Slot No.**	**Sand Pack Mesh Size Name(s)**	**1% Passing Size (D-1), mm**	**Effective Size (D-10), mm**	**30% Passing Size (D-30), mm**
0.125 (0.005)	5	100	0.09 to 0.12	0.14 to 0.17	0.17 to 0.21
0.25 (0.010)	10	16 to 40	0.25 to 0.35	0.4 to 0.5	0.5 to 0.6
0.50 (0.020)	20	10 to 20	0.7 to 0.9	1.0 to 1.2	1.2 to 1.5
0.75 (0.030)	30	10 to 20	0.7 to 0.9	1.0 to 1.2	1.2 to 1.5
1.0 (0.040)	40	8 to 12	1.2 to 1.4	1.6 to 1.8	1.7 to 2.0
1.5 (0.060)	60	6 to 9	1.5 to 1.8	1.7 to 2.0	2.5 to 3.0
2.0 (0.080)	80	4 to 8	2.0 to 2.4	2.4 to 3.0	2.6 to 3.1

In addition to the primary filter pack installed along the screened interval of the monitoring well, a secondary filter pack consisting of finer material will be installed to prevent bentonite pellets from commingling with the primary filter pack. This is discussed further in Section 2.4.1.

Well Riser

Well riser (casing) will consist of new material with threaded, flush joints. The riser material will be of the same diameter and strength material as the well screen and will be a non-contaminating material that is compatible with the anticipated or known ground water chemistry and/or contaminants at the well site. If PVC pipe is used, PVC pipe will bear markings identifying the material as that specified and will carry the seal of the National

Sanitation Foundation and will, as a minimum, conform to the requirements of ASTM F 480-81/SDR 13.5. Schedule 40 PVC is acceptable for wells less than 100 feet deep and Schedule 80 is recommended for wells greater than 100 feet deep. Unless noted in the site-specific work plans, monitoring wells will be nominal 2-inch inside diameter. Riser sections will be joined by threaded, flush-joint couplings. No adhesives or other sealing materials will be used.

Well Plumbness and Alignment

All risers shall be set round, plumb, and true to line. Centralizers may be required for deep wells or wells being installed in caving material. To verify plumbness and alignment, a ten-foot section of pipe will be run through the entire length of the well. The pipe shall be decontaminated between well in accordance with TNFLD011A. String or rope used to lower the pipe will be discarded in between each well.

Bentonite Seal

A minimum 2-feet thick bentonite seal will be tremied into place above the filter pack seal. The bentonite seal will be composed of commercially manufactured sodium bentonite pellets, which do not exceed 0.25-inch diameter. Clean, potable water will be used to hydrate the bentonite (minimum 4-hours of hydration), as discussed in Section 2.4.1 of this SOP.

Annular Seal

Cement grout will be placed above the bentonite seal to the ground surface. The cement grout will consist of a mixture of Portland cement (ASTM C 150) and water in the proportion of approximately six to seven gallons of approved water per bag of cement (94 pounds). In addition, 3 to 5 percent by weight of sodium bentonite powder will be added. The minimum acceptable grout weight will be 14 pounds per gallon (lbs/gal). The cement grout weight will be determined using a mud balance. Water may be added to the mix in small amounts, at the discretion of the field geologist, to increase viscosity as necessary. The following table provides specifications for various grout slurry densities.

Grout Slurry Densities

Percentage Bentonite	Water ratio	Minimum density [pounds per gallon]	Volume (ft^3/sack)
2	6.0 gal/sack of cement	14.7	1.36
3	6.5 gal/sack of cement	14.4	1.45
4	7.2 gal/sack of cement	14.1	1.55
5	7.8 gal/sack of cement	13.8	1.64

Well Protection

At all times during the process of well installation, precautions will be taken to prevent tampering with the well or the entrance of foreign material into the well. Run-off, surface soil or objects (tools, etc.) will be prevented from entering the borehole as the well installation is performed. The wells will be secured at the surface with a stand-up protector pipe or traffic-rated flush mounted well vault equipped with a lock. For wells completed with stand-up pipe in high vehicle traffic areas or areas where well damage could occur due to site activities, brightly painted steel bollards (minimum of three) will be placed around the completed well.

2.4 BOREHOLE COMPLETION

Procedures for the drilling and advancement of soil borings are presented in TNFLD007B and 007D. Drilling techniques employed must minimize disturbance of subsurface samples and must not introduce contamination to the subsurface or allow contaminants within the shallow hydrogeologic units (if any) to migrate to deeper units.

2.4.1 Well Construction

At all times during the progress of the work, precautions will be taken to prevent tampering with the well or entry of foreign materials. Measures will be taken to run-off from entering the well during construction. Prior to well construction, the borehole will be sounded. In competent bedrock, the borehole may be pumped to remove drilling fluid, cuttings, and fine particles resulting from the drilling. Ideally, a stabilized water level will be attained in the borehole prior to well installation.

The casing/screen assembly will be installed as follows:

- Prior to installation of the casing and screen, the lengths and diameters of all components (including the bottom plug or cap) will be measured and recorded on the casing/well screen tally form. The casing riser and screen assembly will be installed round, plumb, and true to line.

- A bottom plug will be attached to the bottom of the screened section.
- Approximately six inches of filter pack sand will be placed in the bottom of the well boring.
- The well screen will be connected to the riser sections of the casing assembly. For wells intended to monitor the upper surficial aquifer near the water table, the well screen will be installed so as to straddle the free water surface, extending both above and below the water table to accommodate seasonal or other variations in its elevation. In all cases, the top of the screen will be located at least 2-feet below the base of the down-hole seal.
- For wells installed to depths exceeding 40-feet, centralizers will be placed at locations just above the screen and above the location of the bentonite seal. The centralizers will be placed at 30-foot intervals along the riser casing. Centralizers will not be used if their installation prevents the placement of the annular materials.
- Well risers will extend between 2- and 2.5-feet above the ground surface. If a flush finish completion is conducted, the placement of annular materials will be done in such a way that the inside of the well casing is protected.
- The primary filter pack will be placed in the annulus between the well material and borehole using a tremie pipe, starting with the tremie at the bottom of the borehole and working the tremie upward as the filter pack is installed. If necessary, potable water may be used to aid tremie installation. The drill casing will be raised incrementally during the installation of the filter pack to prevent bridging. Attempts will be made to keep the bottom of the drill casing below the top of the filter pack during installation. The level of the top of the filter pack in the annulus will be verified by tag-line measurement during all phases of installment.
- Prior to completion of filter pack installation, the well may be pre-developed using a surge block and/or bailer to allow the filter pack to settle.
- The filter pack will extend at least two feet above the top of the screen. A secondary fine-grained filter pack will be installed using a tremie pipe if bentonite slurry seals are used for well construction. The secondary fine grain filter pack will have a minimum thickness of one foot above the primary filter pack. The volume of the installed filter pack will be compared with the annular volume to verify proper placement of the filter pack. Material accounting will be recorded in the field book as will the volume of potable water used (if any).
- A bentonite seal will be placed immediately above the filter pack. At a minimum, either a 3-foot thick granular bentonite seal or a minimum 4-foot thick bentonite slurry seal will be used. Bentonite slurry mixtures will be composed of calcium bentonite with a high solids

content, unless otherwise specified. The density of the recommended bentonite slurry will be confirmed with a mud scale. Pouring of the granular bentonite is acceptable for boreholes less than 50-feet deep where the annular space is large enough to limit the potential for bridging and to allow measurements to insure that the granular bentonite has been placed at proper intervals. For depths greater than 50-feet, the granular bentonite and the bentonite slurry will be installed through a tremie pipe. The level of the top of the bentonite seal will be verified by tag-line measurement prior to grouting. The bottom of the drill casing will be left in the borehole as close as possible above the bentonite seal. Granular bentonite seals will hydrate a minimum of 4-hours.

- For depths greater than 50-feet, the borehole is to be pressure-grouted using a side-discharging tremie pipe that is maintained 3-feet above the bentonite seal and will be used to slowly install the cement/bentonite grout mixture. The drill casing will be pulled incrementally during the grouting procedures to limit borehole collapse. Grout will be pumped into the annulus through the tremie pipe until undiluted grout flows from the borehole at the ground surface. The grout will be allowed to cure for at least 12-hours prior to development. After 12-hours, the depth of the grout will be checked. If it has collapsed more than 10-percent of the well depth, the well will be checked for soundness. The annulus will be refilled with grout to the desired depth.

2.4.2 Double-Cased Wells

Secondary (outer) casings will be installed in the borehole when drilling a monitoring well that will be installed at depths below relatively impermeable (confining) layers or below depths of known contamination. The purpose of the surface casing is to prevent cross-contamination between two aquifer zones and/or, when flowing sands make it impossible to install a monitoring well using conventional methods, to properly install the monitoring well to the desired depth. There are several methods available to accomplish double casing of wells. The following paragraphs present one commonly used method.

A pilot borehole will be drilled and the surface casing installed to slightly below the known depth of contamination or a minimum of 2 feet into the confining layer. The diameter of the surface casing will be sufficient to contain the inner casing and a 2-inch annular space. The material of the surface casing may vary (PVC or carbon steel), but it will be chemically inert and able to withstand potential chemical degradation and any forces exerted on the casing during its installation and the monitoring well construction.

The outer casing will be grouted by the tremie method from the bottom to within 2 feet of the ground surface. The grout will be pumped into the annular space between the outer casing and the borehole wall. This will be accomplished by either placing the tremie tube in the annular space and pumping the grout from the bottom of the borehole to the surface; or placing a grout shoe or plug inside the casing at the bottom of the borehole and pumping the grout through the bottom grout plug and up the annular space on the outside of the casing. If the outer casing is set into very tight clay, both of the above methods may have to be used, because the clay usually forms a tight seal in the bottom and around the outside of the casing preventing grout from flowing freely during grout injection. A minimum of 24 hours will be allowed for the grout seal to cure before attempting to drill through it. The grout mixture used to seal the outer annular space will be a neat cement mixture of one 94-lb bag of Type I Portland Cement, 4 pounds of bentonite powder, and no more than 8 gallons of water.

When drilling through the seal, care will be taken to avoid cracking, shattering, and/or washing out the seal. If caving conditions exist such that the outer casing cannot be sufficiently sealed by grouting, the outer casing will be driven into place and a grout seal placed in the bottom of the casing. The boring will be advanced through the surface casing to the target depth for monitoring well installation. The monitoring well will be installed in accordance with the methods presented in Section 2.2.3. The borehole beneath the surface casing will be of sufficient diameter to maintain a 2-inch annular space between the monitoring well and the borehole well. Removal of outer casings, which are sometimes referred to as temporary surface casings, after the well screens and casings have been installed and grouted is not acceptable. Attempting to remove outer surface casings after the inner casing has been grouted could jeopardize the structural integrity of the well.

2.4.3 Temporary Casing Method Using Rotosonic Drilling Techniques

Rotosonic drilling techniques allow for the construction of monitoring wells through a temporary casing advanced during borehole advancement. The outer casing (to 12-inches in diameter) will be advanced down past the upper aquifer while a bentonite grout mixture is being pumped under pressure into the small annular space between the borehole wall and the outside of the casing.

2.4.4 Well Head Completion

The following well head completion procedures will be followed:

1. Grout to within five feet of the ground surface.
2. Wait a minimum 12-hours prior to well head completion.
3. Place a two-foot layer of fine sand above the grout.
4. Install the stand-up protector pipe (protector pipe size must be at least 2-inches larger in diameter than the well casing) over the well casing.
5. Place concrete between the borehole and stand-up protector pipe casing to a depth of 6-inches beneath the ground surface for installation of the concrete pad.

The protective casing will be provided with a (vented) locking cap and a brass padlock. All locks used at an individual site will be keyed alike. Duplicate keys will be made available to the client.

A minimum of a 3-foot by 3-foot by 6-inch-thick concrete pad, sloped away from the well, will be constructed around the monitoring well with the top outer edge at the final ground elevation. At locations where vehicular traffic is likely, the concrete pad will be reinforced with reinforcement wire or rebar. In trafficked areas, three or four three-inch diameter or larger concrete-filled steel posts (bollards), brightly painted, will be equally spaced around the well and cemented in place around the concrete pad. The base of these posts shall extend two feet bgs and be approximately three feet tall. After the well is installed, the area will be cleaned and all discarded material will be properly disposed.

2.4.5 Documentation and Recording

A well construction form will be completed for each well. The well construction form will include an accurate hand-drawn "as built" diagram of each well. The following information will be recorded on the form:

- Project and site names, well number, and the total depth of the completed well;
- Depth of any grouting or sealing, and the amount of cement and/or bentonite used, and the total borehole depth and elevation;
- Depth, elevation, and type of well casing;
- Installation date or dates, and name of the driller, drilling company, and the geologist installing the well;
- All pertinent construction details of monitoring wells, such as depth to and description of all annular fill materials; gradation of filter packs; length, location (depth and elevation), diameter, slot size, material, and manufacturer of well casing and screen; position of centralizers; and location of any blank pipe or intermediate casing installed in the well;
- Description of surface completion, including protective steel casing, protective pipes, and concrete surface seal; and
- Surveyed coordinates and elevation of top of ground and top of well riser. The accuracy of the survey points will be in accordance with TNFLD004A.

A discussion of information to include in the boring logs is presented in TNFLD007B. All original well record forms, field report forms, and geologic logs will be maintained in the project file.

3.0 WELL DEVELOPMENT

3.1 OBJECTIVE

The primary objective of installing a monitoring well at a site is to collect a groundwater sample that is representative of the quality of groundwater surrounding the well. Well development is an important component of monitoring well completion. Monitoring wells will be sufficiently developed to ensure that they meet their intended data quality objectives. The purposes of well development are the following:

- Assure that groundwater enters the well screen freely and at ambient velocities, thus yielding a representative groundwater sample and an accurate fluid level measurement;
- Remove all water and drilling additives that may have been introduced into the borehole and formation during drilling and installation activities;
- Break up fine materials that may have been smeared along the borehole wall during drilling; and
- Remove fine-grained sediments entrained in the filter pack and within the well itself so that groundwater samples have minimal turbidity and excessive silting of the well does not occur.

The criteria that will be utilized to evaluate whether these objectives have been met are presented in Section 3.3.

3.2 PROCEDURES

3.2.1 General

Well development will be completed no sooner than 24 hours after the grouting is completed. Well development may be performed using a downhole pump, peristaltic pump, bailer and/or surge block. Different equipment may be used sequentially to accomplish well development (e.g., surge block then pump). The water level and thickness of sediment in the well will be measured and recorded in the field logbook prior to development, as discussed below. Any instrumentation or equipment inserted into the well will be properly decontaminated in accordance with TN&A SOP 011A. Downhole tubing will be dedicated to the well until development has been completed at which time the tubing will be discarded.

Before beginning development of a well, place plastic sheeting on the ground around the well head. Open the well cap and obtain an organic vapor reading using a photoionization detector (PID) or comparable equipment. The purpose of the organic vapor reading is to provide important health and safety and water quality information.

3.2.2 Well Development Using a Bailer

A bailer may be used to remove accumulated sediment from the bottom of the well as a first step in well development. A slight surging action may help to mobilize the sediment so that it can be more easily removed.

If a well is slow to recharge such that use of a submersible pump is impracticable, then a bailer may be used to complete well development. This change in well development procedures must be approved by the TN&A Project Manager.

3.2.3 Surging

A surge block may be used to create a surging action for short periods of time to help break up or loosen the sediment that entered the well. A bailer or pump may be used to remove the silty water that results from surging. The surge block will be composed of inert material that will not affect the water quality in the well. The diameter of the surge block will be 0.125 to 0.25 inches smaller than the inside diameter of the well.

Make sure that the block can move freely up and down the inside of the well without obstructions. The vertical action of the surge block will be accomplished either manually or mechanically with drill rods or wireline.

Care will be taken in the length of the strokes, the velocity of the up and down movement, and the duration of each surge block cycle. Surging can be detrimental to the well integrity if performed too vigorously.

NOTE: Surging can increase turbidity in wells constructed in fine-grained aquifers and should be used with caution or should not be performed at all (Paul et al, 1988). Detailed discussions are presented in Aller (1991) and ASTM D 5512 (1994); responsible personnel will review these discussions before beginning well development with the surge block method in wells completed in fine-grained media.

3.2.4 Overpumping

Following the removal of suspended sand-sized sediment, the well development process will include overpumping the well with the submersible bladder pump. In overpumping, the pump is operated at a capacity that substantially exceeds the yield of the formation (i.e., the capacity of the formation to deliver water to the well). This flow velocity well exceeds the flow velocity that will be induced during the purging process of well sampling.

3.3 WELL DEVELOPMENT CRITERIA

During development, measure field parameters and turbidity approximately once every well volume removed (or as practicable) once the water has begun to clear.

If well development is by over-pumping, field parameters will be measured in a flow-through cell attached to the pump outflow tubing. If development is by bailer, field parameters can be measured down-hole, except for turbidity, which will be measured at the surface. (Note: field parameters measured in water dumped from a bailer into an open bucket will have little validity due to agitation and exposure to atmospheric conditions.) Field parameters will be measured in accordance with TN&A SOP No. 005A. Continue well development until the following criteria have been met:

- Three times the volume of water lost to formation during drilling has been purged from the well;
- Field parameters have stabilized for three consecutive measurements. Typical field parameter stabilization criteria include:

pH	± 0.2 pH units
Temperature	less than 10% change
Specific Conductance	less than 10% change
Dissolved Oxygen	± 0.2 mg/L
Turbidity	less than 50 NTUs

(NOTE: Check the site-specific SAP or Field Sampling Plan for criteria to use to determine stabilization)

- The duration of well development has been at least four hours, even if stabilization of parameters has not been met; and
- The yield of the well is representative of the transmissivity of the aquifer.

The TN&A Project Manager will be notified if well development criteria cannot be met and do not seem achievable after four hours of well development activity.

3.4 WELL DEVELOPMENT DOCUMENTATION

Well development will be documented on a well development/purge summary form, which will include the following information:

- Date and weather
- Pre- and post-development water levels
- Method(s) of development, equipment used, duration for each method
- Measured thickness of sediment at bottom of well prior and after the development (if any)
- Field parameter measurements and time of measurement

- Volume of water removed between measurements
- Cumulative total volume of water removed prior to each measurement
- Pumping rate(s), if applicable
- Total time of development

Additional observations, such as apparent yield of the well, detected odors and discoloration will also be noted on the development log.

Optional: After final well development, collect approximately one liter of the well water in a clear glass container for photodocumentation. Hold container against white background, label glass jar with well ID and photograph using color film. The photograph is part of the well development log.

4.0 REFERENCES

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U.S. Environmental Protection Agency, RCRA Ground-Water Monitoring Draft Technical Guidance, Office of Solid Waste, November 1992.

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APPENDIX D
PIPING DESIGN CALCULATIONS

CALCULATIONS FOR DPE AND VE PIPING HEAD LOSS

TABLE D1
HEADLOSS CALCULATION
PERCHED HEADER DPE-A

Enter Pipe ID No. :		Pipe No. 101	Pipe No. 102	Pipe No. 101	Pipe No. 103	Pipe No. 104	Pipe No. 106	Pipe No. 105	Pipe No. 106	Pipe No. 107	Pipe No. 106
	From:	Well Head PA-5	Well Head PA-3	1 1/2" PVC-102 Branch	Well Head PA-4	1 1/2" PVC-101	2" PVC 104	Well Head PA-2	2" PVC-105 Branch	Well head PA-1	2" PVC-107 Branch
	To:	1 1/2" PVC-102 Branch	1 1/2" PVC 101 Header	2" PVC 104 Header	2" PVC 104 Header	6" PVC 106 Header	2" PVC-105 Branch	6" PVC 106 Header	2" PVC-107 Branch	6" PVC 106 Header	8" Manifold

Calculation of the Reynolds Number
$Re = [(d_h\ v\ \rho)/\mu]$

Diameter of Pipe [d_h]:	[inches]	1.59	1.59	1.59	1.59	2.047	6.031	2.047	6.031	2.047	6.031
Assumed STP Temperature [T]:	[ºF]	60	60	60	60	60	60	60	60	60	60
Enter Flow [Q]:	[scfm]	10	10	20	10	30	30	10	40	10	50
Line Pressure [P]:	[psig]	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
Actual Air Flow	[acfm]	39.0	39.0	78.0	39.0	116.9	116.9	39.0	155.9	39.0	194.9
The Velocity [v] is:	[ft/s]	47.12	47.12	94.23	47.12	85.28	9.82	28.43	13.10	28.43	16.37
The Density [ρ] of Air at T = 60ºF	[lbm/ft^3]	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892
Absolute Viscosity [μ] of Air at T = 60ºF:	[lbf-sec/ft^2]	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07
The Reynolds Number [Re] is:	[dimensionless]	**9,807.99**	**9,807.99**	**19,615.98**	**9,807.99**	**22,854.97**	**7,757.27**	**7,618.32**	**10,343.03**	**7,618.32**	**12,928.79**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar: **The Friction Coefficient [λ] is:**	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent: **Enter Friction Coefficient [λ]:**	[dimensionless]	**0.031433**	**0.031433**	**0.026362**	**0.031**	**0.025**	**0.033**	**0.034**	**0.031**	**0.034**	**0.029**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (l/d_h)\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	92	4	23	42	100	31	50	20	16	199
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0988**	**0.0043**	**0.0829**	**0.0451**	**0.2203**	**0.0004**	**0.0162**	**0.0004**	**0.0052**	**0.0063**

TABLE D1
HEADLOSS CALCULATION
PERCHED HEADER DPE-A

Enter Pipe ID No. :		Pipe No. 101	Pipe No. 102	Pipe No. 101	Pipe No. 103	Pipe No. 104	Pipe No. 106	Pipe No. 105	Pipe No. 106	Pipe No. 107	Pipe No. 106
	From:	Well Head PA-5	Well Head PA-3	1 1/2" PVC-102 Branch	Well Head PA-4	1 1/2" PVC-101	2" PVC 104	Well Head PA-2	2" PVC-105 Branch	Well head PA-1	2" PVC-107 Branch
	To:	1 1/2" PVC-102 Branch	1 1/2" PVC 101 Header	2" PVC 104 Header	2" PVC 104 Header	6" PVC 106 Header	2" PVC-105 Branch	6" PVC 106 Header	2" PVC-107 Branch	6" PVC 106 Header	8" Manifold
Headloss From Fittings [h_{lossf}] for PVC:											
Enter Number of STD 45° Elbows:		0	0	0	0	0	1	1	0	0	3
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	8	2.6	0	0	24
Enter Number of 90° Elbows:		1	0	0	1	0	0	0	0	0	1
The Equivalent Length of Pipe is:	[ft]	4	0	0	4	0	0	0	0	0	16.7
Enter Number of Tees (Flow Through Run):		1	0	0	0	0	1	0	1	0	0
The Equivalent Length of Pipe is:	[ft]	2.7	0	0	0	0	12.3	0	12.3	0	0
Enter Number of Gate Valves:		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0	1	0	1	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	10.8	0	10.8	0
Enter Number of Expansion Fittings (d/D = 1/2):		0	0	0	0	2	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	13.6	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	1	1	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	1.7	1.7	0	0	0	0	0	0
Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Additional Fittings:		0	1	1	1	0	0	1	0	1	0
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	8.4	8.4	8.4	0	0	32.7	0	32.7	0
The Equivalent Length of Pipe is:	[ft]	0	8.4	8.4	8.4	0	0	32.7	0	32.7	0
Total Equivalent Length of Pipe From Fittings:	[ft]	6.7	8.4	10.1	14.1	13.6	20.3	46.1	12.3	43.5	40.7
The Friction Coefficient [λ] is:	[dimensionless]	0.031	0.031	0.026	0.031	0.025	0.033	0.034	0.031	0.034	0.029
The Headloss [h_{lossf}] From the Fittings is:	[psi]	0.0072	0.0090	0.0364	0.0151	0.0300	0.0003	0.0150	0.00026	0.0141	0.0013

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		Pipe No. 101	Pipe No. 102	Pipe No. 101	Pipe No. 103	Pipe No. 104	Pipe No. 106	Pipe No. 105	Pipe No. 106	Pipe No. 107	Pipe No. 106
$h_{loss} = h_{lossp} + h_{lossf}$	[psi]	0.1060	0.0133	0.1193	0.0603	0.2502	0.0007	0.0312	0.0007	0.0193	0.0076
Length of Pipe	[ft]	92	4	23	42	100	31	50	20	16	199
h_{loss}/100 ft Pipe	[psi]	0.12	0.33	0.52	0.14	0.25	0.002	0.06	0.003	0.12	0.004

TOTAL HEAD LOSS DPE-A (psi)
0.609

TABLE D1
HEAD LOSS CALCULATION
PERCHED HEADER DPE-B

Enter Pipe ID No. :		Pipe No. 201	Pipe No. 202	Pipe No. 203	Pipe No. 204	Pipe No. 203	Pipe No. 205	Pipe No. 206	Pipe No. 208	Pipe No. 207	Pipe No. 208	Pipe No. 209	Pipe No. 210	Pipe No. 209
	From:	Well Head PB-7	Well Head PB-6	2" PVC 101 Branch	Well Head PB-5	2" PVC 204 Branch	Well Head PB-4	Well head PB-3	2" PVC-205 Branch	Well head PB-2	PVC-207 Branch	4" PVC-203 Header	Well head PB-1	2" PVC-210 Branch
	To:	4" PVC-203 Header	4" PVC-203	2" PVC 204 Branch	4" PVC-203 Header	6" PVC 209 Header	4" PVC-208 Header	4" PVC-208 Header	2" PVC-207 Branch	4" PVC-208 Header	6" PVC 209 Header	2" PVC-210 Branch	6" PVC-209 Header	8" Manifold
Calculation of the Reynolds Number $Re = [(d_h\ v\ \rho)/\mu]$														
Diameter of Pipe [d_h]:	[inches]	2.047	2.047	3.998	2.047	3.998	2.047	2.047	3.998	2.047	3.998	6.031	2.047	6.031
Assumed STP Temperature [T]:	[ºF]	60	60	60	60	60	60	60	60	60	60	60	60	60
Enter Flow [Q]:	[scfm]	10	10	20	10	30	10	10	20	10	30	60	10	70
Line Pressure [P]:	[psig]	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
Actual Air Flow	[acfm]	39.0	39.0	78.0	39.0	116.9	39.0	39.0	78.0	39.0	116.9	233.9	39.0	272.9
The Velocity [v] is:	[ft/s]	28.43	28.43	14.90	28.43	22.36	28.43	28.43	14.90	28.43	22.36	19.65	28.43	22.92
The Density [ρ] of Air at T = 60ºF	[lbm/ft^3]	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892
Absolute Viscosity [μ] of Air at T = 60ºF:	[lbf-sec/ft^2]	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07
The Reynolds Number [Re] is:	[dimensionless]	**7,618.32**	**7,618.32**	**7,801.25**	**7,618.32**	**11,701.88**	**7,618.32**	**7,618.32**	**7,801.25**	**7,618.32**	**11,701.88**	**15,514.55**	**7,618.32**	**18,100.31**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**
Calculation of the Friction Coefficient [λ]														
If Flow is Laminar: **The Friction Coefficient [λ] is:**	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent: **Enter Friction Coefficient [λ]:**	[dimensionless]	**0.033627**	**0.033627**	**0.033300**	**0.034**	**0.030**	**0.034**	**0.034**	**0.033**	**0.034**	**0.030**	**0.028**	**0.034**	**0.027**
Headloss From SVE Pipe [h_{lossp}] for PVC:														
Enter Length [l] of SVE Pipe:	[ft]	83	60	47	10	103	76	10	82	10	20	95	50	449
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0270**	**0.0195**	**0.0021**	**0.0032**	**0.0094**	**0.0247**	**0.0032**	**0.0037**	**0.0032**	**0.0018**	**0.0041**	**0.0162**	**0.0255**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (l / d_h)\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

TABLE D1
HEAD LOSS CALCULATION
PERCHED HEADER DPE-B

Enter Pipe ID No. :		Pipe No. 201	Pipe No. 202	Pipe No. 203	Pipe No. 204	Pipe No. 203	Pipe No. 205	Pipe No. 206	Pipe No. 208	Pipe No. 207	Pipe No. 208	Pipe No. 209	Pipe No. 210	Pipe No. 209
	From:	Well Head PB-7	Well Head PB-6	2" PVC 101 Branch	Well Head PB-5	2" PVC 204 Branch	Well Head PB-4	Well head PB-3	2" PVC-205 Branch	Well head PB-2	PVC-207 Branch	4" PVC-203 Header	Well head PB-1	2" PVC-210 Branch
	To:	4" PVC-203 Header	4" PVC-203	2" PVC 204 Branch	4" PVC-203 Header	6" PVC 209 Header	4" PVC-208 Header	4" PVC-208 Header	2" PVC-207 Branch	4" PVC-208 Header	6" PVC 209 Header	2" PVC-210 Branch	6" PVC-209 Header	8" Manifold
Headloss From Fittings [h_{lossf}] for PVC:														
Enter Number of STD 45° Elbows:		0	0	0	0	0	0	0	0	0	0	1	0	3
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	8	0	24
Enter Number of 90° Elbows:		1	0	0	0	0	0	0	0	0	0	0	0	1
The Equivalent Length of Pipe is:	[ft]	5.7	0	0	0	0	0	0	0	0	0	0	0	16.7
Enter Number of Tees (Flow Through Run):		0	0	2	0	0	0	0	2	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	15.8	0	0	0	0	15.8	0	0	0	0	0
Enter Number of Gate Valves:		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/2):		1	1	0	1	1	1	1	0	1	1	0	1	0
The Equivalent Length of Pipe is:	[ft]	6.8	6.8	0	6.8	14	6.8	6.8	0	6.8	14	0	6.8	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Additional Fittings:		0	1	0	1	0	0	1	0	1	0	1	1	0
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	22	0	22	0	0	22	0	22	0	32.7	32.7	0
The Equivalent Length of Pipe is:	[ft]	0	22	0	22	0	0	22	0	22	0	32.7	32.7	0
Total Equivalent Length of Pipe From Fittings:	[ft]	12.5	28.8	15.8	28.8	14	6.8	28.8	15.8	28.8	14	40.7	39.5	40.7
The Friction Coefficient [λ] is:	[dimensionless]	0.034	0.034	0.033	0.034	0.030	0.034	0.034	0.033	0.034	0.030	0.028	0.034	0.027
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.0041**	**0.0094**	**0.0007**	**0.0094**	**0.0013**	**0.0022**	**0.0094**	**0.00072**	**0.0094**	**0.00128**	**0.0018**	**0.01284**	**0.00231**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		Pipe No. 201	Pipe No. 202	Pipe No. 203	Pipe No. 204	Pipe No. 203	Pipe No. 205	Pipe No. 206	Pipe No. 208	Pipe No. 207	Pipe No. 208	Pipe No. 209	Pipe No. 210	Pipe No. 209
$h_{loss} = h_{lossp} + h_{lossf}$	[psi]	0.0310	0.0289	0.0028	0.0126	0.0107	0.0269	0.0126	0.0044	0.0126	0.0031	0.0059	0.0291	0.0278
Length of Pipe	[ft]	83	60	47	10	103	76	10	82	10	20	95	50	449
h_{loss}/100 ft Pipe	[psi]	0.04	0.05	0.006	0.13	0.010	0.035	0.13	0.005	0.13	0.016	0.006	0.058	0.006

TOTAL HEAD LOSS DPE-B (psi)
0.208

TABLE D1
HEAD LOSS CALCULATION
PERCHED HEADER DPE-C

Enter Pipe ID No. :		Pipe No. 301	Pipe No. 302	Pipe No. 303	Pipe No. 304	Pipe No. 305	Pipe No. 306	Pipe No. 305
	From:	Well Head PC-6	Well Head PC-5	4" PVC 303 Header	Well Head PC-2	4" PVC-303 Header	Well Head PC-1	2" PVC-306 Branch
	To:	4" PVC 303 Header	4" PVC-303 Header	6" PVC-305 Header	6" PVC-305 Header	2" PVC-306 Branch	6" PVC-305 Header	8" Manifold

Calculation of the Reynolds Number
Re = [(d_h v ρ)/μ]

Diameter of Pipe [d_h]:	[inches]	2.047	2.047	3.998	2.047	6.031	2.047	6.031
Assumed STP Temperature [T]:	[ºF]	60	60	60	60	60	60	60
Enter Flow [Q]:	[scfm]	10	10	20	10	30	10	40
Line Pressure [P]:	[psig]	-11	-11	-11	-11	-11	-11	-11
Actual Air Flow	[acfm]	39.0	39.0	78.0	39.0	116.9	39.0	155.9
The Velocity [v] is:	[ft/s]	28.43	28.43	14.90	28.43	9.82	28.43	13.10
The Density [ρ] of Air at T = 60ºF	[lbm/ft^3]	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892
Absolute Viscosity [μ] of Air at T = 60ºF:	[lbf-sec/ft^2]	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07
The Reynolds Number [Re] is:	[dimensionless]	**7,618.32**	**7,618.32**	**7,801.25**	**7,618.32**	**7,757.27**	**7,618.32**	**10,343.03**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar:								
The Friction Coefficient [λ] is:	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent:								
Enter Friction Coefficient [λ]:	[dimensionless]	**0.033627**	**0.033627**	**0.033300**	**0.034**	**0.033**	**0.034**	**0.031**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss h_{loss} = λ (l/ d_h) (ρ v^2/2)
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	96	17	276	9	125	24	96
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0312**	**0.0055**	**0.0125**	**0.0029**	**0.0016**	**0.0078**	**0.0021**

TABLE D1
HEAD LOSS CALCULATION
PERCHED HEADER DPE-C

Enter Pipe ID No. :		Pipe No. 301	Pipe No. 302	Pipe No. 303	Pipe No. 304	Pipe No. 305	Pipe No. 306	Pipe No. 305
	From:	Well Head PC-6	Well Head PC-5	4" PVC 303 Header	Well Head PC-2	4" PVC-303 Header	Well Head PC-1	2" PVC-306 Branch
	To:	4" PVC 303 Header	4" PVC-303 Header	6" PVC-305 Header	6" PVC-305 Header	2" PVC-306 Branch	6" PVC-305 Header	8" Manifold
Headloss From Fittings [h_{lossf}] for PVC:								
Enter Number of STD 45° Elbows:		1	0	0	0	0	0	1
The Equivalent Length of Pipe is:	[ft]	2.6	0	0	0	0	0	8
Enter Number of 90° Elbows:		0	0	0	0	0	0	1
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	16.7
Enter Number of Tees (Flow Through Run):		0	0	1	0	2	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	7.9	0	24.6	0	0
Enter Number of Gate Valves:		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	1	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	10.8	0
Enter Number of Expansion Fittings (d/D = 1/2):		1	1	1	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	10.8	6.8	6.8	0	0	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Additional Fittings:		0	1	0	1	0	1	0
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	22	0	32.7	0	32.7	0
The Equivalent Length of Pipe is:	[ft]	0	22	0	32.7	0	32.7	0
Total Equivalent Length of Pipe From Fittings:	[ft]	13.4	28.8	14.7	32.7	24.6	43.5	24.7
The Friction Coefficient [λ] is:	[dimensionless]	0.034	0.034	0.033	0.034	0.033	0.034	0.031
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.0044**	**0.0094**	**0.0007**	**0.0106**	**0.00032**	**0.0141**	**0.00053**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		**Pipe No. 301**	**Pipe No. 302**	**Pipe No. 303**	**Pipe No. 304**	**Pipe No. 305**	**Pipe No. 306**	**Pipe No. 305**
$h_{loss} = h_{lossp} + h_{lossf}$	**[psi]**	**0.0356**	**0.0149**	**0.0132**	**0.0136**	**0.0020**	**0.0219**	**0.0026**
Length of Pipe	**[ft]**	**96**	**17**	**276**	**9**	**125**	**24**	**96**
h_{loss}/100 ft Pipe	**[psi]**	**0.04**	**0.09**	**0.005**	**0.151**	**0.0016**	**0.09**	**0.003**

TOTAL HEAD LOSS DPE-C (psi)
0.104

TABLE D1
HEAD LOSS CALCULATION
PERCHED HEADER DPE-D

Enter Pipe ID No. :		**Pipe No. 401**	**Pipe No. 402**	**Pipe No. 404**	**Pipe No. 403**	**Pipe No. 404**	**Pipe No. 405**	**Pipe No. 404**	**Pipe No. 406**	**Pipe No. 404**	**Pipe No. 407**	**Pipe No. 408**	**Pipe No. 409**	**Pipe No. 408**
	From:	Well Head PD-9	Well Head PD-8	2" PVC 401 Branch	Well Head PD-7	2" PVC 403 Branch	Well Head PD-6	2" PVC 405 Branch	Well Head PD-5	2" PVC 406 Branch	Well Head PD-4	4" PVC-404 Header	Well Head PD-1	2" PVC 409 Branch
	To:	4" PVC-404 Header	4" PVC-404 Header	2" PVC 403 Branch	4" PVC-404 Header	2" PVC 405 Branch	4" PVC-404 Header	2" PVC 406 Branch	4" PVC-404 Header	6" PVC-408 Header	6" PVC-408 Header	2" PVC 409 Branch	6" PVC-408 Header	8" Manifold

Calculation of the Reynolds Number
$Re = [(d_h\ v\ \rho)/\mu]$

Diameter of Pipe [d_h]:	[inches]	2.047	2.047	3.998	2.047	3.998	2.047	3.998	2.047	3.998	2.047	6.031	2.047	6.031
Assumed STP Temperature [T]:	[°F]	60	60	60	60	60	60	60	60	60	60	60	60	60
Enter Flow [Q]:	[scfm]	10	10	20	10	30	10	40	10	50	10	60	10	70
Line Pressure [P]:	[psig]	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
Actual Air Flow:	[acfm]	39.0	39.0	78.0	39.0	116.9	39.0	155.9	39.0	194.9	39.0	233.9	39.0	272.9
The Velocity [v] is:	[ft/s]	28.43	28.43	14.90	28.43	22.36	28.43	29.81	28.43	37.26	28.43	19.65	28.43	22.92
The Density [ρ] of Air at T = 60°F	[lbm/ft^3]	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892
Absolute Viscosity [μ] of Air at T = 60°F:	[$lbf\text{-}sec/ft^2$]	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07
The Reynolds Number [Re] is:	[dimensionless]	**7,618.32**	**7,618.32**	**7,801.25**	**7,618.32**	**11,701.88**	**7,618.32**	**15,602.51**	**7,618.32**	**19,503.14**	**7,618.32**	**15,514.55**	**7,618.32**	**18,100.31**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar:														
The Friction Coefficient [λ] is:	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent:														
Enter Friction Coefficient [λ]:	[dimensionless]	**0.033627**	**0.033627**	**0.033300**	**0.034**	**0.030**	**0.034**	**0.028**	**0.034**	**0.026**	**0.034**	**0.028**	**0.034**	**0.027**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (l/d_h)\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE P	[ft]	67	25	45	40	36	37	59	37	95	33	360	36	143
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0218**	**0.0081**	**0.0020**	**0.0130**	**0.0033**	**0.0120**	**0.0089**	**0.0120**	**0.0211**	**0.0107**	**0.0156**	**0.0117**	**0.0081**

TABLE D1
HEAD LOSS CALCULATION
PERCHED HEADER DPE-D

Enter Pipe ID No. :		**Pipe No. 401**	**Pipe No. 402**	**Pipe No. 404**	**Pipe No. 403**	**Pipe No. 404**	**Pipe No. 405**	**Pipe No. 404**	**Pipe No. 406**	**Pipe No. 404**	**Pipe No. 407**	**Pipe No. 408**	**Pipe No. 409**	**Pipe No. 408**
	From:	Well Head PD-9	Well Head PD-8	2" PVC 401 Branch	Well Head PD-7	2" PVC 403 Branch	Well Head PD-6	2" PVC 405 Branch	Well Head PD-5	2" PVC 406 Branch	Well Head PD-4	4" PVC-404 Header	Well Head PD-1	2" PVC 409 Branch
	To:	4" PVC-404 Header	4" PVC-404 Header	2" PVC 403 Branch	4" PVC-404 Header	2" PVC 405 Branch	4" PVC-404 Header	2" PVC 406 Branch	4" PVC-404 Header	6" PVC-408 Header	6" PVC-408 Header	2" PVC 409 Branch	6" PVC-408 Header	8" Manifold
Headloss From Fittings [h_{lossf}] for PVC:														
Enter Number of STD 45° Elbows:		0	0	0	0	0	0	0	0	0	0	1	0	3
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	8	0	24
Enter Number of 90° Elbows:		0	0	0	0	0	0	0	0	0	0	0	0	1
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	16.7
Enter Number of Tees (Flow Through Run):		0	0	2	0	1	0	1	0	0	0	2	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	15.8	0	7.9	0	7.9	0	0	0	24.6	0	0
Enter Number of Gate Valves:		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/2):		1	1	0	1	0	1	0	1	1	1	0	1	0
The Equivalent Length of Pipe is:	[ft]	6.8	6.8	0	6.8	0	6.8	0	6.8	14	6.8	0	6.8	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Additional Fittings:		0	1	0	1	0	1	0	1	0	1	0	1	0
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	22	0	22	0	22	0	22	0	32.7	0	32.7	0
The Equivalent Length of Pipe is:	[ft]	0	22	0	22	0	22	0	22	0	32.7	0	32.7	0
Total Equivalent Length of Pipe From Fittings:	[ft]	6.8	28.8	15.8	28.8	7.9	28.8	7.9	28.8	14	39.5	32.6	39.5	40.7
The Friction Coefficient [λ] is:	[dimensionless]	0.034	0.034	0.033	0.034	0.030	0.034	0.028	0.034	0.026	0.034	0.028	0.034	0.027
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.0022**	**0.0094**	**0.0007**	**0.0094**	**0.0007**	**0.0094**	**0.0012**	**0.00936**	**0.0031**	**0.01284**	**0.0014**	**0.01284**	**0.00231**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		**Pipe No. 401**	**Pipe No. 402**	**Pipe No. 404**	**Pipe No. 403**	**Pipe No. 404**	**Pipe No. 405**	**Pipe No. 404**	**Pipe No. 406**	**Pipe No. 404**	**Pipe No. 407**	**Pipe No. 408**	**Pipe No. 409**	**Pipe No. 408**
$h_{loss} = h_{lossp} + h_{lossf}$	**[psi]**	**0.0240**	**0.0175**	**0.0028**	**0.0224**	**0.0040**	**0.0214**	**0.0101**	**0.0214**	**0.0242**	**0.0236**	**0.0170**	**0.0245**	**0.0104**
Length of Pipe	**[ft]**	**67**	**25**	**45**	**40**	**36**	**37**	**59**	**37**	**95**	**33**	**360**	**36**	**143**
h_{loss}/100 ft Pipe	**[psi]**	**0.04**	**0.07**	**0.006**	**0.06**	**0.011**	**0.058**	**0.017**	**0.058**	**0.03**	**0.071**	**0.005**	**0.0682**	**0.007**

TOTAL HEAD LOSS DPE-D (psi)
0.223

TABLE D2
HEAD LOSS CALCULATION
VAPOR EXTRACTION HEADER VE-1

Enter Pipe ID No. :		Pipe No. 501	Pipe No. 502	Pipe No. 508	Pipe No. 503	Pipe No. 508	Pipe No. 504	Pipe No. 508	Pipe No. 505	Pipe No. 509	Pipe No. 506	Pipe No. 509	Pipe No. 507
	From:	Well Head DAB-1	Well Head DAB-2	2" PVC-501 Branch	Well Head DAB-3	2" PVC 503 Branch	Well Head DAB-4	2" PVC 504 Branch	Well Head DAB-5	4" PVC 508 Header	Well Head DAB-6	2" PVC 506 Branch	Well Head DAB-7
	To:	4" PVC-508 Header	4" PVC-508 Header	2" PVC-503 Branch	4" PVC-508 Header	2" PVC 504 Branch	4" PVC-508 Header	6" PVC 509 Header	6" PVC-509 Header	2" PVC 506 Branch	6" PVC 509 Header	8" Manifold	6" PVC 509 Header

Calculation of the Reynolds Number
$Re = [(d_h\ v\ p)/\mu]$

Diameter of Pipe [d_h]:	[inches]	2.047	2.047	3.998	2.047	3.998	2.047	3.998	2.047	6.031	2.047	6.031	2.047
Assumed STP Temperature [T]:	[°F]	60	60	60	60	60	60	60	60	60	60	60	60
Enter Flow [Q]:	[scfm]	7	7	14	7	21	7	28	7	35	7	49	7
Line Pressure [P]:	[psig]	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
Actual Air Flow:	[acfm]	27.3	27.3	54.6	27.3	81.9	27.3	109.1	27.3	136.4	27.3	191.0	27.3
The Velocity [v] is:	[ft/s]	19.90	19.90	10.43	19.90	15.65	19.90	20.87	19.90	11.46	19.90	16.05	19.90
The Density [ρ] of Air at T = 60°F	[lbm/ft^3]	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892
Absolute Viscosity [μ] of Air at T = 60°F:	[lbf-sec/ft^2]	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07
The Reynolds Number [Re] is:	[dimensionless]	**5,332.83**	**5,332.83**	**5,460.88**	**5,332.83**	**8,191.32**	**5,332.83**	**10,921.76**	**5,332.83**	**9,050.15**	**5,332.83**	**12,670.21**	**5,332.83**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar: **The Friction Coefficient [λ] is:**	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent: **Enter Friction Coefficient [λ]:**	[dimensionless]	**0.037**	**0.037**	**0.037**	**0.037**	**0.033**	**0.037**	**0.030**	**0.037**	**0.032**	**0.037**	**0.029**	**0.037**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (l/\ d_h)\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	50	10	185	10	120	10	107	23	141	28	128	82
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0088**	**0.0018**	**0.0046**	**0.0018**	**0.0059**	**0.0018**	**0.0087**	**0.0041**	**0.0024**	**0.0049**	**0.0039**	**0.0145**

TABLE D2
HEAD LOSS CALCULATION
VAPOR EXTRACTION HEADER VE-1

Enter Pipe ID No. :		Pipe No. 501	Pipe No. 502	Pipe No. 508	Pipe No. 503	Pipe No. 508	Pipe No. 504	Pipe No. 508	Pipe No. 505	Pipe No. 509	Pipe No. 506	Pipe No. 509	Pipe No. 507
	From:	Well Head DAB-1	Well Head DAB-2	2" PVC-501 Branch	Well Head DAB-3	2" PVC 503 Branch	Well Head DAB-4	2" PVC 504 Branch	Well Head DAB-5	4" PVC 508 Header	Well Head DAB-6	2" PVC 506 Branch	Well Head DAB-7
	To:	4" PVC-508 Header	4" PVC-508 Header	2" PVC-503 Branch	4" PVC-508 Header	2" PVC 504 Branch	4" PVC-508 Header	6" PVC 509 Header	6" PVC-509 Header	2" PVC 506 Branch	6" PVC 509 Header	8" Manifold	6" PVC 509 Header
Headloss From Fittings [h_{lossf}] for PVC:													
Enter Number of STD 45° Elbows:		0	0	0	0	0	0	3	1	1	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	15.3	2.6	5.1	0	0	0
Enter Number of 90° Elbows:		1	0	0	0	0	0	0	0	0	1	2	1
The Equivalent Length of Pipe is:	[ft]	5.7	0	0	0	0	0	0	0	0	5.7	33.4	5.7
Enter Number of Tees (Flow Through Run):		0	0	2	0	1	0	0	0	2	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	15.8	0	7.9	0	0	0	24.6	0	0	0
Enter Number of Gate Valves:		0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0	1	0	1
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	10.8	0	10.8
Enter Number of Expansion Fittings (d/D = 1/2):		1	1	0	1	0	1	1	1	0	1	0	0
The Equivalent Length of Pipe is:	[ft]	6.8	6.8	0	6.8	0	6.8	14	6.8	0	6.8	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0	1	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	12	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Additional Fittings:		0	1	0	1	0	1	0	1	0	0	1	1
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	22	0	22	0	22	0	32.7	0	0	32.7	32.7
The Equivalent Length of Pipe is:	[ft]	0	22	0	22	0	22	0	32.7	0	0	32.7	32.7
Total Equivalent Length of Pipe From Fittings:	[ft]	12.5	28.8	15.8	28.8	7.9	28.8	29.3	54.1	29.7	23.3	66.1	49.2
The Friction Coefficient [λ] is:	[dimensionless]	0.037	0.037	0.037	0.037	0.033	0.037	0.030	0.037	0.032	0.037	0.029	0.037
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.00221**	**0.0051**	**0.00039**	**0.0051**	**0.0004**	**0.0051**	**0.0024**	**0.0096**	**0.0005**	**0.0041**	**0.0020**	**0.0087**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		**Pipe No. 501**	**Pipe No. 502**	**Pipe No. 508**	**Pipe No. 503**	**Pipe No. 508**	**Pipe No. 504**	**Pipe No. 508**	**Pipe No. 505**	**Pipe No. 509**	**Pipe No. 506**	**Pipe No. 509**	**Pipe No. 507**
$h_{loss} = h_{lossp} + h_{lossf}$	**[psi]**	**0.0110**	**0.0069**	**0.0049**	**0.0069**	**0.0063**	**0.0069**	**0.0110**	**0.0136**	**0.0029**	**0.0091**	**0.0059**	**0.0232**
Length of Pipe	**[ft]**	**50**	**10**	**185**	**10**	**120**	**10**	**107**	**23**	**141**	**28**	**128**	**82**
h_{loss}/100 ft Pipe	**[psi]**	**0.02**	**0.07**	**0.003**	**0.07**	**0.005**	**0.07**	**0.010**	**0.06**	**0.002**	**0.03**	**0.005**	**0.03**

TOTAL HEAD LOSS VE-1 (psi)
0.109

TABLE D2
HEAD LOSS CALCULATION
VAPOR EXTRACTION HEADER VE-2

Enter Pipe ID No. :		Pipe No. 601	Pipe No. 602	Pipe No. 603	Pipe No. 615	Pipe No. 617	Pipe No. 618	Pipe No. 619	Pipe No. 609	Pipe No. 610	Pipe No. 616	Pipe No. 604	Pipe No. 605	Pipe No. 606	Pipe No. 607	Pipe No. 608	Pipe No. 613	Pipe No. 614	Pipe No. 616	Pipe No. 616
	From:	Well Head DAB-8	Well Head DA-1	Well Head DB-1	2" PVC-601 Branch	Well Head DA-7	Well Head DB-7	2" PVC 619 Header	Well Head DA-4	Well Head DB-4	2" PVC-619 Header	Well Head DA-2	Well Head DB-2	Well Head DA-3	Well Head DB-3	2" PVC 605 Branch	Well Head DA-6	Well Head DB-6	4" PVC 608 Header	4" PVC 614 Header
	To:	4" PVC-615 Header	4" PVC-615 Header	2" PVC-602 Branch	6" PVC 615 Header	2" PVC-619 Header	2" PVC-619 Header	6" PVC-616 Header	6" PVC-616 Header	6" PVC-616 Header	4" PVC 608 Header	2" PVC 605 Branch	4" PVC 608 Header	4" PVC-608 Header	4" PVC-608 Header	6" PVC 616 Header	2" PVC-614 Branch	6" PVC 616 Branch	2" PVC 614 Branch	8" Manifold

Calculation of the Reynolds Number
$Re = [(d_h\ v\ \rho)/\mu]$

Diameter of Pipe [d_h]:	[inches]	2.047	2.047	2.047	3.998	2.047	2.047	2.047	2.047	2.047	6.031	2.047	2.047	2.047	2.047	3.998	2.047	2.047	6.031	6.031
Assumed STP Temperature [T]:	[°F]	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Enter Flow [Q]:	[scfm]	7	14	7	21	7	7	14	7	7	49	7	14	7	7	28	7	14	91	105
Line Pressure [P]:	[psig]	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
Actual Air Flow:	[acfm]	27.3	54.6	27.3	81.9	27.3	27.3	54.6	27.3	27.3	191.0	27.3	54.6	27.3	27.3	109.1	27.3	54.6	354.7	409.3
The Velocity [v] is:	[ft/s]	19.90	39.80	19.90	15.65	19.90	19.90	39.80	19.90	19.90	16.05	19.90	39.80	19.90	19.90	20.87	19.90	39.80	29.80	34.39
The Density [ρ] of Air at T = 60°F	[lbm/ft^3]	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892
Absolute Viscosity [μ] of Air at T = 60°F:	[lbf-sec/ft^2]	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07
The Reynolds Number [Re] is:	[dimensionless]	**5,332.83**	**10,665.65**	**5,332.83**	**8,191.32**	**5,332.83**	**5,332.83**	**10,665.65**	**5,332.83**	**5,332.83**	**12,670.21**	**5,332.83**	**10,665.65**	**5,332.83**	**5,332.83**	**10,921.76**	**5,332.83**	**10,665.65**	**23,530.40**	**27,150.46**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar:																				
The Friction Coefficient [λ] is:	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent:																				
Enter Friction Coefficient [λ]:	[dimensionless]	**0.037**	**0.031**	**0.037**	**0.033**	**0.037**	**0.037**	**0.031**	**0.037**	**0.037**	**0.029**	**0.037**	**0.031**	**0.037**	**0.037**	**0.030**	**0.037**	**0.031**	**0.025**	**0.024**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (\ l/\ d_h\ )\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	110	8	8	132	12	12	90	10	10	156	5	110	5	5	154	20	55	79	157
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0194**	**0.0046**	**0.0014**	**0.0065**	**0.0021**	**0.0021**	**0.0523**	**0.0018**	**0.0018**	**0.0048**	**0.0009**	**0.0639**	**0.0009**	**0.0009**	**0.0125**	**0.0035**	**0.0320**	**0.0071**	**0.0181**

TABLE D2
HEAD LOSS CALCULATION
VAPOR EXTRACTION HEADER VE-2

Enter Pipe ID No. :		Pipe No. 601	Pipe No. 602	Pipe No. 603	Pipe No. 615	Pipe No. 617	Pipe No. 618	Pipe No. 619	Pipe No. 609	Pipe No. 610	Pipe No. 616	Pipe No. 604	Pipe No. 605	Pipe No. 606	Pipe No. 607	Pipe No. 608	Pipe No. 613	Pipe No. 614	Pipe No. 616	Pipe No. 616
	From:	Well Head DAB-8	Well Head DA-1	Well Head DB-1	2" PVC-601 Branch	Well Head DA-7	Well Head DB-7	2" PVC 619 Header	Well Head DA-4	Well Head DB-4	2" PVC-619 Header	Well Head DA-2	Well Head DB-2	Well Head DA-3	Well Head DB-3	2" PVC 605 Branch	Well Head DA-6	Well Head DB-6	4" PVC 608 Header	4" PVC 614 Header
	To:	4" PVC-615 Header	4" PVC-615 Header	2" PVC-602 Branch	6" PVC 615 Header	2" PVC-619 Header	2" PVC-619 Header	6" PVC-616 Header	6" PVC-616 Header	6" PVC-616 Header	4" PVC 608 Header	2" PVC 605 Branch	4" PVC 608 Header	4" PVC-608 Header	4" PVC-608 Header	6" PVC 616 Header	2" PVC-614 Branch	6" PVC 616 Branch	2" PVC 614 Branch	8" Manifold
Headloss From Fittings [h_{lossf}] for PVC:																				
Enter Number of STD 45° Elbows:		0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0	0	4
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	10.2	0	0	0	0	0	0	0	15.3	0	0	0	32
Enter Number of 90° Elbows:		0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	1	0	0	1
The Equivalent Length of Pipe is:	[ft]	0	0	5.7	0	5.7	0	0	0	0	0	5.7	0	0	0	11.4	5.7	0	0	16.7
Enter Number of Tees (Flow Through Run):		0	0	0	1	1	0	1	0	0	3	1	0	0	0	2	0	1	1	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	7.9	4	0	7.9	0	0	36.9	4	0	0	0	15.8	0	12	12.3	0
Enter Number of Gate Valves:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	10.8	10.8	0	0	0	0	0	0	0	33	0	0
Enter Number of Expansion Fittings (d/D = 1/2):		1	1	0	1	0	0	2	0	0	0	0	1	1	1	1	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	6.8	6.8	0	14	0	0	20.8	0	0	0	0	6.8	4	4	14	0	0	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enter Number of Additional Fittings:		0	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	0	0
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	22	12	0	0	12	0	32.7	32.7	32.7	32.7	12	22	22	32.7	12	32.7	0	0
The Equivalent Length of Pipe is:	[ft]	0	22	12	0	0	12	0	32.7	32.7	32.7	32.7	12	22	22	32.7	12	32.7	0	0
Total Equivalent Length of Pipe From Fittings:	[ft]	6.8	28.8	17.7	21.9	9.7	12	38.9	43.5	43.5	69.6	42.4	18.8	26	26	95.2	17.7	77.7	12.3	48.7
The Friction Coefficient [λ] is:	[dimensionless]	0.037	0.031	0.037	0.033	0.037	0.037	0.031	0.037	0.037	0.029	0.037	0.031	0.037	0.037	0.030	0.037	0.031	0.025	0.024
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.00120**	**0.0167**	**0.00313**	**0.0011**	**0.0017**	**0.0021**	**0.0226**	**0.0077**	**0.0077**	**0.0021**	**0.0075**	**0.0109**	**0.0046**	**0.0046**	**0.0077**	**0.0031**	**0.0451**	**0.0011**	**0.0056**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		Pipe No. 601	Pipe No. 602	Pipe No. 603	Pipe No. 615	Pipe No. 617	Pipe No. 618	Pipe No. 619	Pipe No. 609	Pipe No. 610	Pipe No. 616	Pipe No. 604	Pipe No. 605	Pipe No. 606	Pipe No. 607	Pipe No. 608	Pipe No. 613	Pipe No. 614	Pipe No. 616	Pipe No. 616
$h_{loss} = h_{lossp} + h_{lossf}$	**[psi]**	**0.0206**	**0.0214**	**0.0045**	**0.0076**	**0.0038**	**0.0042**	**0.0749**	**0.0094**	**0.0094**	**0.0069**	**0.0084**	**0.0748**	**0.0055**	**0.0055**	**0.0202**	**0.0067**	**0.0771**	**0.0082**	**0.0238**
Length of Pipe	**[ft]**	**110**	**8**	**8**	**132**	**12**	**12**	**90**	**10**	**10**	**156**	**5**	**110**	**5**	**5**	**154**	**20**	**55**	**79**	**157**
h_{loss}/100 ft Pipe	**[psi]**	**0.019**	**0.27**	**0.057**	**0.006**	**0.032**	**0.04**	**0.083**	**0.09**	**0.09**	**0.004**	**0.167**	**0.07**	**0.11**	**0.109**	**0.013**	**0.033**	**0.140**	**0.010**	**0.015**

TOTAL HEAD LOSS VE-2 (psi)
0.171

f 2

TABLE D2
HEAD LOSS CALCULATION
VAPOR EXTRACTION HEADER VE-3

Enter Pipe ID No. :		Pipe No. 701	Pipe No. 702	Pipe No. 703	Pipe No. 704	Pipe No. 705	Pipe No. 708	Pipe No. 708	Pipe No. 706	Pipe No. 707	Pipe No. 708
	From:	Well Head DA-9	Well Head DB-9	Well Head DA-10	Well Head DB-10	2" PVC-701 Branch	4" CPVC-705 Header	ERH Stub-up	Well Head DA-8	Well Head DB-8	2" CPVC-706 Branch
	To:	4" CPVC-705 Header	2" PVC-701 Header	4" CPVC-705 Header	4" CPVC-705 Header	6" CPVC-708 Header	ERH Stub-up	2" CPVC-706 Branch	6" CPVC-706 Header	6" CPVC-706 Header	8" Manifold

Calculation of the Reynolds Number

$Re = [(d_h\ v\ \rho)/\mu]$

Diameter of Pipe [d_h]:	[inches]	1.913	1.913	1.913	1.913	3.786	5.709	5.709	1.913	1.913	5.709
Assumed STP Temperature [T]:	[°F]	60	60	60	60	60	60	60	60	60	60
Enter Flow [Q]:	[scfm]	14	7	7	7	28	28	278	7	7	292
Line Pressure [P]:	[psig]	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
Actual Air Flow:	[acfm]	54.6	27.3	27.3	27.3	109.1	109.1	1083.6	27.3	27.3	1138.2
The Velocity [v] is:	[ft/s]	45.57	22.78	22.78	22.78	23.27	10.23	101.60	22.78	22.78	106.72
The Density [ρ] of Air at T = 60°F	[lbm/ft^3]	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892
Absolute Viscosity [μ] of Air at T = 60°F:	[$lbf\text{-}sec/ft^2$]	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07
The Reynolds Number [Re] is:	[dimensionless]	**11,412.75**	**5,706.37**	**5,706.37**	**5,706.37**	**11,533.33**	**7,648.48**	**75,938.49**	**5,706.37**	**5,706.37**	**79,762.73**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar: **The Friction Coefficient [λ] is:**	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent: **Enter Friction Coefficient [λ]:**	[dimensionless]	**0.030**	**0.037**	**0.037**	**0.037**	**0.030**	**0.033**	**0.019**	**0.037**	**0.037**	**0.019**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (l/\ d_h)\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	120	5	5	5	120	105	95	20	20	115
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0961**	**0.0012**	**0.0012**	**0.0012**	**0.0126**	**0.0016**	**0.0807**	**0.0049**	**0.0049**	**0.1067**

TABLE D2
HEAD LOSS CALCULATION
VAPOR EXTRACTION HEADER VE-3

Enter Pipe ID No. :		Pipe No. 701	Pipe No. 702	Pipe No. 703	Pipe No. 704	Pipe No. 705	Pipe No. 708	Pipe No. 708	Pipe No. 706	Pipe No. 707	Pipe No. 708
	From:	Well Head DA-9	Well Head DB-9	Well Head DA-10	Well Head DB-10	2" PVC-701 Branch	4" CPVC-705 Header	ERH Stub-up	Well Head DA-8	Well Head DB-8	2" CPVC-706 Branch
	To:	4" CPVC-705 Header	2" PVC-701 Header	4" CPVC-705 Header	4" CPVC-705 Header	6" CPVC-708 Header	ERH Stub-up	2" CPVC-706 Branch	6" CPVC-706 Header	6" CPVC-706 Header	8" Manifold
Headloss From Fittings [h_{lossf}] for PVC:											
Enter Number of STD 45° Elbows:		0	0	0	0	0	0	2	0	0	2
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	16	0	0	16
Enter Number of 90° Elbows:		1	0	0	0	0	0	0	0	0	1
The Equivalent Length of Pipe is:	[ft]	5.7	0	0	0	0	0	0	0	0	16.7
Enter Number of Tees (Flow Through Run):		1	0	0	0	2	1	1	0	0	1
The Equivalent Length of Pipe is:	[ft]	4	0	0	0	15.8	12.3	12.3	0	0	12.3
Enter Number of Gate Valves:		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0	0	1	1	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	10.8	10.8	0
Enter Number of Expansion Fittings (d/D = 1/2):		1	0	1	1	1	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	6.8	0	6.8	6.8	14	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0	0
Enter Number of Additional Fittings:		0	1	1	1	0	0	0	1	1	0
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	12	22.4	22.4	0	0	0	32.7	32.7	0
The Equivalent Length of Pipe is:	[ft]	0	12	22.4	22.4	0	0	0	32.7	32.7	0
Total Equivalent Length of Pipe From Fittings:	[ft]	16.5	12	29.2	29.2	29.8	12.3	28.3	43.5	43.5	45
The Friction Coefficient [λ] is:	[dimensionless]	0.030	0.037	0.037	0.037	0.030	0.033	0.019	0.037	0.037	0.019
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.01322**	**0.0029**	**0.00709**	**0.0071**	**0.0031**	**0.0002**	**0.0240**	**0.0106**	**0.0106**	**0.0417**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		Pipe No. 701	Pipe No. 702	Pipe No. 703	Pipe No. 704	Pipe No. 705	Pipe No. 708	Pipe No. 708	Pipe No. 706	Pipe No. 707	Pipe No. 708
$h_{loss} = h_{lossp} + h_{lossf}$	**[psi]**	**0.1093**	**0.0041**	**0.0083**	**0.0083**	**0.0157**	**0.0018**	**0.1047**	**0.0154**	**0.0154**	**0.1484**
Length of Pipe	**[ft]**	**120**	**5**	**5**	**5**	**120**	**105**	**95**	**20**	**20**	**115**
h_{loss}/100 ft Pipe	**[psi]**	**0.09**	**0.08**	**0.166**	**0.17**	**0.013**	**0.0017**	**0.1102**	**0.077**	**0.077**	**0.129**

TOTAL HEAD LOSS VE-3 (psi)
0.431

TABLE D2
HEAD LOSS CALCULATION
VAPOR EXTRACTION HEADER VE-4

Enter Pipe ID No. :		Pipe No. 801	Pipe No. 802	Pipe No. 805	Pipe No. 803	Pipe No. 804	Pipe No. 805
	From:	Well Head DA-11	Well Head DB-11	2" CPVC-801 Branch	Well Head DA-12	Well Head DB-12	ERH Stub-up
	To:	6" CPVC-805 Header	6" CPVC-805 Header	ERH Stub-up	6" CPVC-805 Header	6" CPVC-805 Header	8" Manifold

Calculation of the Reynolds Number
Re = [(d_h v ρ)/μ]

Diameter of Pipe [d_h]:	[inches]	1.913	1.913	5.709	1.913	1.913	5.709
Assumed STP Temperature [T]:	[°F]	60	60	60	60	60	60
Enter Flow [Q]:	[scfm]	7	7	14	7	7	278
Line Pressure [P]:	[psig]	-11	-11	-11	-11	-11	-11
Actual Air Flow:	[acfm]	27.3	27.3	54.6	27.3	27.3	1083.6
The Velocity [v] is:	[ft/s]	22.78	22.78	5.12	22.78	22.78	101.60
The Density [ρ] of Air at T = 60°F	[lbm/ft^3]	0.01892	0.01892	0.01892	0.01892	0.01892	0.01892
Absolute Viscosity [μ] of Air at T = 60°F:	[lbf-sec/ft^2]	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07	3.74E-07
The Reynolds Number [Re] is:	[dimensionless]	**5,706.37**	**5,706.37**	**3,824.24**	**5,706.37**	**5,706.37**	**75,938.49**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar: **The Friction Coefficient [λ] is:**	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**

If Flow is Turbulent: **Enter Friction Coefficient [λ]:**	[dimensionless]	**0.037**	**0.037**	**0.041**	**0.037**	**0.037**	**0.019**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss h_{loss} = λ (l/ d_h) (ρ v^2/2)
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	9	9	105	11	11	213
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0022**	**0.0022**	**0.0005**	**0.0027**	**0.0027**	**0.1809**

TABLE D2
HEAD LOSS CALCULATION
VAPOR EXTRACTION HEADER VE-4

Enter Pipe ID No. :		Pipe No. 801	Pipe No. 802	Pipe No. 805	Pipe No. 803	Pipe No. 804	Pipe No. 805
	From:	Well Head DA-11	Well Head DB-11	2" CPVC-801 Branch	Well Head DA-12	Well Head DB-12	ERH Stub-up
	To:	6" CPVC-805 Header	6" CPVC-805 Header	ERH Stub-up	6" CPVC-805 Header	6" CPVC-805 Header	8" Manifold
Headloss From Fittings [h_{lossf}] for PVC:							
Enter Number of STD 45° Elbows:		0	0	0	0	0	3
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	24
Enter Number of 90° Elbows:		1	0	0	0	0	1
The Equivalent Length of Pipe is:	[ft]	5.7	0	0	0	0	16.7
Enter Number of Tees (Flow Through Run):		0	0	2	0	0	2
The Equivalent Length of Pipe is:	[ft]	0	0	24.6	0	0	24.6
Enter Number of Gate Valves:		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		1	1	0	1	1	0
The Equivalent Length of Pipe is:	[ft]	10.8	10.8	0	10.8	10.8	0
Enter Number of Expansion Fittings (d/D = 1/2):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Additional Fittings:		0	1	0	1	1	0
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	32.7	0	32.7	32.7	0
The Equivalent Length of Pipe is:	[ft]	0	32.7	0	32.7	32.7	0
Total Equivalent Length of Pipe From Fittings:	[ft]	16.5	43.5	24.6	43.5	43.5	65.3
The Friction Coefficient [λ] is:	[dimensionless]	0.037	0.037	0.041	0.037	0.037	0.019
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.00401**	**0.0106**	**0.00011**	**0.0106**	**0.0106**	**0.0554**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		**Pipe No. 801**	**Pipe No. 802**	**Pipe No. 805**	**Pipe No. 803**	**Pipe No. 804**	**Pipe No. 805**
$h_{loss} = h_{lossp} + h_{lossf}$	**[psi]**	**0.0062**	**0.0127**	**0.0006**	**0.0132**	**0.0132**	**0.2363**
Length of Pipe	**[ft]**	**9**	**9**	**105**	**11**	**11**	**213**
h_{loss}/100 ft Pipe	**[psi]**	**0.07**	**0.14**	**0.0006**	**0.12**	**0.12**	**0.11**

TOTAL HEAD LOSS VE-4 (psi)
0.282

REFERENCES
FOR
DPE AND VE PIPING HEAD LOSS

Compressible Flow Pressure Loss Results	Piping, Valves, and Fittings
Pressure Loss (psi): 0.034	
Job Number: DPE-C **Client:** US EPA **Date:** 2/8/06 **Line Number:** Pipe 301 Confirmation **Fluid:** Air **Piping/Tubing Inner Diameter (in):** 2.047 **Flow Rate:** 10 SCFM **Piping Length (ft):** 96 **Viscosity (cP):** 0.018 **Inlet Pressure (PSIG):** -11 **Temperature (F):** 60 **Pipe Roughness (ft):** 0.00021 **Actual Pipe ID (in.):** 2.047 **Fluid Velocity (ft/sec):** 28.99 **Reynolds Number:** 7862 **Flow Region:** Turbulent **Friction Factor:** 0.0346 **Pressure Loss (psi):** 0.034 **Net Expansion Factor:** 0.995 **Inlet Mach Number:** 0.026 **Outlet Mach Number:** 0.026 **Density at Inlet:** 0.019 **Specific Volume at Inlet:** 52 **K1:** 1054.83 **K2:** 1035.36 **Overall K:** 19.47 **Specific Heat Ratio:** 1.4 **M iterations:** 167 **Friction Factor iterations:** 6	

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

Flow Velocity & Friction Loss

FRICTION LOSS

Friction loss through PVC and CPVC pipe is most commonly obtained by the use of the Hazen-Williams equations as expressed below for water:

$$f = .2083 \times \left(\frac{100}{C}\right)^{1.852} \times \frac{G^{1.852}}{di^{4.8655}}$$

where:

f = friction head of feet of water per 100′ for the specific pipe size and I.D.

C = a constant for internal pipe roughness. 150 is the commonly accepted value for PVC and CPVC pipe.

G = flow rate of gallons per minute (U.S. gallons).

di = inside diameter of pipe in inches.

Compared to other materials on construction for pipe, thermoplastic pipe smoothness remains relatively constant throughout its service life.

WATER VELOCITIES

Velocities for water in feet per second at different GPM's and pipe inside diameters can be calculated as follows:

$$V = .3208 \frac{G}{A}$$

where:

V = velocity in feet per second

G = gallons per minute

A = inside cross sectional area in square inches

THRUST BLOCKING

In addition to limiting velocities to 5′/sec., especially with larger diameters (6″ and above), consideration should be given to stresses induced with intermittent pump operation, quick opening valves and back flow in elevated discharge lines. Use of bypass piping with electrically actuated time cycle valves or variable speed pumps and check valves on the discharge side are suggested with the higher GPM rates.

Thrust blocking should be considered for directional changes and pump operations in buried lines 10″ and above, particularly where fabricated fittings are utilized. Above grade installations 10″ and above should have equivalent bracing to simulate thrust blocking at directional changes and for intermittent pump operations. Thrust blocking of directional changes and time cycle valves are also recommended for large diameter drain lines in installations such as large swimming pools and tanks. Use of appropriate pump vibration dampers are also recommended.

Pipe Size Inches	Socket Depth (In.)	THRUST IN POUNDS FROM STATIC INTERNAL PRESSURE: For Plug, Cap Tee & 60° Ell	For 22½° Ell	For 45° Ell	For 90° Ell	Joint Resistance To Thrust	90° Ell Safety Factor
6	6	7,170	2,800	5,480	10,140	37,464	3.7
8	6	11,240	4,380	8,590	15,890	48,774	3.1
10	8	16,280	6,350	12,440	23,020	81,054	3.5
12	8½	23,040	8,990	17,600	32,580	102,141	3.1
14	9	26,610	10,380	20,330	37,630	115,752	3.1
16	10	34,910	13,620	26,670	49,360	150,798	3.1
18	12	44,290	17,270	33,840	62,630	203,577	3.3
20	12	43,410	16,540	32,400	59,970	226,194	3.8
24	14	61,040	23,810	46,640	86,310	316,500	3.7

Socket depths are from ASTMD 2672 for belled end PVC pipe. Working pressures utilized for the tabulation above are for Sch 80 2″-18″ sizes and SDR 160 psi for 20″ and 24″ sizes.

The calculation for thrusts due to static internal pressure is

$$\text{Thrust} = \frac{(\text{Av I.D.})^2 \pi}{4} (\text{working pressure}) (x)$$

x = 1.0 for tees, 60° ells, plugs and caps, .390 for 22½° bends, .764 for 45° ells, 1.414 for 90° ells

Joint Resistance to Thrust = (O.D.) (π) (socket depth) (300 psi)

300 psi = Min cement shear strength with good field cementing technique.

FRICTION LOSS THROUGH FITTINGS

Friction loss through fittings is expressed in equivalent feet of the same pipe size and schedule for the system flow rate. Schedule 40 head loss per 100′ values are usually used for other wall thicknesses and standard iron pipe size O.D.'s.

Average Friction Loss for PVC and CPVC Fittings in Equivalent Feet of Straight Run Pipe

Item	½	¾	1	1¼	1½	2	2½	3	4	6	8	10	12	14	16	18	20	24
Tee Run	1.0	1.4	1.7	2.3	2.7	4.0	4.9	6.1	7.9	12.3	14.0	17.5	20.0	25.0	27.0	32.0	35.0	42.0
Tee Branch	3.8	4.9	6.0	7.3	8.4	12.0	14.7	16.4	22.0	32.7	49.0	57.0	67.0	78.0	88.0	107.0	118.0	137.0
90° Ell	1.5	2.0	2.5	3.8	4.0	5.7	6.9	7.9	11.4	16.7	21.0	26.0	32.0	37.0	43.0	53.0	58.0	67.0
45° Ell	.8	1.1	1.4	1.8	2.1	2.6	3.1	4.0	5.1	8.0	10.6	13.5	15.5	18.0	20.0	23.0	25.0	30.0

Values 10″-24″: Approximate values from Nomograph

PRESSURE DROP IN VALVES & STRAINERS

Pressure drop calculations can be made for valves and strainers for different fluids, flow rates and sizes using the CV values and the following equation:

$$P = \frac{(G)^2 \ (\text{specific gravity liquid})}{(\text{CV Factor})^2}$$

where:

P = Pressure drop in PSI; feet of water = $\frac{PSI}{.4332}$

G = Gallons per minute

CV = Gallons per minute per 1 PSI pressure drop

CV Factors GPM

Item	¼	⅜	½	¾	1	1¼	1½	2	2½	3	4
True Union Ball Valve	1.0	8.0	8.0	15.0	29.0	75.0	90.0	140.0	330.0	480.0	600.0
Single Entry Ball Valve	1.0	8.0	8.0	16.0	29.0	75.0	90.0	140.0	330.0	480.0	600.0
OIC Ball Valve	—	—	8.0	15.0	29.0	75.0	90.0	140.0	—	—	—
True Check Ball Valve	1.0	3.0	4.6	10.0	28.0	45.0	55.0	90.0	225.0	324.0	345.0
Y-Check Valve	—	—	5.0	6.0	12.5	40.0	40.0	65.0	130.0	160.0	250.0
3-Way Flanged Ball Valve	—	—	5.0	10.0	16.0	—	45.0	55.0	—	200.0	350.0
Needle Valve Full Open	5.0	7.5	8.0	—	—	—	—	—	—	—	—
Angle Valve	1.0	—	5.0	10.0	16.0	—	45.0	70.0	—	—	—
Y-Strainer (clean screen)	—	—	3.8	6.6	8.4	20.0	25.0	35.0	60.0	60.0	95.0
Simplex Basket Strainer (clean screen)	—	—	6.0	9.5	29.0	—	40.0	55.0	—	125.0	155.0
Duplex Basket Strainer (clean screen)	—	—	5.0	6.0	7.0	—	28.0	35.0	—	80.0	100.0

PVC SCHEDULE 40 PIPE

SAFE FOR CONVEYING POTABLE WATER

SPECIFICATIONS

- N.S.F.: All PVC Pipe from the Ryan Herco Products Corp. will meet or exceed the requirements of the National Sanitation Foundation No. 61 for conveying potable water.
- ASTM: The material used in the manufacture of pipe for the Ryan Herco Products Corp. will meet ASTM-D-1784-65T for a PVC Type 1 material. The Schedule 40 and Schedule 80 Pipe conforms to ASTM-D-1785.
- CS (Commercial Standard): CS-207-60 is the industry standard for Schedule 40 and Schedule 80 PVC pipe, and is met by pipe from the Ryan Herco Products Corp. in both schedules. PVC pipe meeting this specification has the same O.D. and I.D. as the corresponding schedule of iron or galvanized pipe.

ORDER: 3900.(Size No.) PVC PIPE, SCHEDULE 40   20 ft. length standard

Size No.	Nom. Pipe Size (in.)	O.D. in.	O.D. (mm)	Average I.D. in.	Average I.D. (mm)	Minimum Wall Thickness in.	Minimum Wall Thickness (mm)	Nom. Wt. (lbs./ 100 ft.)	Max. Work Pressure (psi)*	Price Per Foot Plain End
002	1/4	0.540	(13.7)	0.344	(8.7)	0.088	(2.2)	7.8	780	$.34
003	3/8	0.675	(17.1)	0.473	(12.0)	0.091	(2.3)	10.5	620	.46
005	1/2	0.840	(21.3)	0.602	(15.3)	0.119	(2.8)	16.4	600	.20
007	3/4	1.050	(26.7)	0.804	(20.4)	0.123	(2.9)	21.8	480	.26
010	1	1.315	(33.4)	1.029	(26.1)	0.143	(3.6)	32.1	450	.38
012	1-1/4	1.660	(42.2)	1.360	(34.5)	0.150	(3.8)	43.4	370	.50
015	1-1/2	1.900	(48.3)	1.590	(40.4)	0.155	(3.9)	51.8	330	.60
020	2	2.375	(60.3)	2.047	(52.0)	0.164	(4.1)	69.4	280	.80
025	2-1/2	2.875	(73.0)	2.445	(62.1)	0.215	(5.4)	110.0	300	1.26
030	3	3.500	(88.9)	3.042	(77.3)	0.229	(5.9)	143.4	260	1.64
040	4	4.500	(114.3)	3.998	(101.5)	0.251	(6.3)	204.1	220	2.32
050	5	5.563	(141.3)	5.015	(127.4)	0.273	(6.9)	272.6	190	3.18
060	6	6.625	(168.3)	6.031	(153.2)	0.297	(7.5)	359.7	180	4.08
080	8	8.625	(219.1)	7.941	(201.7)	0.341	(8.7)	547.9	160	6.18

SCHEDULE 40 LARGE-DIAMETER PROCESS PIPE   20 ft. length standard

Size No.	Nom. Pipe Size (in.)	O.D. in.	O.D. (mm)	Average I.D. in.	Average I.D. (mm)	Minimum Wall Thickness in.	Minimum Wall Thickness (mm)	Nom. Wt. (lbs./ 100 ft.)	Max. Work Pressure (psi)*	Price Per Foot Plain End
100	10	10.750	(273.1)	9.976	(253.4)	0.365	(9.3)	753.2	140	8.50
120	12	12.750	(323.9)	11.890	(302.0)	0.406	(10.3)	994.9	130	11.22
140	14	14.000	(356.0)	13.072	(332.0)	0.438	(11.1)	1181.0	130	22.68
160	16	16.000	(406.0)	14.940	(379.0)	0.500	(12.7)	1542.0	130	29.60
180	18	18.000	(457.2)	16.809	(426.9)	0.562	(14.3)	2011.2	130	42.07
200	20	20.000	(508.0)	18.743	(476.1)	0.593	(15.1)	2362.4	120	92.60
240	24	24.000	(609.6)	22.540	(572.6)	0.687	(17.4)	3287.3	120	75.17

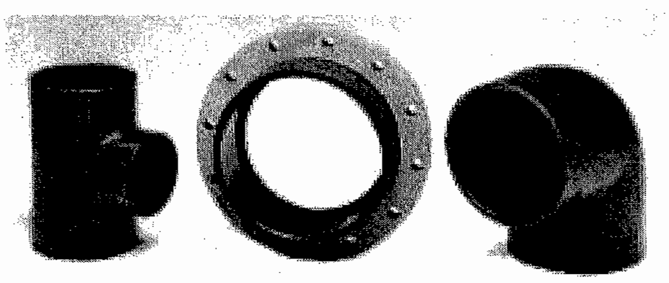
We can square-cut pipe to your requirements.
Minimum available quantity is one length.

*Maximum working pressure is calculated at 73˚F.

110.310.110 All

NOT RECOMMENDED FOR COMPRESSED AIR OR GAS

LARGE DIAMETER MOLDED PIPE FITTINGS



FEATURES

- We have tees and elbows available, injection-molded from type 1 PVC at 73˚F for the pressures (listed at ambient temperatures) shown in parentheses.
- Ten through sixteen-inch couplings are fabricated from Schedule 40 PVC pipe.
- Complete listings of other fabricated fittings appear on pages 146-147.

TEES, all-socket, PVC
- **3401.100 tee, 10" (140 psi) $655.06**
- **3401.120 tee, 12" (130 psi) 967.88**

90˚ ELL, socket x socket, PVC
- **3406.100 ell, 10" (140 psi) 526.21**
- **3406.120 ell, 12" (130 psi) 705.75**

45˚ ELL, socket x socket, PVC
- **3417.100 ell, 10" (140 psi) 343.77**
- **3417.120 ell, 12" (130 psi) 509.44**

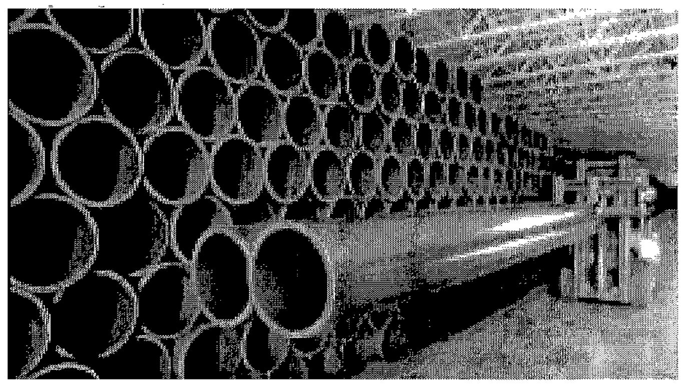
COUPLING, socket x socket, PVC
- **3429.100 coupling, 10" (140 psi) 57.58**
- **3429.120 coupling, 12" (130 psi) 84.76**
- **3429.140F coupling, 14" (130 psi) 137.63**
- **3429.160F coupling, 16" (130 psi) 153.50**

110.320.110 Tee
110.340.110 90˚
110.340.230 45˚
110.410.180 Cplg

RyanHerco FLUID FLOW SOLUTIONS

PVC SCHEDULE 80 PIPE

SPECIFICATIONS
- ASTM: Material meets ASTM-D-1784-65T for a PVC Type 1 material. Schedule 40 and Schedule 80 Pipe conforms to ASTM-D-1785.
- CS (Commercial Standard): CS-207-60 is the industry standard for Schedule 40 and Schedule 80 PVC pipe and is met by pipe from Ryan Herco Products Corp. in both schedules. PVC pipe meeting this specification has the same O.D. and I.D. as the corresponding schedule of iron or galvanized pipe.
- Standard length: 20 feet.
- Minimum available quantity is one length.



3905.(Size No.) PVC HEAVY WALL PIPE, SCHEDULE 80
3905H(Size No.) HARVEL HIGH QUALITY PVC, SCHEDULE 80

PVC PIPE & FITTINGS NOT RECOMMENDED FOR COMPRESSED AIR OR GAS

Size No.	Nom. Pipe Size (in.)	O.D. in. (mm)	Avg. I.D. in. (mm)	Min. Wall Thick. in. (mm)	Nom. Wt. (lbs./ 100 ft.)	Max. Work Pressure (psi)*	Price per Foot 3905	3905H
001	1/8	0.405 (10.3)	0.203 (5.2)	0.095 (2.4)	5.8	1225	—	$ .46
002	1/4	0.540 (13.7)	0.288 (7.2)	0.119 (3.0)	9.8	1130	—	.64
003	3/8	0.675 (17.1)	0.407 (10.2)	0.126 (3.2)	13.6	920	—	.86
005	1/2	0.840 (21.3)	0.528 (13.4)	0.147 (3.7)	20.5	850	$.28	.28
007	3/4	1.050 (26.7)	0.724 (18.3)	0.154 (3.9)	27.8	690	.36	.36
010	1	1.315 (33.4)	0.935 (23.7)	0.179 (4.5)	40.9	630	.54	.54
012	1-1/4	1.660 (42.2)	1.256 (31.9)	0.191 (4.9)	56.6	520	.74	.74
015	1-1/2	1.900 (48.3)	1.476 (37.5)	0.200 (5.1)	68.5	470	.90	.90
020	2	2.375 (60.3)	1.913 (48.6)	0.218 (5.5)	94.8	400	1.24	1.24
025	2-1/2	2.875 (73.0)	2.289 (58.2)	0.276 (7.0)	144.8	420	1.88	1.88
030	3	3.500 (88.9)	2.864 (72.7)	0.300 (7.6)	193.7	370	2.50	2.50
040	4	4.500 (114.3)	3.786 (96.2)	0.337 (8.6)	283.1	320	3.66	3.66
050	5	5.563 (141.3)	4.767 (121.7)	0.375 (9.5)	386.7	290	5.52	5.52
060	6	6.625 (168.3)	5.709 (144.8)	0.432 (11.0)	540.6	280	6.98	6.98
080	8	8.625 (219.1)	7.565 (192.2)	0.500 (12.7)	821.2	240	10.72	10.72

SCH. 80 LARGE-DIAMETER PROCESS PIPE

115.110.020

Size No.	Nom. Pipe Size (in.)	O.D. in. (mm)	Avg. I.D. in. (mm)	Min. Wall Thick. in. (mm)	Nom. Wt. (lbs./ 100 ft.)	Max. Work Pressure (psi)*	Price per Foot 3905	3905H
100	10	10.750 (273.1)	9.492 (241.1)	0.593 (15.1)	1195.6	230	$17.44	$15.88
120	12	12.750 (323.9)	11.294 (286.9)	0.687 (17.4)	1643.7	230	24.08	21.82
140	14	14.000 (355.6)	12.410 (315.2)	0.750 (19.1)	1979.0	220	—	34.54
160	16	16.000 (406.4)	14.214 (361.0)	0.843 (21.4)	2543.0	220	—	57.82
180	18	18.000 (457.2)	16.014 (406.8)	0.937 (23.8)	3183.0	220	—	72.38
200	20	20.000 (508.0)	17.814 (452.5)	1.031 (26.2)	4009.1	220	—	52.98
240	24	24.000 (609.6)	21.418 (544.0)	1.218 (30.9)	5688.2	210	—	75.17

* The maximum working pressure is calculated at 73°F. See General Information Section to derate for higher temperatures.

BLUE 75 THREAD SEALANT

FORMULATED, DESIGNED & TESTED FOR PLASTIC PIPING PRODUCTS

FEATURES
- Anti-seize properties allow easy assembly and positive seal without over tightening.
- NSF tested and certified safe for use with potable water.
- Will not transfer taste or odor to the sealed system.
- Available in 1/4 pint, 1/2 pint, 1 pint and 1 quart metal cans with brush top applicators.
- For use with all thermoplastic piping system components, including PVC and CPVC products, CPVC fire sprinkler products, CPVC CTS (Copper-Tube-Size) products, and plastic-to-metal transition products.
- Suitable for sealing threads in metal, ABS, PVC, CPVC and Nylon piping systems. For use in metal and plastic systems properly designed for handling a wide variety of liquids and gases (not recommended for use in oxygen handling systems).

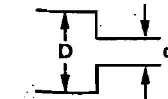
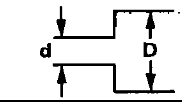
SPECIFICATIONS
- Color: Light blue.
- Consistency: Grit-free, crushable paste.
- Potable water approval: NSF (National Sanitation Foundation).

ORDER INFORMATION:

8040.005 BLUE 75 THREAD SEALANT, 1/4 Pint **$6.89**
8040.010 BLUE 75 THREAD SEALANT, 1/2 Pint **10.99**
8040.020 BLUE 75 THREAD SEALANT, 1 Pint **17.77**
8040.030 BLUE 75 THREAD SEALANT, 1 Quart **37.93**

190.220.150

Table 1 - Normal Fittings - Equivalent Lengths

Pipe Size d (in.)	Vessel Outlet	Vessel Inlet	Elbows 45 deg Thd	Elbows 45 deg Weld/Flg	Elbows 90 deg (short radius) Thd	Elbows 90 deg (short radius) Weld/Flg	Elbows 90 deg (long radius) Thd	Elbows 90 deg (long radius) Weld/Flg	Run of Tee	Branch of Tee	Gate Valve	Globe Valve	Plug Cock	Angle Valve	[1] Full Port Ball and Plug Valve	Butter-fly Valve	Sudden Contraction d/D = 1/4	Sudden Contraction d/D = 1/2	Sudden Contraction d/D = 3/4	Sudden Enlargement d/D = 1/4	Sudden Enlargement d/D = 1/2	Sudden Enlargement d/D = 3/4	[2] Swing Check
																							
	Equivalent Length (ft)																						
1/2	1.9	3.7	0.8	0.4	1.7	---	1.1	0.7	1.1	3.3	0.7	17	0.9	7.3	0.7	---	1.6	1.2	0.7	3.2	2.1	0.7	6.8
3/4	2.5	4.9	1.0	0.6	2.1	---	1.4	0.9	1.4	4.2	0.9	23	1.2	9.7	0.9	---	2.1	1.6	0.9	4.3	2.7	0.9	9.0
1	3.1	6.2	1.2	0.7	2.6	1.6	1.8	1.2	1.8	5.3	1.1	28	1.5	12.1	1.1	---	2.7	2.0	1.1	5.4	3.4	1.1	11.3
1-1/2	4.9	9.9	1.9	1.1	4.1	2.4	2.7	1.8	2.7	8.1	1.7	45	4	19	1.7	---	4.3	1.6	1.7	8.7	5.5	1.7	18
2	6.2	12.3	2.4	1.5	5.2	3.1	3.5	2.3	3.5	10.4	2.2	59	3	25	2.2	---	5.3	4.0	2.2	10.8	6.8	2.2	23
2-1/2	7.7	15.4	2.9	1.7	6.2	3.7	4.2	2.7	4.2	12.4	2.7	---	3.8	---	2.7	---	6.7	5.0	2.7	13.5	8.5	2.7	28
3	9.3	19	3.6	2.2	7.7	5.	5.2	3.4	5.7	15.5	3.3	86	4.5	38	3.3	---	8.1	6.0	3.3	16.3	10.3	3.3	34
4	12	25	5	3	10	7	7	4	7	20	4	112	6	48	4	7	11	8	4	22	14	4	45
6	16	37	8	5	15	10	10	7	10	30	7	170	9	73	7	20	16	12	6	33	21	6	70
8	23	46	9	6	20	13	13	9	13	40	9	225	12	98	9	28	20	15	8	43	26	8	90
10	30	60	13	7	25	16	17	11	17	52	12	280	15	121	12	34	26	20	11	53	34	11	110
12	37	74	14	9	30	19	20	13	20	60	13	340	18	145	13	40	32	24	13	65	41	13	135
14	42	84	---	10	---	21	---	15	22	66	15	397	21	169	15	44	36	28	15	74	47	15	158
16	50	100	---	11	---	24	---	17	25	78	17	453	23	193	17	50	43	33	18	88	53	18	180
18	58	111	---	13	---	27	---	19	28	85	19	510	27	218	19	56	50	38	19	98	62	19	203
20	62	123	---	14	---	29	---	21	32	95	21	567	30	242	21	60	53	40	21	108	68	21	225
24	74	148	---	17	---	35	---	26	40	120	25	680	36	290	25	76	64	48	25	130	82	25	270
30	93	185	---	21	---	44	---	32	50	150	32	850	46	360	32	100	80	60	32	163	103	32	338
36	111	222	---	25	---	53	---	39	60	175	38	1,020	53	435	38	120	96	72	38	195	123	38	405
42	130	259	---	30	----	63	---	45	68	200	46	1,190	62	508	46	140	112	84	46	228	144	46	473

[1] For reduced port, check manufacturer's catalog

[2] For mission duo-chek valve, check manufacturer's catalog

CALCUATIONS FOR GROUNDWATER PIPING HEAD LOSS

TABLE D3
HEAD LOSS CALCULATION
SOUTH TRENCH GROUNDWATER LINE GW-1

Enter Pipe ID No. :		Pipe No. 901	Pipe No. 902	Pipe No. 903	Pipe No. 904	Pipe No. 905	Pipe No. 906	Pipe No. 907
	From:	Well Head DAB-1	DAB-2 Branch	DAB-3 Branch	DAB-4 Branch	DAB-5 Branch	DAB-6 Branch	Well Head DAB-7
	To:	DAB-2 Branch	DAB-3 Branch	DAB-4 Branch	DAB-5 Branch	DAB-6 Branch	DAB-7 Branch	GW Sump

Calculation of the Reynolds Number
$Re = [(d_h\ v\ \rho)/\mu]$

Diameter of Pipe [d_h]:	[inches]	2.047	2.047	2.047	3.998	3.998	3.998	3.998
Assumed Operating Temperature [T]:	[°F]	60	60	60	60	60	60	60
Extraction Flow [Q]:	[gpm]	4.6	9.2	13.8	18.4	23.0	27.6	32.2
Extraction Flow [Q]:	[ft^3/min]	0.615	1.230	1.845	2.460	3.075	3.690	4.305
The Velocity [v] is:	[ft/s]	0.45	0.90	1.35	0.47	0.59	0.71	0.82
The Density [ρ] of Water at T = 60°F	[lbm/ft^3]	62.353	62.353	62.353	62.353	62.353	62.353	62.353
Absolute Viscosity [μ] of Water at T = 60°F:	[lbf-sec/ft^2]	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05
The Reynolds Number [Re] is:	[dimensionless]	**6,320.08**	**12,640.16**	**18,960.25**	**12,943.68**	**16,179.60**	**19,415.52**	**22,651.44**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar: **The Friction Coefficient [λ] is:**	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent: **Enter Friction Coefficient [λ]:**	[dimensionless]	**0.035**	**0.029**	**0.026**	**0.029**	**0.027**	**0.026**	**0.025**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (l/\ d_h)\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	105	115	115	118	116	117	173
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0295**	**0.1070**	**0.2173**	**0.0153**	**0.0222**	**0.0307**	**0.0596**

Headloss From Fittings [h_{lossf}] for PVC:

Enter Number of STD 45° Elbows:		0	0	0	1	1	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	5.1	5.1	0	0
Enter Number of 90° Elbows:		1	0	0	0	0	0	3
The Equivalent Length of Pipe is:	[ft]	5.7	0	0	0	0	0	34.2
Enter Number of Tees (Flow Through Run):		1	1	1	1	1	0	1
The Equivalent Length of Pipe is:	[ft]	4	4	4	7.9	7.9	0	7.9
Enter Number of Gate Valves:		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/2):		0	0	1	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	6.8	0	0	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0
Enter Number of Additional Fittings (Tee w/Flow thru Branch):		0	1	1	1	1	2	1
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	12	22	22	22	22	22
The Equivalent Length of Pipe is:	[ft]	0	12	22	22	22	44	22
Total Equivalent Length of Pipe From Fittings:	[ft]	9.7	16	32.8	35	35	44	64.1
The Friction Coefficient [λ] is:	[dimensionless]	0.035	0.029	0.026	0.029	0.027	0.026	0.025
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.00273**	**0.0149**	**0.06198**	**0.0045**	**0.0067**	**0.0116**	**0.0221**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		Pipe No. 901	Pipe No. 902	Pipe No. 903	Pipe No. 904	Pipe No. 905	Pipe No. 906	Pipe No. 907
$h_{loss} = h_{lossp} + h_{lossf}$	**[psi]**	**0.0323**	**0.1218**	**0.2793**	**0.0198**	**0.0288**	**0.0423**	**0.0817**
Length of Pipe	**[ft]**	**105**	**115**	**115**	**118**	**116**	**117**	**173**
h_{loss}/100 ft Pipe	**[psi]**	**0.031**	**0.106**	**0.243**	**0.017**	**0.025**	**0.036**	**0.047**

TOTAL HEAD LOSS GW-1 (psi)
0.606

Note:
1. This calculation includes conveyance pipe headloss calculations (well head and down well head loss is not included).
2. All conveyance pipe fittings are included in the calculation.

TABLE D3
HEAD LOSS CALCULATION
WEST TRENCH GROUNDWATER LINE GW-2

Enter Pipe ID No. :		Pipe No. 1001	Pipe No. 1002	Pipe No. 1003	Pipe No. 1004	Pipe No. 1005	Pipe No. 1006	Pipe No. 1007	Pipe No. 1008	Pipe No. 1009
	From:	Well Head DAB-8	DA/B-1 Branch	Well Head DA/B-7	DA/B-4 Branch	Well Head DA/B-2	DA/B-3 Branch	DA/B-5 Branch	Well Head DA/B-6	4"-1007 Header
	To:	DA/B-1 Branch	DA/B-4 Branch	4"-1002 Header	DA/B-5 Branch	DA/B-3 Branch	4"-1007 Header	4"-1009 Header	4"-1009 Header	GW Sump

Calculation of the Reynolds Number
$Re = [(d_h\ v\ \rho)/\mu]$

Diameter of Pipe [d_h]:	[inches]	2.047	3.998	2.047	3.998	2.047	3.998	3.998	2.047	3.998
Assumed Operating Temperature [T]:	[°F]	60	60	60	60	60	60	60	60	60
Extraction Flow [Q]:	[gpm]	4.6	9.2	4.6	18.4	4.6	9.2	32.2	4.6	36.8
Extraction Flow [Q]:	[ft^3/min]	0.61	1.23	0.61	2.46	0.61	1.23	4.30	0.61	4.92
The Velocity [v] is:	[ft/s]	0.45	0.24	0.45	0.47	0.45	0.24	0.82	0.45	0.94
The Density [ρ] of Water at T = 60°F	[lbm/ft^3]	62.353	62.353	62.353	62.353	62.353	62.353	62.353	62.353	62.353
Absolute Viscosity [μ] of Water at T = 60°F:	[lbf-sec/ft^2]	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05	2.34E-05
The Reynolds Number [Re] is:	[dimensionless]	**6,320.08**	**6,471.84**	**6,320.08**	**12,943.68**	**6,320.08**	**6,471.84**	**22,651.44**	**6,320.08**	**25,887.36**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar: **The Friction Coefficient [λ] is:**	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent: **Enter Friction Coefficient [λ]:**	[dimensionless]	**0.035**	**0.035**	**0.035**	**0.029**	**0.035**	**0.035**	**0.025**	**0.035**	**0.024**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (l/\ d_h)\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	113	125	127	103	120	110	83	53	119
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0318**	**0.0049**	**0.0357**	**0.0133**	**0.0337**	**0.0043**	**0.0286**	**0.0149**	**0.0519**

Headloss From Fittings [h_{lossf}] for PVC:

Enter Number of STD 45° Elbows:		0	1	1	0	0	0	0	0	3
The Equivalent Length of Pipe is:	[ft]	0	5.1	2.6	0	0	0	0	0	15.3
Enter Number of 90° Elbows:		0	0	1	0	1	1	0	1	1
The Equivalent Length of Pipe is:	[ft]	0	0	5.7	0	5.7	11.4	0	5.7	11.4
Enter Number of Tees (Flow Through Run):		1	1	2	3	2	1	2	1	1
The Equivalent Length of Pipe is:	[ft]	4	7.9	11.9	23.7	11.9	7.9	15.8	4	7.9
Enter Number of Gate Valves:		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/2):		1	0	1	0	1	0	0	1	0
The Equivalent Length of Pipe is:	[ft]	6.8	0	6.8	0	6.8	0	0	6.8	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Additional Fittings (Tee w/Flow thru Branch):		0	3	1	3	1	3	2	2	1
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	22	22	22	22	22	22	22	22
The Equivalent Length of Pipe is:	[ft]	0	66	22	66	22	66	44	44	22
Total Equivalent Length of Pipe From Fittings:	[ft]	10.8	79	49	89.7	46.4	85.3	59.8	60.5	56.6
The Friction Coefficient [λ] is:	[dimensionless]	0.035	0.035	0.035	0.029	0.035	0.035	0.025	0.035	0.024
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.00304**	**0.0031**	**0.01378**	**0.0116**	**0.0130**	**0.0033**	**0.0206**	**0.0170**	**0.0247**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		Pipe No. 1001	Pipe No. 1002	Pipe No. 1003	Pipe No. 1004	Pipe No. 1005	Pipe No. 1006	Pipe No. 1007	Pipe No. 1008	Pipe No. 1009
$h_{loss} = h_{lossp} + h_{lossf}$	**[psi]**	**0.0348**	**0.0080**	**0.0495**	**0.0250**	**0.0468**	**0.0077**	**0.0492**	**0.0319**	**0.0765**
Length of Pipe	**[ft]**	**113**	**125**	**127**	**103**	**120**	**110**	**83**	**53**	**119**
h_{loss}**/100 ft Pipe**	**[psi]**	**0.031**	**0.006**	**0.039**	**0.024**	**0.039**	**0.007**	**0.059**	**0.060**	**0.064**

TOTAL HEAD LOSS GW-2 (psi)
0.329

Note:
1. This calculation includes conveyance pipe headloss calculations (well head and down well head loss is not included).
2. All pipe fittings are included in the calculation.

TABLE D3
HEAD LOSS CALCULATION
EAST TRENCH GROUNDWATER LINE GW-3

Enter Pipe ID No. :		Pipe No. 1101	Pipe No. 1102	Pipe No. 1103	Pipe No. 1104	Pipe No. 1105	Pipe No. 1106
	From:	Well Head DA/B-9	DA/B-10 Branch	DA/B-11 Branch	MW-24-140	DA/B-12 Branch	DA/B-8 Branch
	To:	DA/B-10 Branch	DA/B-11 Branch	DA/B-12 Branch	4"-1103 Header	DA/B-8 Branch	GW Sump

Calculation of the Reynolds Number
$Re = [(d_h\ v\ \rho)/\mu]$

Diameter of Pipe [d_h]:	[inches]	2.047	3.786	3.786	1.913	3.786	3.786
Assumed Operating Temperature [T]:	[°F]	60	120	120	120	120	120
Extraction Flow [Q]:	[gpm]	4.6	9.2	13.8	2	20.4	25
Extraction Flow [Q]:	[ft^3/min]	0.61	1.23	1.84	0.27	2.73	3.34
The Velocity [v] is:	[ft/s]	0.45	0.26	0.39	0.22	0.58	0.71
The Density [ρ] of Water at T	[lbm/ft^3]	62.353	61.71	61.71	61.71	61.71	61.71
Absolute Viscosity [μ] of Water at T	[lbf-sec/ft^2]	2.34E-05	1.16E-05	1.16E-05	1.16E-05	1.16E-05	1.16E-05
The Reynolds Number [Re] is:	[dimensionless]	**6,320.08**	**13,620.49**	**20,430.74**	**5,860.04**	**30,201.96**	**37,012.21**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar:							
The Friction Coefficient [λ] is:	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**

If Flow is Turbulent:							
Enter Friction Coefficient [λ]:	[dimensionless]	**0.035**	**0.029**	**0.026**	**0.036**	**0.024**	**0.022**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (l/\ d_h)\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	126	107	117	40	78	107
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0354**	**0.0044**	**0.0099**	**0.0030**	**0.0131**	**0.0258**

Headloss From Fittings [h_{lossf}] for PVC:

Enter Number of STD 45° Elbows:		0	0	0	0	2	1
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	10.2	5.1
Enter Number of 90° Elbows:		1	0	0	0	0	1
The Equivalent Length of Pipe is:	[ft]	5.7	0	0	0	0	11.4
Enter Number of Tees (Flow Through Run):		2	2	3	0	2	1
The Equivalent Length of Pipe is:	[ft]	11.9	15.8	23.7	0 ·	15.8	7.9
Enter Number of Gate Valves:		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/2):		1	0	0	1	0	0
The Equivalent Length of Pipe is:	[ft]	6.8	0	0	6.8	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	1	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	12	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Additional Fittings (Tee w/Flow thru Branch):		1	2	3	1	2	2
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	12	22	22	22	22	22
The Equivalent Length of Pipe is:	[ft]	12	44	66	22	44	44

Total Equivalent Length of Pipe From Fittings:	[ft]	36.4	59.8	89.7	40.8	70	68.4
The Friction Coefficient [λ] is:	[dimensionless]	0.035	0.029	0.026	0.036	0.024	0.022
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.01024**	**0.0025**	**0.00757**	**0.0031**	**0.0118**	**0.0165**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		Pipe No. 1101	Pipe No. 1102	Pipe No. 1103	Pipe No. 1104	Pipe No. 1105	Pipe No. 1106
$h_{loss} = h_{lossp} + h_{lossf}$	[psi]	0.0457	0.0069	0.0174	0.0061	0.0249	0.0422
Length of Pipe	[ft]	126	107	117	40	78	107
h_{loss}/100 ft Pipe	[psi]	0.036	0.006	0.015	0.015	0.032	0.039

TOTAL HEAD LOSS GW-3 (psi)
0.143

Note:
1. This calculation includes conveyance pipe headloss calculations (well head and down well head loss is not included).
2. All pipe fittings are included in the calculation.

REFERENCES
FOR
GROUNDWATER PIPING HEAD LOSS

Straight Line Loss Calculation Results

Pressure Loss (psi): 0.049 **Head Loss (ft):** 0.113

Job Number: Groundwater Line GW-2
Client:
Date: 2/8/08
Line Number: Pipe 1009 Confirmation
Fluid: Water
Pipe/Tubing ID (in): 4.026
Flow Rate (gpm): 36.8
Viscosity (cP): 1
Specific Gravity (water=1): 1
Temperature (F): 70
Pipe Roughness (ft): 0.000005
Fluid Velocity (ft/sec): 0.93
Reynolds Number: 28908
Flow Region: Turbulent
Friction Factor: 0.024
Piping Length (ft): 119
Pressure Loss (psi): 0.049
Head Loss (ft): 0.113
Iterations: 5

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

Straight Line Loss Calculation Results

Pressure Loss (psi): 0.2 **Head Loss (ft):** 0.463

Job Number: Groundwater Line GW-1
Client:
Date: 2/8/08
Line Number: Pipe 903 Confirmation
Fluid: Water
Pipe/Tubing ID (in): 2.067
Flow Rate (gpm): 13.8
Viscosity (cP): 1
Specific Gravity (water=1): 1
Temperature (F): 60
Pipe Roughness (ft): 0.000005
Fluid Velocity (ft/sec): 1.32
Reynolds Number: 21114
Flow Region: Turbulent
Friction Factor: 0.026
Piping Length (ft): 115
Pressure Loss (psi): 0.2
Head Loss (ft): 0.463
Iterations: 5

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

Flow Velocity & Friction Loss

FRICTION LOSS

Friction loss through PVC and CPVC pipe is most commonly obtained by the use of the Hazen-Williams equations as expressed below for water:

$$f = .2083 \times \left(\frac{100}{C}\right)^{1.852} \times \frac{G^{1.852}}{di^{4.8655}}$$

where:
- f = friction head of feet of water per 100′ for the specific pipe size and I.D.
- C = a constant for internal pipe roughness. 150 is the commonly accepted value for PVC and CPVC pipe.
- G = flow rate of gallons per minute (U.S. gallons).
- di = inside diameter of pipe in inches.

Compared to other materials on construction for pipe, thermoplastic pipe smoothness remains relatively constant throughout its service life.

WATER VELOCITIES

Velocities for water in feet per second at different GPM's and pipe inside diameters can be calculated as follows:

$$V = .3208\ \frac{G}{A}$$

where:
- V = velocity in feet per second
- G = gallons per minute
- A = inside cross sectional area in square inches

THRUST BLOCKING

In addition to limiting velocities to 5′/sec., especially with larger diameters (6″ and above), consideration should be given to stresses induced with intermittent pump operation, quick opening valves and back flow in elevated discharge lines. Use of bypass piping with electrically actuated time cycle valves or variable speed pumps and check valves on the discharge side are suggested with the higher GPM rates.

Thrust blocking should be considered for directional changes and pump operations in buried lines 10″ and above, particularly where fabricated fittings are utilized. Above grade installations 10″ and above should have equivalent bracing to simulate thrust blocking at directional changes and for intermittent pump operations. Thrust blocking of directional changes and time cycle valves are also recommended for large diameter drain lines in installations such as large swimming pools and tanks. Use of appropriate pump vibration dampers are also recommended.

Pipe Size Inches	Socket Depth (In.)	THRUST IN POUNDS FROM STATIC INTERNAL PRESSURE: For Plug, Cap Tee & 60° Ell	For 22½° Ell	For 45° Ell	For 90° Ell	Joint Resistance To Thrust	90° Ell Safety Factor
6	6	7,170	2,800	5,480	10,140	37,464	3.7
8	6	11,240	4,380	8,590	15,890	48,774	3.1
10	8	16,280	6,350	12,440	23,020	81,054	3.5
12	8½	23,040	8,990	17,600	32,580	102,141	3.1
14	9	26,610	10,380	20,330	37,630	115,752	3.1
16	10	34,910	13,620	26,670	49,360	150,798	3.1
18	12	44,290	17,270	33,840	62,630	203,577	3.3
20	12	43,410	16,840	32,400	59,970	226,194	3.8
24	14	61,040	23,810	46,640	86,310	316,500	3.7

Socket depths are from ASTMD 2672 for belled end PVC pipe. Working pressures utilized for the tabulation above are for Sch 80 2″-18″ sizes and SDR 160 psi for 20″ and 24″ sizes.

The calculation for thrusts due to static internal pressure is

$$\text{Thrust} = \frac{((\text{Av I.D.})^2 \pi)}{4}(\text{working pressure})(x)$$

x = 1.0 for tees, 60° ells, plugs and caps, .390 for 22½° bends, .764 for 45° ells, 1.414 for 90° ells

Joint Resistance to Thrust = (O.D.) (π) (socket depth) (300 psi)

300 psi = Min cement shear strength with good field cementing technique.

FRICTION LOSS THROUGH FITTINGS

Friction loss through fittings is expressed in equivalent feet of the same pipe size and schedule for the system flow rate. Schedule 40 head loss per 100′ values are usually used for other wall thicknesses and standard iron pipe size O.D.'s.

Average Friction Loss for PVC and CPVC Fittings in Equivalent Feet of Straight Run Pipe

Item	½	¾	1	1¼	1½	2	2½	3	4	6	8	10	12	14	16	18	20	24
Tee Run	1.0	1.4	1.7	2.3	2.7	4.0	4.9	6.1	7.9	12.3	14.0	17.5	20.0	25.0	27.0	32.0	35.0	42.0
Tee Branch	3.8	4.9	6.0	7.3	8.4	12.0	14.7	16.4	22.0	32.7	49.0	57.0	67.0	78.0	88.0	107.0	118.0	137.0
90° Ell	1.5	2.0	2.5	3.8	4.0	5.7	6.9	7.9	11.4	16.7	21.0	26.0	32.0	37.0	43.0	53.0	58.0	67.0
45° Ell	.8	1.1	1.4	1.8	2.1	2.6	3.1	4.0	5.1	8.0	10.6	13.5	15.5	18.0	20.0	23.0	25.0	30.0

Values 10″-24″: Approximate values from Nomograph

PRESSURE DROP IN VALVES & STRAINERS

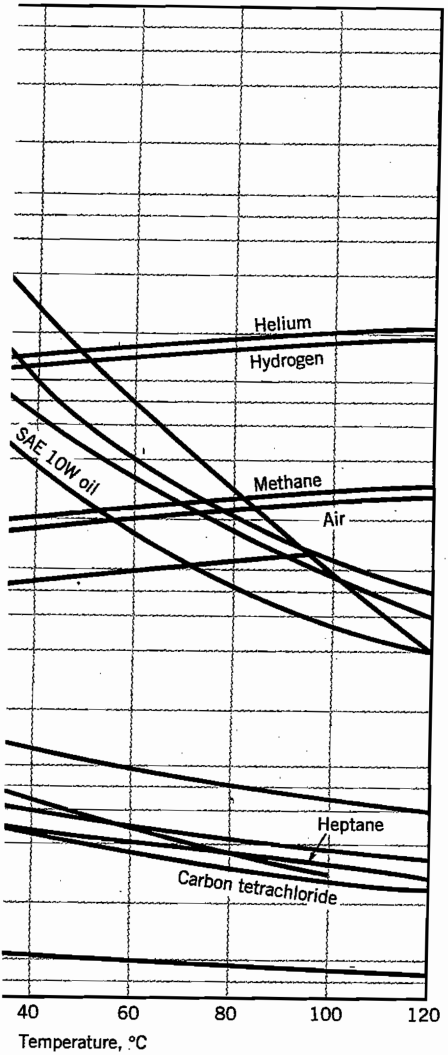
Pressure drop calculations can be made for valves and strainers for different fluids, flow rates and sizes using the CV values and the following equation:

$$P = \frac{(G)^2\ (\text{specific gravity liquid})}{(\text{CV Factor})^2}$$

where:
- P = Pressure drop in PSI; feet of water = $\frac{\text{PSI}}{.4332}$
- G = Gallons per minute
- CV = Gallons per minute per 1 PSI pressure drop

CV Factors GPM

Item	¼	⅜	½	¾	1	1¼	1½	2	2½	3	4
True Union Ball Valve	1.0	8.0	8.0	15.0	29.0	75.0	90.0	140 0	330.0	480.0	600.0
Single Entry Ball Valve	1.0	8.0	8.0	16.0	29.0	75.0	90.0	140.0	330.0	480.0	600.0
OIC Ball Valve	—	—	8.0	15.0	29.0	75.0	90.0	140.0	—	—	—
True Check Ball Valve	1.0	3.0	4.6	10.0	28.0	45.0	55.0	90.0	226.0	324.0	345.0
Y-Check Valve	—	—	5.0	6.0	12.5	40.0	40.0	65.0	130.0	160.0	250.0
3-Way Flanged Ball Valve	—	—	5.0	10.0	16.0	—	45.0	55.0	—	200.0	350.0
Needle Valve Full Open	5.0	7.5	8.0	—	—	—	—	—	—	—	—
Angle Valve	1.0	—	5.0	10.0	16.0	—	45.0	70.0	—	—	—
Y-Strainer (clean screen)	—	—	3.8	6.6	8.4	20.0	25.0	35.0	60.0	60.0	95.0
Simplex Basket Strainer (clean screen)	—	—	6.0	9.5	29.0	—	40.0	55.0	—	125.0	155.0
Duplex Basket Strainer (clean screen)	—	—	5.0	6.0	7.0	—	28.0	35 0	—	80.0	100.0



iscosity of common fluids (at atmospheric pressure) as a ... to BG units of ft²/s multiply m²/s by 10.76. Curves from ... roduction to Fluid Mechanics, Third Edition, Wiley, New

■ TABLE B.1
Physical Properties of Water (BG Units)[a]

Temperature (°F)	Density, ρ (slugs/ft³)	Specific Weight[b], γ (lb/ft³)	Dynamic Viscosity, μ (lb·s/ft²)	Kinematic Viscosity, ν (ft²/s)	Surface Tension[c], σ (lb/ft)	Vapor Pressure, p_v [lb/in.²(abs)]	Speed of Sound[d], c (ft/s)
32	1.940	62.42	3.732 E − 5	1.924 E − 5	5.18 E − 3	8.854 E − 2	4603
40	1.940	62.43	3.228 E − 5	1.664 E − 5	5.13 E − 3	1.217 E − 1	4672
50	1.940	62.41	2.730 E − 5	1.407 E − 5	5.09 E − 3	1.781 E − 1	4748
60	1.938	62.37	2.344 E − 5	1.210 E − 5	5.03 E − 3	2.563 E − 1	4814
70	1.936	62.30	2.037 E − 5	1.052 E − 5	4.97 E − 3	3.631 E − 1	4871
80	1.934	62.22	1.791 E − 5	9.262 E − 6	4.91 E − 3	5.069 E − 1	4819
90	1.931	62.11	1.500 E − 5	8.233 E − 6	4.86 E − 3	6.979 E − 1	4960
100	1.927	62.00	1.423 E − 5	7.383 E − 6	4.79 E − 3	9.493 E − 1	4995
120	1.918	61.71	1.164 E − 5	6.067 E − 6	4.67 E − 3	1.692 E + 0	5049
140	1.908	61.38	9.743 E − 6	5.106 E − 6	4.53 E − 3	2.888 E + 0	5091
160	1.896	61.00	8.315 E − 6	4.385 E − 6	4.40 E − 3	4.736 E + 0	5101
180	1.883	60.58	7.207 E − 6	3.827 E − 6	4.26 E − 3	7.507 E + 0	5195
200	1.869	60.12	6.342 E − 6	3.393 E − 6	4.12 E − 3	1.152 E + 1	5089
212	1.860	59.83	5.886 E − 6	3.165 E − 6	4.04 E − 3	1.469 E + 1	5062

[a]Based on data from *Handbook of Chemistry and Physics*, 69th Ed., CRC Press, 1988. Where necessary, values obtained by interpolation.
[b]Density and specific weight are related through the equation $\gamma = \rho g$. For this table, g = 32.174 ft/s².
[c]In contact with air.
[d]From R. D. Blevins, *Applied Fluid Dynamics Handbook*, Van Nostrand Reinhold Co., Inc., New York, 1984.

■ TABLE B.2
Physical Properties of Water (SI Units)[a]

Temperature (°C)	Density, ρ (kg/m³)	Specific Weight[b], γ (kN/m³)	Dynamic Viscosity, μ (N·s/m²)	Kinematic Viscosity, ν (m²/s)	Surface Tension[c], σ (N/m)	Vapor Pressure, p_v [N/m²(abs)]	Speed of Sound[d], c (m/s)
0	999.9	9.806	1.787 E − 3	1.787 E − 6	7.56 E − 2	6.105 E + 2	1403
5	1000.0	9.807	1.519 E − 3	1.519 E − 6	7.49 E − 2	8.722 E + 2	1427
10	999.7	9.804	1.307 E − 3	1.307 E − 6	7.42 E − 2	1.228 E + 3	1447
20	998.2	9.789	1.002 E − 3	1.004 E − 6	7.28 E − 2	2.338 E + 3	1481
30	995.7	9.765	7.975 E − 4	8.009 E − 7	7.12 E − 2	4.243 E + 3	1507
40	992.2	9.731	6.529 E − 4	6.580 E − 7	6.96 E − 2	7.376 E + 3	1526
50	988.1	9.690	5.468 E − 4	5.534 E − 7	6.79 E − 2	1.233 E + 4	1541
60	983.2	9.642	4.665 E − 4	4.745 E − 7	6.62 E − 2	1.992 E + 4	1552
70	977.8	9.589	4.042 E − 4	4.134 E − 7	6.44 E − 2	3.116 E + 4	1555
80	971.8	9.530	3.547 E − 4	3.650 E − 7	6.26 E − 2	4.734 E + 4	1555
90	965.3	9.467	3.147 E − 4	3.260 E − 7	6.08 E − 2	7.010 E + 4	1550
100	958.4	9.399	2.818 E − 4	2.940 E − 7	5.89 E − 2	1.013 E + 5	1543

[a]Based on data from *Handbook of Chemistry and Physics*, 69th Ed., CRC Press, 1988.
[b]Density and specific weight are related through the equation $\gamma = \rho g$. For this table, g = 9.807 m/s².
[c]In contact with air.
[d]From R. D. Blevins, *Applied Fluid Dynamics Handbook*, Van Nostrand Reinhold Co., Inc., New York, 1984.

PVC SCHEDULE 40 PIPE

SAFE FOR CONVEYING POTABLE WATER

SPECIFICATIONS

- N.S.F.: All PVC Pipe from the Ryan Herco Products Corp. will meet or exceed the requirements of the National Sanitation Foundation No. 61 for conveying potable water.
- ASTM: The material used in the manufacture of pipe for the Ryan Herco Products Corp. will meet ASTM-D-1784-65T for a PVC Type 1 material. The Schedule 40 and Schedule 80 Pipe conforms to ASTM-D-1785.
- CS (Commercial Standard): CS-207-60 is the industry standard for Schedule 40 and Schedule 80 PVC pipe, and is met by pipe from the Ryan Herco Products Corp. in both schedules. PVC pipe meeting this specification has the same O.D. and I.D. as the corresponding schedule of iron or galvanized pipe.

ORDER: 3900.(Size No.) PVC PIPE, SCHEDULE 40 20 ft. length standard

Size No.	Nom. Pipe Size (in.)	O.D. in.	O.D. (mm)	Average I.D. in.	Average I.D. (mm)	Minimum Wall Thickness in.	Minimum Wall Thickness (mm)	Nom. Wt. (lbs./ 100 ft.)	Max. Work Pressure (psi)*	Price Per Foot Plain End
002	1/4	0.540	(13.7)	0.344	(8.7)	0.088	(2.2)	7.8	780	$.34
003	3/8	0.675	(17.1)	0.473	(12.0)	0.091	(2.3)	10.5	620	.46
005	1/2	0.840	(21.3)	0.602	(15.3)	0.119	(2.8)	16.4	600	.20
007	3/4	1.050	(26.7)	0.804	(20.4)	0.123	(2.9)	21.8	480	.26
010	1	1.315	(33.4)	1.029	(26.1)	0.143	(3.6)	32.1	450	.38
012	1-1/4	1.660	(42.2)	1.360	(34.5)	0.150	(3.8)	43.4	370	.50
015	1-1/2	1.900	(48.3)	1.590	(40.4)	0.155	(3.9)	51.8	330	.60
020	2	2.375	(60.3)	2.047	(52.0)	0.164	(4.1)	69.4	280	.80
025	2-1/2	2.875	(73.0)	2.445	(62.1)	0.215	(5.4)	110.0	300	1.26
030	3	3.500	(88.9)	3.042	(77.3)	0.229	(5.9)	143.4	260	1.64
040	4	4.500	(114.3)	3.998	(101.5)	0.251	(6.3)	204.1	220	2.32
050	5	5.563	(141.3)	5.015	(127.4)	0.273	(6.9)	272.6	190	3.18
060	6	6.625	(168.3)	6.031	(153.2)	0.297	(7.5)	359.7	180	4.08
080	8	8.625	(219.1)	7.941	(201.7)	0.341	(8.7)	547.9	160	6.18

SCHEDULE 40 LARGE-DIAMETER PROCESS PIPE 20 ft. length standard

Size No.	Nom. Pipe Size (in.)	O.D. in.	O.D. (mm)	Average I.D. in.	Average I.D. (mm)	Minimum Wall Thickness in.	Minimum Wall Thickness (mm)	Nom. Wt. (lbs./ 100 ft.)	Max. Work Pressure (psi)*	Price Per Foot Plain End
100	10	10.750	(273.1)	9.976	(253.4)	0.365	(9.3)	753.2	140	8.50
120	12	12.750	(323.9)	11.890	(302.0)	0.406	(10.3)	994.9	130	11.22
140	14	14.000	(356.0)	13.072	(332.0)	0.438	(11.1)	1181.0	130	22.68
160	16	16.000	(406.0)	14.940	(379.0)	0.500	(12.7)	1542.0	130	29.60
180	18	18.000	(457.2)	16.809	(426.9)	0.562	(14.3)	2011.2	130	42.07
200	20	20.000	(508.0)	18.743	(476.1)	0.593	(15.1)	2362.4	120	92.60
240	24	24.000	(609.6)	22.540	(572.6)	0.687	(17.4)	3287.3	120	75.17

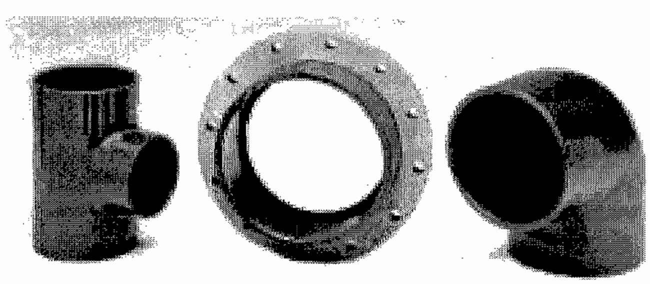
We can square-cut pipe to your requirements.
Minimum available quantity is one length.

*Maximum working pressure is calculated at 73°F.

NOT RECOMMENDED FOR COMPRESSED AIR OR GAS

110.310.110 All

LARGE DIAMETER MOLDED PIPE FITTINGS



FEATURES

- We have tees and elbows available, injection-molded from type 1 PVC at 73°F for the pressures (listed at ambient temperatures) shown in parentheses.
- Ten through sixteen-inch couplings are fabricated from Schedule 40 PVC pipe.
- Complete listings of other fabricated fittings appear on pages 146-147.

TEES, all-socket, PVC
- **3401.100 tee, 10" (140 psi) $655.06**
- **3401.120 tee, 12" (130 psi) 967.88**

90° ELL, socket x socket, PVC
- **3406.100 ell, 10" (140 psi) 526.21**
- **3406.120 ell, 12" (130 psi) 705.75**

45° ELL, socket x socket, PVC
- **3417.100 ell, 10" (140 psi) 343.77**
- **3417.120 ell, 12" (130 psi) 509.44**

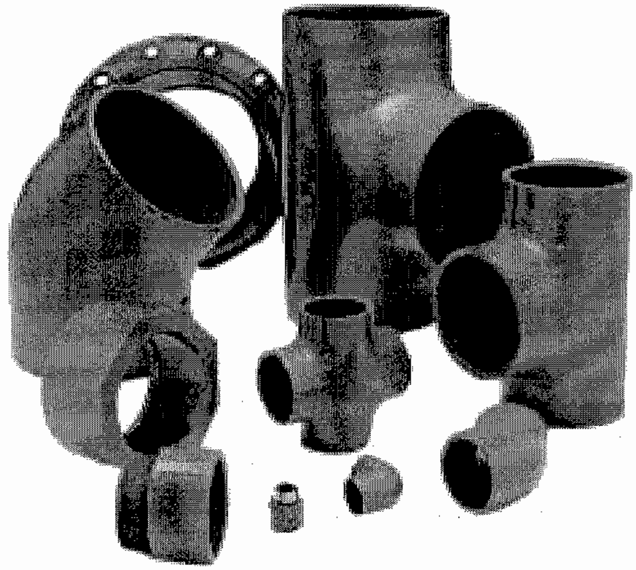
COUPLING, socket x socket, PVC
- **3429.100 coupling, 10" (140 psi) 57.58**
- **3429.120 coupling, 12" (130 psi) 84.76**
- **3429.140F coupling, 14" (130 psi) 137.63**
- **3429.160F coupling, 16" (130 psi) 153.50**

110.320.110 Tee
110.340.110 90°
110.340.230 45°
110.410.180 Cplg

HI-TEMP CPVC PIPE

FEATURES
- Conforms to the following standards:
- ASTM-F-1784–CPVC compound used in the manufacture of pipe and fittings.
- ASTM-F-441–CPVC Schedules 40 and 80 pipe dimensions.
- ASTM-F-437–CPVC threaded fittings, Schedule 80.
- ASTM-F-439–CPVC socket fittings, Schedule 80.
- ASTM-F-493–Solvent cement.
- Temperature ratings up to 210˚F.
- Joining systems: Solvent-cementing pipe to socket fittings is the most common joining method. Threaded systems permit approximately one-half the working pressure of a solvent-cemented joint at ambient temperatures.
- Your Ryan Herco Service Center can provide a number of other products in CPVC to complete your system including pumps, valves, switches, and other accessory items.

SPECIFICATIONS
- Material: CPVC type 4, grade 1 (Cell Classification 23477-B) meets the specifications for rigid CPVC per ASTM-D-1784.
- Dimensions: Schedule 80 CPVC fittings from your Ryan Herco Service Center meet or exceed the requirements of ASTM-F-437 (threaded fittings) and ASTM-F-439 (socket fittings).



NOT RECOMMENDED FOR COMPRESSED AIR OR GAS

NOTE: DO NOT THREAD SCHEDULE 40 PIPE

3668.(Size No.) CPVC STANDARD PIPE, SCHEDULE 40

Standard Lengths: 20 ft.

Size No.	Nominal Pipe Size (in.)	O.D. in.	O.D. (mm)	Avg. I.D. In.	Avg. I.D. (mm)	Minimum Wall Thickness in.	Minimum Wall Thickness (mm)	Nominal Weight (lbs./ 100 ft.)	Maximum Working Pressure (PSI)*	Price per Foot Plain End
002	1/4	0.540	(13.7)	0.364	(8.7)	0.088	(2.2)	8.7	780	**$.60**
003	3/8	0.675	(17.1)	0.473	(12.0)	0.091	(2.3)	11.7	620	**.78**
005	1/2	0.840	(21.3)	0.602	(15.3)	0.109	(2.8)	18.0	590	**.82**
007	3/4	1.050	(26.7)	0.804	(20.4)	0.113	(2.9)	23.9	480	**1.08**
010	1	1.315	(33.4)	1.029	(26.1)	0.133	(3.4)	35.2	450	**1.60**
012	1-1/4	1.660	(42.2)	1.360	(34.5)	0.140	(3.6)	47.5	365	**2.16**
015	1-1/2	1.900	(48.3)	1.590	(40.4)	0.145	(3.7)	56.8	330	**2.58**
020	2	2.375	(60.3)	2.047	(52.0)	0.154	(3.9)	76.1	275	**3.44**
025	2-1/2	2.875	(73.0)	2.445	(62.1)	0.203	(5.2)	120.1	300	**5.42**
030	3	3.500	(88.9)	3.042	(77.3)	0.216	(5.5)	157.2	260	**7.10**
040	4	4.500	(114.3)	3.998	(101.5)	0.237	(6.0)	223.9	220	**10.12**
060	6	6.625	(168.3)	6.031	(153.2)	0.280	(7.1)	394.5	175	**18.66**
080	8	8.625	(219.1)	7.943	(201.8)	0.322	(8.2)	595.8	160	**32.00**
100	10	10.750	(273.1)	9.976	(253.4)	0.365	(9.3)	845.8	140	**54.72**
120	12	12.750	(323.9)	11.890	(302.0)	0.406	(10.3)	1117.2	130	**72.28**

110.110.110 Standard 110.120.110 Heavy Wall

3670.(Size No.) CPVC HEAVY WALL PIPE, SCHEDULE 80

Size No.	Nominal Pipe Size (in.)	O.D. in.	O.D. (mm)	Avg. I.D. In.	Avg. I.D. (mm)	Minimum Wall Thickness in.	Minimum Wall Thickness (mm)	Nominal Weight (lbs./ 100 ft.)	Maximum Working Pressure (PSI)*	Price per Foot Plain End
002	1/4	0.540	(13.7)	0.282	(7.2)	0.119	(3.0)	10.9	1130	**$1.24**
003	3/8	0.675	(17.1)	0.403	(10.2)	0.126	(3.2)	15.2	915	**1.70**
005	1/2	0.840	(21.3)	0.526	(13.4)	0.146	(3.7)	22.2	850	**.88**
007	3/4	1.050	(26.7)	0.722	(18.3)	0.154	(3.9)	30.1	690	**1.18**
010	1	1.315	(33.4)	0.935	(23.7)	0.176	(4.5)	44.2	630	**1.72**
012	1-1/4	1.660	(42.2)	1.256	(31.9)	0.191	(4.9)	61.2	520	**2.38**
015	1-1/2	1.900	(48.3)	1.476	(37.5)	0.200	(5.1)	74.1	470	**2.88**
020	2	2.375	(60.3)	1.913	(48.6)	0.218	(5.5)	102.5	400	**4.00**
025	2-1/2	2.875	(73.0)	2.291	(58.2)	0.276	(7.0)	156.6	425	**6.08**
030	3	3.500	(88.9)	2.864	(72.7)	0.300	(7.6)	209.4	375	**8.14**
040	4	4.500	(114.3)	3.786	(96.2)	0.337	(8.6)	306.1	320	**11.90**
060	6	6.625	(168.3)	5.709	(144.8)	0.432	(11.0)	584.5	270	**23.16**
080	8	8.625	(219.1)	7.565	(192.2)	0.500	(12.7)	887.8	240	**37.82**
100	10	10.750	(273.1)	9.492	(241.1)	0.593	(15.1)	1342.9	230	**63.74**
120	12	12.750	(323.9)	11.294	(286.9)	0.687	(17.4)	1845.8	230	**87.62**

* The maximum working pressure is calculated at 73˚F. See the Ryan Herco engineering section, page 635, to derate for higher temperatures. Minimum available quantity is one length.

YES! WE OFFER QUANTITY DISCOUNTS

Table 1 - Normal Fittings - Equivalent Lengths

Pipe Size d (in.)	Vessel Outlet	Vessel Inlet	Elbows 45 deg Thd	Elbows 45 deg Weld/Flg	Elbows 90 deg (short radius) Thd	Elbows 90 deg (short radius) Weld/Flg	Elbows 90 deg (long radius) Thd	Elbows 90 deg (long radius) Weld/Flg	Run of Tee	Branch of Tee	Gate Valve	Globe Valve	Plug Cock	Angle Valve	[1] Full Port Ball and Plug Valve	Butter-fly Valve	Sudden Contraction d/D = 1/4	Sudden Contraction d/D = 1/2	Sudden Contraction d/D = 3/4	Sudden Enlargement d/D = 1/4	Sudden Enlargement d/D = 1/2	Sudden Enlargement d/D = 3/4	[2] Swing Check
	Equivalent Length (ft)																						
1/2	1.9	3.7	0.8	0.4	1.7	---	1.1	0.7	1.1	3.3	0.7	17	0.9	7.3	0.7	---	1.6	1.2	0.7	3.2	2.1	0.7	6.8
3/4	2.5	4.9	1.0	0.6	2.1	---	1.4	0.9	1.4	4.2	0.9	23	1.2	9.7	0.9	---	2.1	1.6	0.9	4.3	2.7	0.9	9.0
1	3.1	6.2	1.2	0.7	2.6	1.6	1.8	1.2	1.8	5.3	1.1	28	1.5	12.1	1.1	---	2.7	2.0	1.1	5.4	3.4	1.1	11.3
1-1/2	4.9	9.9	1.9	1.1	4.1	2.4	2.7	1.8	2.7	8.1	1.7	45	4	19	1.7	---	4.3	1.6	1.7	8.7	5.5	1.7	18
2	6.2	12.3	2.4	1.5	5.2	3.1	3.5	2.3	3.5	10.4	2.2	59	3	25	2.2	---	5.3	4.0	2.2	10.8	6.8	2.2	23
2-1/2	7.7	15.4	2.9	1.7	6.2	3.7	4.2	2.7	4.2	12.4	2.7	---	3.8	---	2.7	---	6.7	5.0	2.7	13.5	8.5	2.7	28
3	9.3	19	3.6	2.2	7.7	5.	5.2	3.4	5.7	15.5	3.3	86	4.5	38	3.3	---	8.1	6.0	3.3	16.3	10.3	3.3	34
4	12	25	5	3	10	7	7	4	7	20	4	112	6	48	4	7	11	8	4	22	14	4	45
6	16	37	8	5	15	10	10	7	10	30	7	170	9	73	7	20	16	12	6	33	21	6	70
8	23	46	9	6	20	13	13	9	13	40	9	225	12	98	9	28	20	15	8	43	26	8	90
10	30	60	13	7	25	16	17	11	17	52	12	280	15	121	12	34	26	20	11	53	34	11	110
12	37	74	14	9	30	19	20	13	20	60	13	340	18	145	13	40	32	24	13	65	41	13	135
14	42	84	---	10	---	21	---	15	22	66	15	397	21	169	15	44	36	28	15	74	47	15	158
16	50	100	---	11	---	24	---	17	25	78	17	453	23	193	17	50	43	33	18	88	53	18	180
18	58	111	---	13	---	27	---	19	28	85	19	510	27	218	19	56	50	38	19	98	62	19	203
20	62	123	---	14	---	29	---	21	32	95	21	567	30	242	21	60	53	40	21	108	68	21	225
24	74	148	---	17	---	35	---	26	40	120	25	680	36	290	25	76	64	48	25	130	82	25	270
30	93	185	---	21	---	44	---	32	50	150	32	850	46	360	32	100	80	60	32	163	103	32	338
36	111	222	---	25	---	53	---	39	60	175	38	1,020	53	435	38	120	96	72	38	195	123	38	405
42	130	259	---	30	---	63	---	45	68	200	46	1,190	62	508	46	140	112	84	46	228	144	46	473

[1] For reduced port, check manufacturer's catalog

[2] For mission duo-chek valve, check manufacturer's catalog

CALCULATIONS FOR COMPRESSED AIR PIPING HEAD LOSS

TABLE D4
HEAD LOSS CALCULATION
SOUTH TRENCH COMPRESSED AIR-LINE ABS-1

Enter Pipe ID No. :		Pipe No. 1201	Pipe No. 1202	Pipe No. 1203	Pipe No. 1204	Pipe No. 1205	Pipe No. 1206	Pipe No. 1207	Pipe No. 1208
	From:	Well Head DAB-1	DAB-2 Branch	DAB-3 Branch	DAB-4 Branch	DAB-5 Branch	DAB-6 Branch	DAB-7 Wellhead	3/4"-1206
	To:	DAB-2 Branch	DAB-3 Branch	DAB-4 Branch	DAB-5 Branch	DAB-6 Branch	3/4"-1208 Header	3/4"-1208 Header	Air Compressor

Calculation of the Reynolds Number
Re = [(d$_h$ v ρ)/μ]

Diameter of Pipe [d$_h$]:	[inches]	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754
Assumed STP Temperature [T]:	[°F]	65	65	65	65	65	65	65	65
Line Pressure [P]	[psig]	70	70	70	70	70	70	70	70
Enter Flow [Q]:	[scfm]	3.542	7.084	10.626	7.084	17.71	21.252	3.542	24.794
Actual Flow:	[acfm]	0.6088	1.2176	1.8264	1.2176	3.0440	3.6527	0.6088	4.2615
The Velocity [v] is:	[ft/s]	3.27	6.54	9.82	6.54	16.36	19.63	3.27	22.91
The Density [ρ] of Air at T = 65°F	[lbm/ft^3]	0.436	0.436	0.436	0.436	0.436	0.436	0.436	0.436
Absolute Viscosity [μ] of Air at T = 65°F:	[lbf-sec/ft^2]	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07
The Reynolds Number [Re] is:	[dimensionless]	**7,287.94**	**14,575.87**	**21,863.81**	**14,575.87**	**36,439.69**	**43,727.62**	**7,287.94**	**51,015.56**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar: **The Friction Coefficient [λ] is:**	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent: **Enter Friction Coefficient [λ]:**	[dimensionless]	**0.034**	**0.029**	**0.026**	**0.029**	**0.024**	**0.023**	**0.034**	**0.022**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (l/\ d_h)\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h$_{lossp}$] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	105	115	115	118	116	64	79	50
The Headloss [h$_{lossp}$] From the SVE Pipe is:	[psi]	**0.0289**	**0.1060**	**0.2171**	**0.1088**	**0.5466**	**0.4194**	**0.0218**	**0.4336**

Headloss From Fittings [h$_{lossf}$] for PVC:

Enter Number of STD 45° Elbows:		0	0	0	1	2	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	1.1	2.2	0	0	0
Enter Number of 90° Elbows:		1	0	0	0	0	0	1	1
The Equivalent Length of Pipe is:	[ft]	2.1	0	0	0	0	0	2.1	2.1
Enter Number of Tees (Flow Through Run):		0	1	1	1	1	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	1.4	1.4	1.4	1.4	0	0	0
Enter Number of Gate Valves:		0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/2):		0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0
Enter Number of Additional Fittings (Tee w/Flow thru Branch):		0	1	1	1	1	2	1	1
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	5.1	5.1	5.1	5.1	5.1	5.1	5.1
The Equivalent Length of Pipe is:	[ft]	0	5.1	5.1	5.1	5.1	10.2	5.1	5.1
Total Equivalent Length of Pipe From Fittings:	[ft]	2.1	6.5	6.5	7.6	8.7	10.2	7.2	7.2
The Friction Coefficient [λ] is:	[dimensionless]	0.034	0.029	0.026	0.029	0.024	0.023	0.034	0.022
The Headloss [h$_{lossf}$] From the Fittings is:	[psi]	**0.00058**	**0.0060**	**0.01227**	**0.0070**	**0.0410**	**0.0668**	**0.0020**	**0.0624**

TOTAL HEADLOSS [h$_{loss}$] DUE TO FRICTION AND FITTINGS:

Pipe No.		Pipe No. 1201	Pipe No. 1202	Pipe No. 1203	Pipe No. 1204	Pipe No. 1205	Pipe No. 1206	Pipe No. 1207	Pipe No. 1208
$h_{loss} = h_{lossp} + h_{lossf}$	[psi]	0.0295	0.1120	0.2294	0.1158	0.5876	0.4862	0.0238	0.4960
Length of Pipe	[ft]	105	115	115	118	116	64	79	50
h_{loss}/100 ft Pipe	[psi]	0.028	0.10	0.20	0.10	0.507	0.76	0.030	0.992

TOTAL HEAD LOSS ABS-1 (psi)
2.080

Note:
1. This table includes conveyance pipe headloss calculations (well head and down well head loss is not included).
2. All conveyance pipe fittings are included in the calculation.

TABLE D4
HEAD LOSS CALCULATION
WEST TRENCH COMPRESSED AIR-LINE ABS-2

Enter Pipe ID No. :		Pipe No. 1301	Pipe No. 1302	Pipe No. 1303	Pipe No. 1304	Pipe No. 1305	Pipe No. 1306	Pipe No. 1307	Pipe No. 1308	Pipe No. 1309
	From:	Well Head DAB-8	DA/B-1 Branch	Well Head DA/B-7	DA/B-4 Branch	DA/B-2 Branch	DA/B-3 Branch	DA/B-5 Branch	Well Head DA/B-6	3/4"-1309 Header
	To:	DA/B-1 Branch	DA/B-4 Branch	3/4"-1302 Header	DA/B-5 Branch	DA/B-3 Branch	DA/B-5 Branch	BA/B-6 Branch	3/4"-1309 Header	Air Compressor

Calculation of the Reynolds Number
$Re = [(d_h\ v\ \rho)/\mu]$

Diameter of Pipe [d_h]:	[inches]	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754	0.754
Assumed STP Temperature [T]:	[°F]	65	65	65	65	65	65	65	65	65
Line Pressure [P]	[psig]	70	70	70	70	70	70	70	70	70
Enter Flow [Q]:	[scfm]	3.542	7.17	3.628	14.426	3.628	7.256	25.31	3.628	28.938
Actual Flow:	[acfm]	0.6088	1.2324	0.6236	2.4795	0.6236	1.2471	4.3502	0.6236	4.9738
The Velocity [v] is:	[ft/s]	3.27	6.62	3.35	13.33	3.35	6.70	23.38	3.35	26.73
The Density [ρ] of Air at T = 65°F	[lbm/ft^3]	0.436	0.436	0.436	0.436	0.436	0.436	0.436	0.436	0.436
Absolute Viscosity [μ] of Air at T = 65°F:	[lbf-sec/ft^2]	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07
The Reynolds Number [Re] is:	[dimensionless]	**7,287.94**	**14,752.83**	**7,464.89**	**29,682.60**	**7,464.89**	**14,929.78**	**52,077.27**	**7,464.89**	**59,542.16**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar: **The Friction Coefficient [λ] is:**	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**
If Flow is Turbulent: **Enter Friction Coefficient [λ]:**	[dimensionless]	**0.034**	**0.029**	**0.034**	**0.025**	**0.034**	**0.029**	**0.022**	**0.034**	**0.022**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (\ l / d_h\ )\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	113	156	127	103	120	110	83	53	150
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0311**	**0.1469**	**0.0365**	**0.3356**	**0.0345**	**0.1057**	**0.7473**	**0.0152**	**1.7248**

Headloss From Fittings [h_{lossf}] for PVC:

Enter Number of STD 45° Elbows:		0	0	1	0	0	0	0	0	3
The Equivalent Length of Pipe is:	[ft]	0	0	1.1	0	0	0	0	0	3.3
Enter Number of 90° Elbows:		0	0	1	0	1	1	0	1	2
The Equivalent Length of Pipe is:	[ft]	0	0	2.1	0	2.1	2.1	0	2.1	4.2
Enter Number of Tees (Flow Through Run):		1	2	2	3	2	1	2	1	1
The Equivalent Length of Pipe is:	[ft]	1.4	2.8	2.8	4.2	2.8	1.4	2.8	1.4	1.4
Enter Number of Gate Valves:		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/2):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0	0	0	0
Enter Number of Additional Fittings (Tee w/Flow thru Branch):		0	3	1	2	1	3	1	2	1
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	0	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
The Equivalent Length of Pipe is:	[ft]	0	15.3	5.1	10.2	5.1	15.3	5.1	10.2	5.1
Total Equivalent Length of Pipe From Fittings:	[ft]	1.4	18.1	11.1	14.4	10	18.8	7.9	13.7	14
The Friction Coefficient [λ] is:	[dimensionless]	0.034	0.029	0.034	0.025	0.034	0.029	0.022	0.034	0.022
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.00039**	**0.0170**	**0.00319**	**0.0469**	**0.0029**	**0.0181**	**0.0711**	**0.0039**	**0.1610**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		Pipe No. 1301	Pipe No. 1302	Pipe No. 1303	Pipe No. 1304	Pipe No. 1305	Pipe No. 1306	Pipe No. 1307	Pipe No. 1308	Pipe No. 1309
$h_{loss} = h_{lossp} + h_{lossf}$	**[psi]**	**0.0315**	**0.1639**	**0.0397**	**0.3826**	**0.0373**	**0.1238**	**0.8184**	**0.0192**	**1.8857**
Length of Pipe	**[ft]**	**113**	**156**	**127**	**103**	**120**	**110**	**83**	**53**	**150**
h_{loss}/100 ft Pipe	**[psi]**	**0.0279**	**0.1051**	**0.0312**	**0.3714**	**0.0311**	**0.1126**	**0.9860**	**0.0362**	**1.2572**

TOTAL HEAD LOSS ABS-2 (psi)
3.502

Note:
1. This table includes conveyance pipe headloss calculations (well head and down well head loss is not included).
2. All conveyance pipe fittings are included in the calculation.

TABLE D4
HEAD LOSS CALCULATION
EAST TRENCH COMPRESSED AIR-LINE ABS-3

Enter Pipe ID No. :		Pipe No. 1401	Pipe No. 1402	Pipe No. 1403	Pipe No. 1404	Pipe No. 1405	Pipe No. 1406
	From:	Well Head DA/B-9	DA/B-10 Branch	DA/B-11 Branch	MW-24-140	DA/B-12 Branch	DA/B-8
	To:	DA/B-10 Branch	DA/B-11 Branch	DA/B-12 Branch	3/4"-1403 Header	DA/B-8 Branch	Air Compressor

Calculation of the Reynolds Number
$Re = [(d_h\ v\ \rho)/\mu]$

Diameter of Pipe [d_h]:	[inches]	0.754	0.754	0.754	0.754	0.754	0.754
Assumed STP Temperature [T]:	[ºF]	65	65	65	65	65	65
Line Pressure [P]	[psig]	100	100	100	100	100	100
Enter Flow [Q]:	[scfm]	3.628	7.256	13.134	2.25	16.762	20.39
Actual Flow:	[acfm]	0.4605	0.9209	1.6670	0.2856	2.1275	2.5879
The Velocity [v] is:	[ft/s]	2.48	4.95	8.96	1.53	11.44	13.91
The Density [ρ] of Air at T = 60ºF	[lbm/ft^3]	0.59	0.59	0.59	0.59	0.59	0.59
Absolute Viscosity [μ] of Air at T = 60ºF:	[lbf-sec/ft^2]	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07	3.82E-07
The Reynolds Number [Re] is:	[dimensionless]	**7,459.39**	**14,918.79**	**27,004.32**	**4,626.14**	**34,463.71**	**41,923.11**
		The Flow is Turbulent.	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**	**The Flow is Turbulent.**

Calculation of the Friction Coefficient [λ]

If Flow is Laminar: **The Friction Coefficient [λ] is:**	[dimensionless]	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**	**Flow Not Laminar**

If Flow is Turbulent: **Enter Friction Coefficient [λ]:**	[dimensionless]	**0.034**	**0.029**	**0.025**	**0.039**	**0.024**	**0.023**

Calculation of Major Headloss Due to Friction Loss
Using the Darcy-Weisbach Equation

Headloss $h_{loss} = \lambda\ (\ l/\ d_h\ )\ (\rho\ v^2/2)$
Relative Roughness for PVC, CPVC & ABS [ε] = 0.0000233

Headloss From SVE Pipe [h_{lossp}] for PVC:

Enter Length [l] of SVE Pipe:	[ft]	126	107	117	40	78	109
The Headloss [h_{loss}] From the SVE Pipe is:	[psi]	**0.0267**	**0.0759**	**0.2378**	**0.0037**	**0.2457**	**0.4890**

Headloss From Fittings [h_{lossf}] for PVC:

Enter Number of STD 45º Elbows:		0	0	0	0	2	2
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	2.2	2.2
Enter Number of 90º Elbows:		1	0	0	0	0	1
The Equivalent Length of Pipe is:	[ft]	2.1	0	0	0	0	2.1
Enter Number of Tees (Flow Through Run):		2	2	3	0	2	2
The Equivalent Length of Pipe is:	[ft]	2.8	2.8	4.2	0	2.8	2.8
Enter Number of Gate Valves:		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Globe Valves:		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Ball Valves:		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 1/2):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Expansion Fittings (d/D = 3/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 1/2):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Reducer Fittings (d/D = 3/4):		0	0	0	0	0	0
The Equivalent Length of Pipe is:	[ft]	0	0	0	0	0	0
Enter Number of Additional Fittings (Tee w/Flow thru Branch):		1	2	2	1	2	3
Enter the Equivalent Length of Pipe for That Fitting:	[ft]	5.1	5.1	5.1	5.1	5.1	5.1
The Equivalent Length of Pipe is:	[ft]	5.1	10.2	10.2	5.1	10.2	15.3

Total Equivalent Length of Pipe From Fittings:	[ft]	10	13	14.4	5.1	15.2	22.4
The Friction Coefficient [λ] is:	[dimensionless]	0.034	0.029	0.025	0.039	0.024	0.023
The Headloss [h_{lossf}] From the Fittings is:	[psi]	**0.00212**	**0.0092**	**0.02927**	**0.0005**	**0.0479**	**0.1005**

TOTAL HEADLOSS [h_{loss}] DUE TO FRICTION AND FITTINGS:

Pipe No.		**Pipe No. 1401**	**Pipe No. 1402**	**Pipe No. 1403**	**Pipe No. 1404**	**Pipe No. 1405**	**Pipe No. 1406**
$h_{loss} = h_{lossp} + h_{lossf}$	**[psi]**	**0.0288**	**0.0851**	**0.2671**	**0.0042**	**0.2935**	**0.5895**
Length of Pipe	**[ft]**	**126**	**107**	**117**	**40**	**78**	**109**
h_{loss}/100 ft Pipe	**[psi]**	**0.02**	**0.08**	**0.228**	**0.01**	**0.376**	**0.5408**

TOTAL HEAD LOSS ABS-3 (psi)
1.268

Note:
1. This table includes conveyance pipe headloss calculations (well head and down well head loss is not included).
2. All conveyance pipe fittings are included in the calculation.

REFERENCES
FOR
COMPRESSED AIR PIPING HEAD LOSS

Compressible Flow Pressure Loss Results	Piping, Valves, and Fittings
Pressure Loss (psi): 0.034	
Job Number: Pemaco Friction Loss **Client:** **Date:** 6/1/06 **Line Number:** ABS-1, Pipe 1201 **Fluid:** Compressed Air **Piping/Tubing Inner Diameter (in):** 0.754 **Flow Rate:** 3.542 SCFM **Piping Length (ft):** 107 **Viscosity (cP):** 0.018 **Inlet Pressure (PSIG):** 70 **Temperature (F):** 65 **Pipe Roughness (ft):** 0.00021 **Actual Pipe ID (in.):** 0.754 **Fluid Velocity (ft/sec):** 3.34 **Reynolds Number:** 7560 **Flow Region:** Turbulent **Friction Factor:** 0.0375 **Pressure Loss (psi):** 0.034 **Net Expansion Factor:** 0.994 **Inlet Mach Number:** 0.003 **Outlet Mach Number:** 0.003 **Density at Inlet:** 0.436 **Specific Volume at Inlet:** 2.293 **K1:** 80844.07 **K2:** 80780.21 **Overall K:** 63.86 **Specific Heat Ratio:** 1.4 **M iterations:** 169 **Friction Factor iterations:** 5	

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

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PROJECT	Pemaco Remedial Design	REMARKS	
SUBJECT	ABS Piping Design	CALC BY Danny Chen	DATE 01/18/06
		CHK BY	DATE

Assumed STP Temp = 65 °F

The Density of Air at 65 °F = 0.0748 lb/ft³
↳ online calculator

Absolute Viscosity [μ] of Air at 65 °F

$$\Rightarrow \quad \mu = \mu_0 \left(\frac{a}{b}\right)\left(\frac{T}{T_0}\right)^{\frac{3}{2}}$$

$a = 0.555\, T_0 + C$

$b = 0.555\, T + C$

For standard air
$C = 120$
$T_0 = 524.07\ °R$
$\mu_0 = 0.01827$ centipoise

$\Rightarrow \quad a = 0.555 \times 524.07 + 120$
$= \underline{410.86}$

$\Rightarrow \quad b = 0.555 \times 524.67 + 120$
$= \underline{411.19}$

$T = 65°F = 524.67\ °R$

$$\Longrightarrow \quad \mu = 0.01827 \left(\frac{410.86}{411.19}\right)\left(\frac{524.07}{524.67}\right)^{\frac{3}{2}}$$

$= 1.8224 \times 10^{-2}$ cP

$= \boxed{3.8192 \times 10^{-7}}$ lbf - sec / ft²

↳ http://www.lmnoeng.com/Flow/GasViscosity.htm

Double checked w/ the web calculator shown above
The answer is confirmed.

Gas Viscosity Calculator	Enter temperature to compute gas dynamic (absolute) viscosity. Air, natural gas, hydrocarbon vapor, ammonia, carbon dioxide, carbon monoxide, hydrogen, nitrogen, sulfur dioxide

Your browser does not support Java, or Java is disabled in your browser. Calculation should be here.

Units:
°C=degrees Celsuis, K=Kelvin, °F=degrees Fahrenheit, °R=degrees Rankine, lb-s/ft^2=pound-second per square foot, slug/ft-s=slug per foot per second, N-s/m^2=Newton-second per square meter, kg/m-s=kilogram per meter per second, SG=specific gravity

The viscosity on this page is the dynamic (or absolute) viscosity. Dynamic viscosity of gases is primarily a function of temperature. This variation is provided in Crane (1988) as a graph for hydrocarbon vapors and natural gases, and as an equation for other common gases. The impact of pressure is minor and the viscosity correction for pressure is less than 10% for the gases in our calculation for pressures up to 500 psi (34.5 bar) (Crane, 1988).

Hydrocarbon vapors and Natural gases
The LMNO Engineering calculation takes the user input temperature and extracts viscosity from the graph on page A-5 in Crane (1988), performing linear interpolation if needed. The input temperature is restricted to the range $0 \leq$ temperature ≤ 1000°F.

Other gases
Viscosity is computed using Sutherland's formula (Crane, 1988):

$$\mu = \mu_o*(a/b)*(T/To)^{3/2}$$

$$a = 0.555T_o + C$$
$$b = 0.555T + C$$

where
μ = viscosity in centipoise at input temperature T
μ_o = reference viscosity in centipoise at reference temperature T_o
T = input temperature in degrees Rankine
T_o = reference temperature in degrees Rankine
C = Sutherland's constant

The following table gives the values of Sutherland's constant and the reference temperature and viscosity for the gases used in the LMNO Engineering calculation. Values of Sutherland's constant are from Crane (1988, p.A-5). The reference temperatures and viscosities were selected from CRC (1984, pp.F-42-44).

	Sutherland's constant,C	T_o (°R)	μ_o (centipoise)
standard air	120	524.07	0.01827
ammonia, NH_3	370	527.67	0.00982
carbon dioxide, CO_2	240	527.67	0.01480
carbon monoxide, CO	118	518.67	0.01720

hydrogen, H_2	72	528.93	0.00876
nitrogen, N_2	111	540.99	0.01781
oxygen, O_2	127	526.05	0.02018
sulfur dioxide, SO_2	416	528.57	0.01254

Validity

For hydrocarbon vapors and natural gases, input temperature T is restricted to the range
$0 \leq$ temperature $\leq 1000^{o}$F.

For other gases, input temperature must be at least absolute zero (0 K).

If the input temperature is outside the valid range, an error message is printed and viscosity is not computed.

The impact of pressure is minor, and the viscosity correction for pressure is less than 10% for the gases in our calculation for pressures up to 500 psi (34.5 bar) (Crane, 1988).

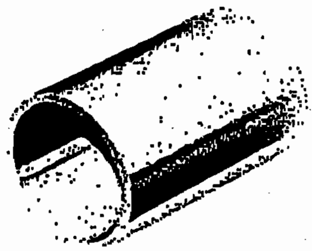
References

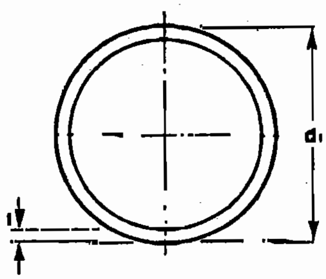
Chemical Rubber Company (CRC). 1984. CRC Handbook of Chemistry and Physics. Weast, Robert C., editor. 65th edition. CRC Press, Inc. Boca Raton, Florida. USA.

Crane Company. 1988. Flow of fluids through valves, fittings, and pipe. Technical Paper No. 410 (TP 410).

LMNO Engineering, Research, and Software, Ltd.
7860 Angel Ridge Rd. Athens, Ohio 45701 USA +1 (740) 592-1890
LMNO@LMNOeng.com http://www.LMNOeng.com

Pipe 185 psi

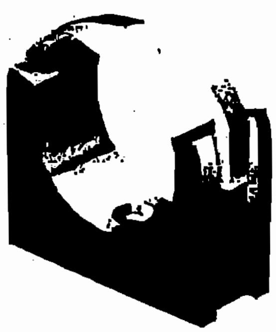


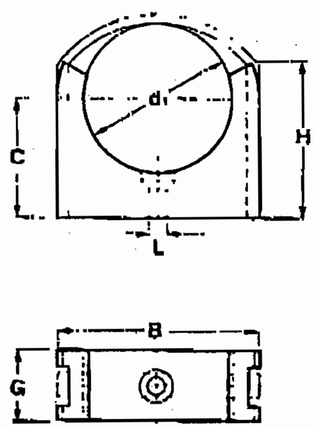


I.D. = 0.754 inch

Pipe Size		d₁ (nominal)		t (nominal)		min. sch. 40 wall thickness	
mm	inch	mm	inch	mm	inch	inches	Code
20	1/2	20.1	.79	2.9	.114	.109	3553306
25	3/4	25.1	.99	3.0	.118	.113	3553307
32	1	32.1	1.26	3.6	.141	.133	3553308
50	1½	50.1	1.97	4.8	.19	.145	3553310
63	2	63.1	2.48	5.9	.23	.154	3553311
90	3	90.2	3.55	8.2	.32	.216	3553313
110	4	110.2	4.34	9.9	.39	.237	3553314

Pipe clip

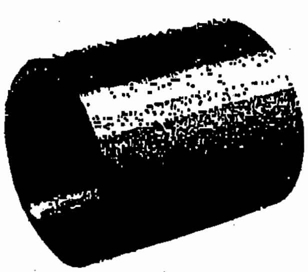


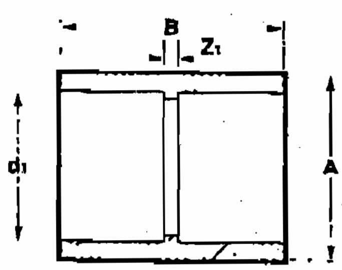


d_1	B	C	G	H	L	Wt. Oz.	Code
20	1.25	.98	.62	1.25	.19	.35	434 306
25	1.65	1.06	.66	1.37	.21	.39	434 307
32	1.92	1.18	.66	1.53	.21	.46	434 308
50	2.67	1.57	.90	2.04	.23	1.20	434 310
63	3.14	1.96	.90	2.79	.27	1.59	434 311
75	3.74	2.28	.98	3.26	.33	2.44	434 312
90	4.64	2.75	1.06	3.85	.33	3.88	434 313
110	5.43	3.14	1.06	4.33	.33	5.30	434 314

Illustration refers to 50mm and above sizes only, smaller sizes are without retaining strap.
Bolts/screws not supplied.

Coupling-socket





d_1	Z_1	A	B	Wt. Oz.	Code
20	.11	.98	1.42	.25	100 306
25	.11	1.22	1.62	.42	100 307
32	.11	1.56	1.89	.88	100 308
50	.11	2.43	2.66	2.72	100 310
63	.11	3.07	3.17	5.44	100 311
90	.15	4.38	4.33	13.41	100 313
110	.23	5.35	5.19	24.36	100 314

Airline is metric sized. Equivalent inch sizes are: 20 (1/2"), 25 (3/4"), 32 (1"), 50 (1½"), 63 (2"), 90 (3"), 110 (4").

Example 2

Given a flow of 1000 scfm of free air, an initial pressure of 120 psig, and an assumed pipe diameter of 2 inches, what is the pressure drop per 100 feet of pipe?

Solution: The ratio of compression is $r = \frac{120 + 14.7}{14.7} = 9.163$, or see Table II.

Read opposite 1000 scfm and below 2-inch diameter in the table to find a Z value = 57.4. The pressure drop per 100 feet of pipe is:

$$\frac{Z}{r} = \frac{57.4}{9.163} = 6.3 \text{ psi}$$

Example 3

Given a required flow of 40 scfm free air, a pipe diameter of 3/4 inches, and a desired pressure drop of less than 2 psi per 100 feet of pipe, what initial operating pressure (P_1) will be required?

Solution: In the table opposite 40 scfm for a 3/4 inch pipe, the Z value is 8.81. The compression ratio for a pressure drop of 2 psi per 100 feet of pipe is:

$$r = \frac{Z}{\Delta P} = \frac{8.81}{2} = 4.405$$

Since: $r = \frac{P_1 + 14.7}{14.7}$, $P_1 = (14.7 \text{ x } r) - 14.7$

Therefore:

$$P_1 = (14.7 \text{ x } 4.405) - 14.7 = 50 \text{ psig}$$

Example 4

Given 1 1/2 inch diameter pipe, an initial pressure of 80 psig, and a pressure drop (ΔP) of about 1.6 psi per 100 feet of pipe, what will be the flow in scfm of free air?

Solution: The desired Z value can be determined as follows:

The compression ratio $r = \frac{80 + 14.7}{14.7} = 6.442$, or see Table II.

The Z value = $r \text{ x } \Delta P = 6.442 \text{ x } 1.6 = 10.3$.

Looking down the column in Table V for 1 1/2 inch pipe, a Z value of 10.9 is found opposite 225 scfm, while a value of 8.81 is found opposite 200 scfm. Therefore, the answer is slightly less than 225 scfm.

Pressure drop in fittings—Due to their more complex internal configurations, fittings, valves, filters, and other piping accessories can significantly affect friction losses in a piping system. To determine the friction losses caused by fittings, use an equivalent length of pipe of the same diameter. Table VI outlines the equivalent pipe length in feet for various sizes of several common fittings. By using Table V and Table VI, the pressure loss for fittings can be calculated for air flows at any pressure.

Table VI

Friction Loss in Fittings—Equivalent Length of Pipe, Feet

Type Fitting	Size Fitting							
	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	3"	4"
90° Standard Elbow	1.6	2.1	2.6	3.5	4.0	5.5	7.7	10.1
45° Standard Elbow	.8	1.1	1.4	1.8	2.1	2.8	4.1	5.4
90° Long Radius Elbow	1.0	1.4	1.7	2.3	2.7	4.3	6.3	8.3
180° Dropper End	3.1	3.9						
Standard Tee								
- w/flow thru run	1.0	1.4	1.7	2.7	2.3	4.3	6.3	8.3
- w/flow thru branch	4.0	5.1	6.0	8.1	6.9	12.0	16.3	22.1
Transition 90	2.8							
Transition Coupling	2.0	3.2						

Example

To determine the pressure loss across a 2" 90° elbow, at 80 psi with a 350 scfm flow rate, use Table VI to find the equivalent length for a 2" 90° elbow, which is 5.5 feet of pipe. From Table V, the friction loss in 5.5 feet of 2" Chem-Aire pipe operating at 80 psi with 350 scfm air flow would be:

$$\text{Pressure Drop } (\Delta P) = \frac{5.5 \text{ ft.}}{100 \text{ ft.}} \text{ x } \frac{Z}{r}$$

Therefore:

$$\Delta P = \frac{5.5 \text{ ft.}}{100 \text{ ft.}} \text{ x } \frac{8.22}{6.442} = 0.07 \text{ psi}$$

If the system were operating at a pressure of 20 psi, the pressure drop would be:

$$\Delta P = \frac{5.5}{100} \text{ x } \frac{8.22}{2.361} = 0.19 \text{ psi}$$

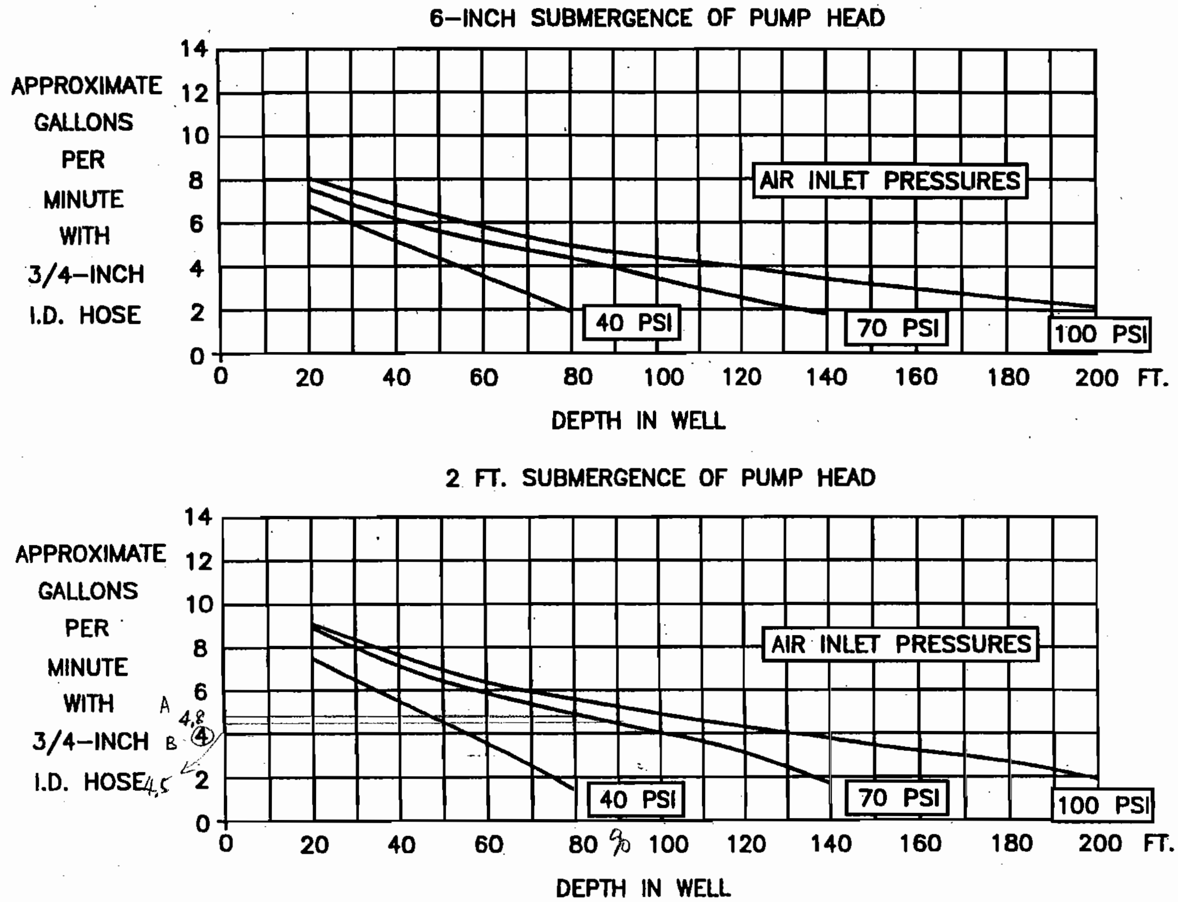
Chem-Aire ball valves are of full-port design, so that at the fully open position they are equivalent to a straight piece of pipe. Therefore, the pressure drop through Chem-Aire ball valves is negligible. For pressure drops across other piping accessories, refer to the particular manufacturers' literature.

Refer to the current Chemtrol Technical Bulletin for compressor lubricants approved for use with Chem-Aire systems.
WARNING: Before mixing compressor oils, contact Chemtrol Technical Service for recommendation. Oils used for in-line lubricators should also follow these guidelines.
NOTE: Chem-Aire is not recommended for the transmission of any flammable gas, above or below ground. Please contact Tech Services for other compressed gas applications.

QED AUTOPUMP
PERFORMANCE CURVES

3/4-INCH INSIDE DIAMETER DISCHARGE HOSE

MAXIMUM FLOW RATES *



A zone : 80 ft depth. 70 psi ⇒ 4.8 gpm (ok)
> 0.7

B zone : 100 ft depth. 70 psi ⇒ 4.0 gpm (ok)
> 1.6

A and B zone : 90 ft depth. 70 psi ⇒ 4.5 gpm (ok)
> 2.3

* FLOW RATES MAY VARY WITH ON-SITE CONDITIONS.
CALL CEE FOR TECHNICAL ASSISTANCE.

600451 03

Figure 23 - Long AP-4/BL Performance Curves: 3/4-inch I.D. Discharge U.S. UNITS (Includes Leachate Models)

 From AP-4 AutoPump Operating Manual, QED Environmental Systems, July 2004

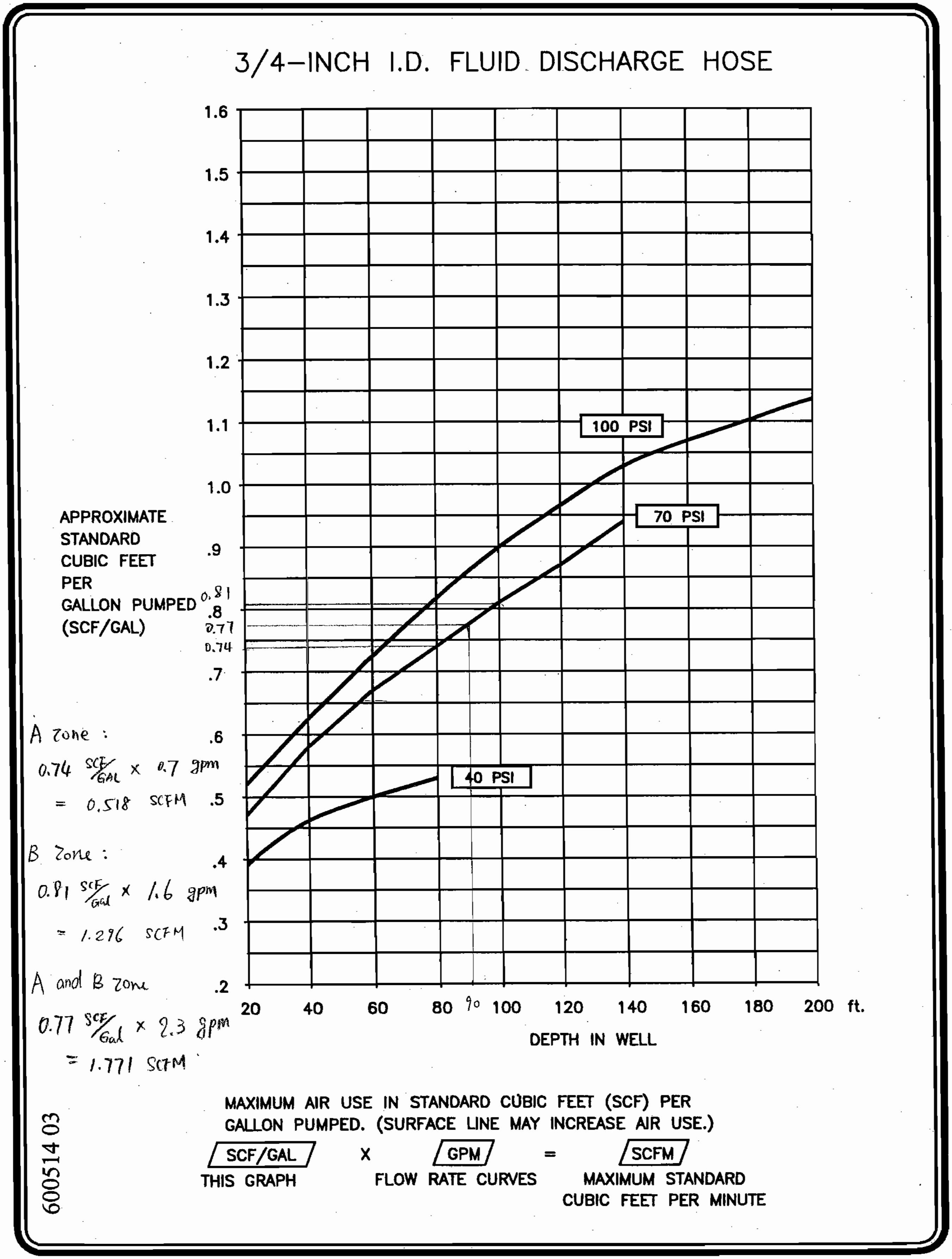
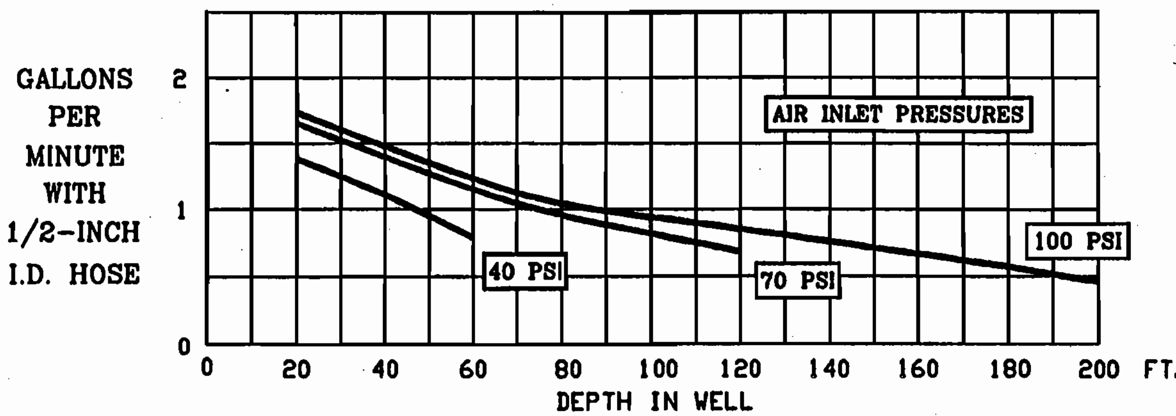


Figure 43 - Long AP-4 Air Consumption Curves: 3/4-inch I.D. Discharge U.S. UNITS (Includes Leachate Models)

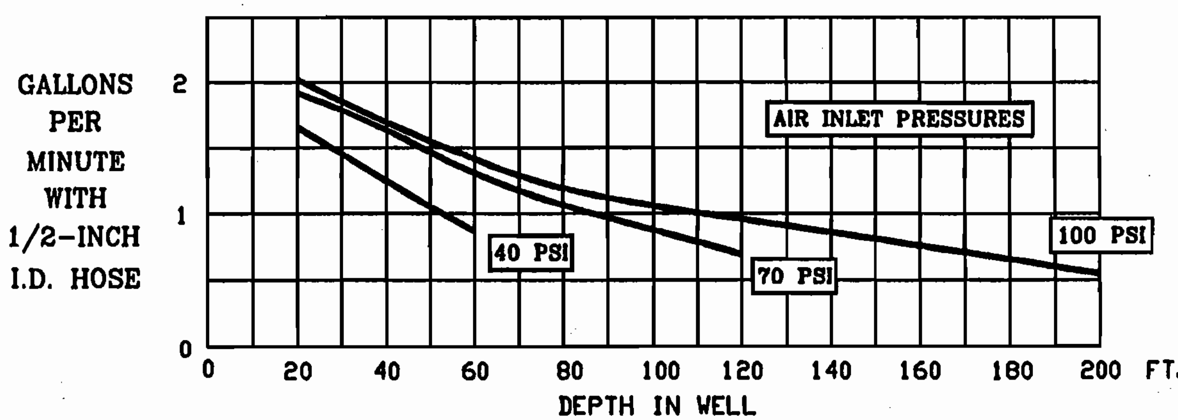
1/2-INCH INSIDE DIAMETER DISCHARGE HOSE

MAXIMUM FLOW RATES*

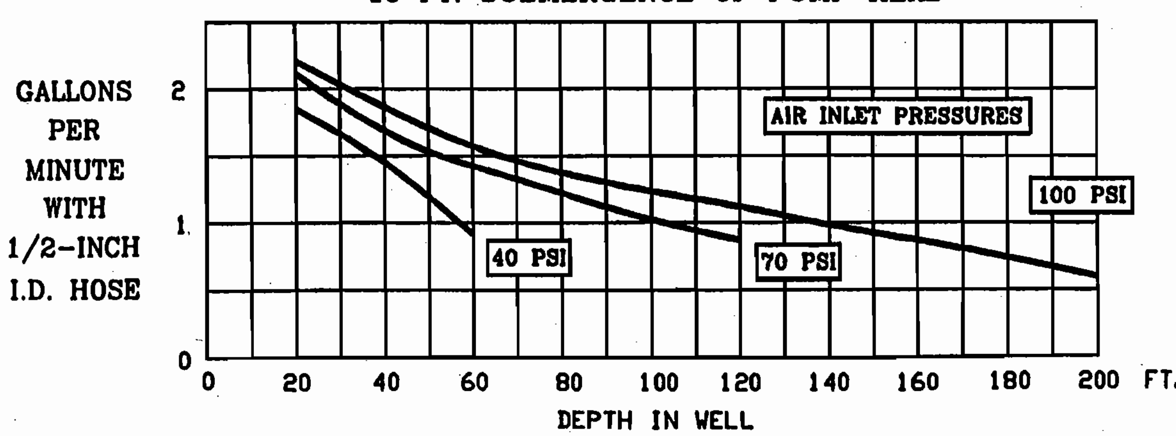
6-INCH SUBMERGENCE OF PUMP HEAD



2 FT. SUBMERGENCE OF PUMP HEAD



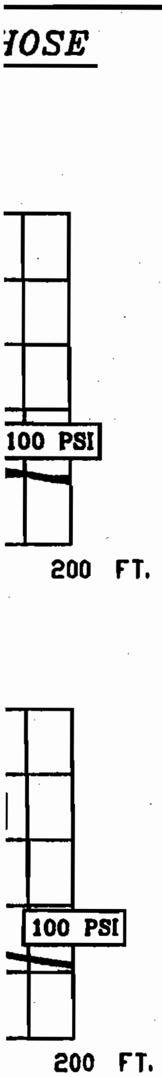
10 FT. SUBMERGENCE OF PUMP HEAD



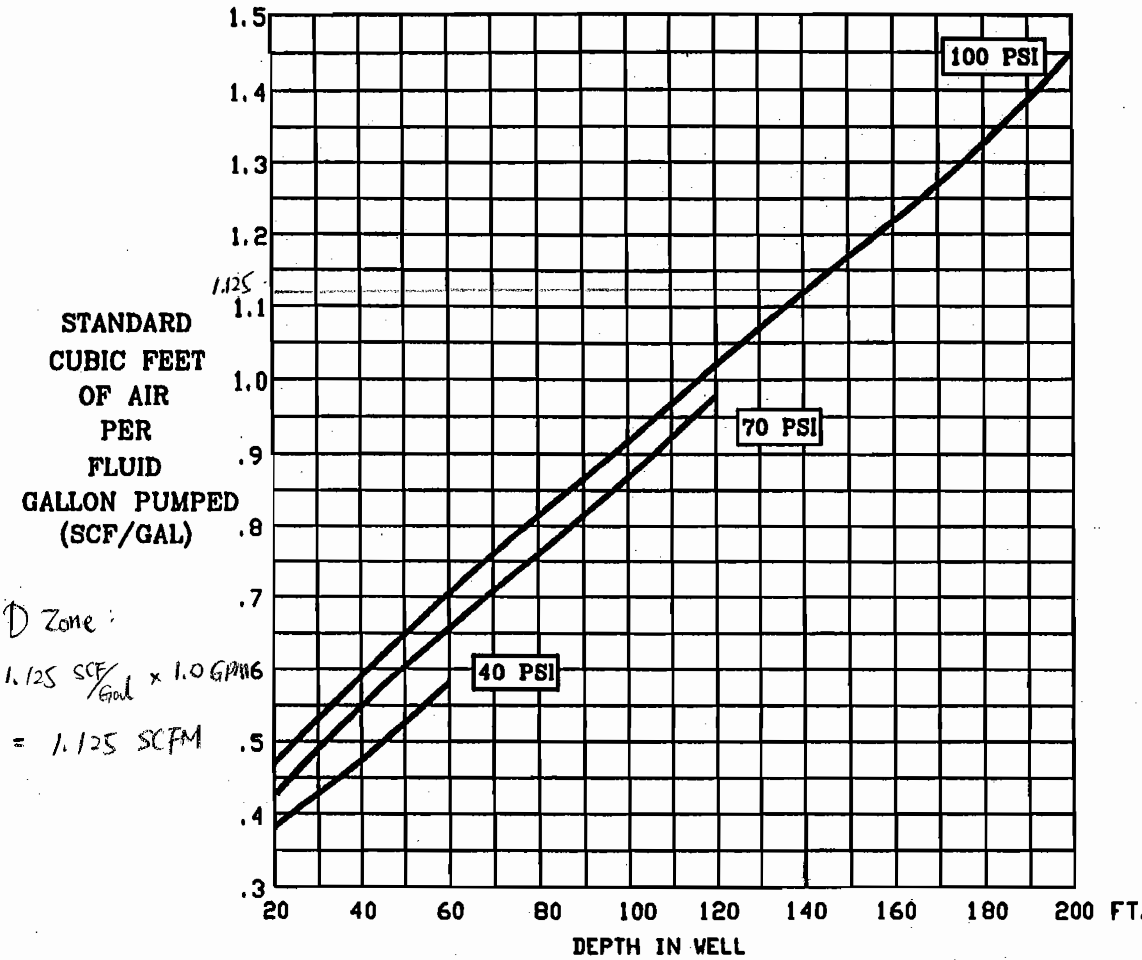
D Zone:
10 ft submergence
140 ft depth
100 psi
⇒ 1.0 gpm

** FLOW RATES MAY VARY WITH ON-SITE CONDITIONS. CALL CEE FOR TECHNICAL ASSISTANCE.*

AP-2BL



1/2-INCH I.D. FLUID DISCHARGE HOSE



D Zone:
1.125 SCF/Gal × 1.0 GPM
= 1.125 SCFM

MAXIMUM AIR USE IN STANDARD CUBIC FEET (SCF) PER GALLON PUMPED. (SURFACE LINE MAY INCREASE AIR USE.)

/SCF/GAL/ × /GPM/ = /SCFM/

THIS GRAPH — FLOW RATE CURVES — MAXIMUM STANDARD CUBIC FEET PER MINUTE

Clean Environment Equipment

EQUIPMENT FOR GROUNDWATER REMEDIATION AND LEACHATE EXTRACTION

1133 7th ST.
OAKLAND, CA 94607
(510) 891-0880 (800) 537-1767 FAX (510) 444-6789

TOLERANCES UNLESS OTHERWISE SPECIFIED	APPROVALS	DATE	TITLE			
ANGULAR ±.50° .X ±.05 .XXX ±.005 .XX ±.01 .XXXX ±.0005	DRAWN RILEY ENGLISH	1-31-96	AP-2/BL PERFORMANCE AND AIR CONSUMPTION CURVES WITH 1/2" HOSE			
	DESIGNER RICK WEBB	2-21-96	DRAWING NO.	600618		REV 02
MATERIAL N/A	CHECKED MIKE FASS	2-21-96	SCALE NONE	SIZE A	SHT 1	OF 1
FINISH N/A	APPROVED MIKE BRESLIN	2-21-96				

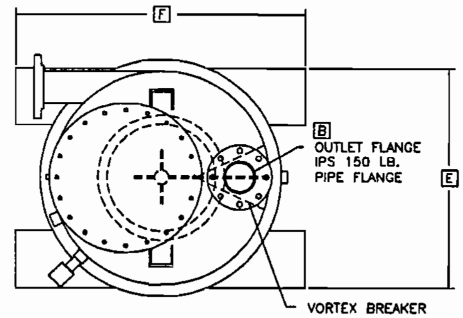
STANDARD AP-2/BL

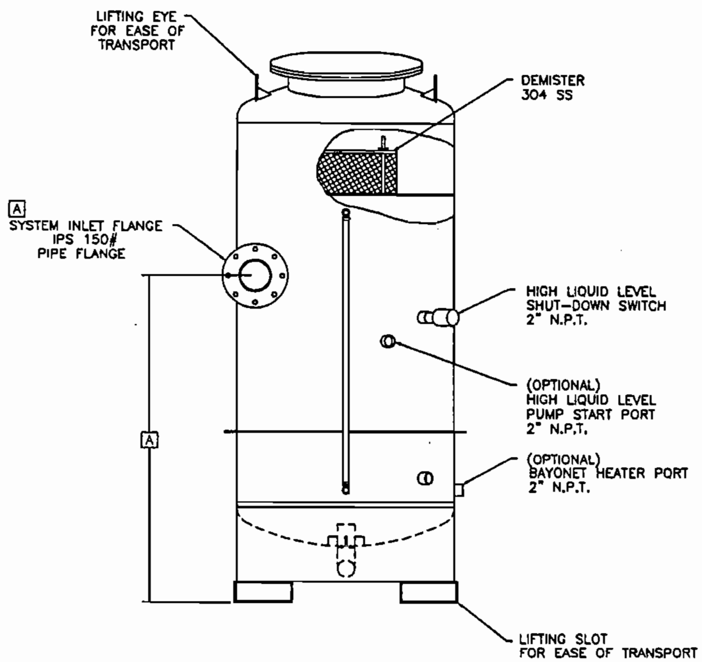
AutoPump® PERFORMANCE AND AIR CONSUMPTION CURVES

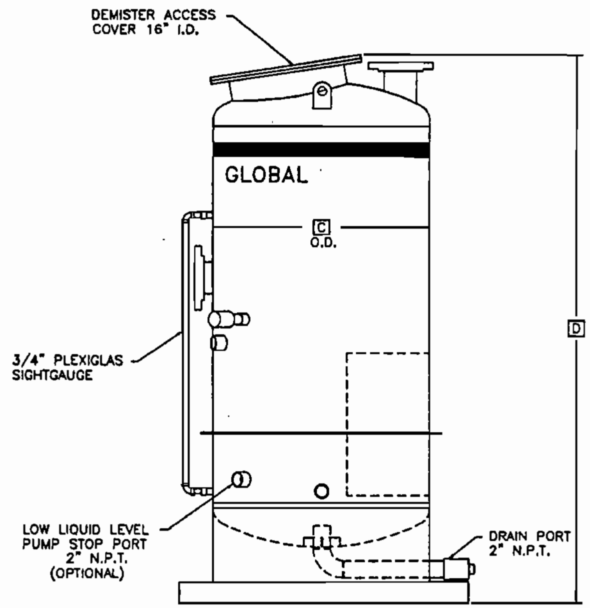
APPENDIX E
Miscellaneous Equipment Design

MOISTURE SEPARATOR SIZING
(KNOCKOUT DRUM)

MODEL	INLET "A"	OUTLET "B"	DIAMETER "C"	HEIGHT "D"	BASE "E" x "F"	WEIGHT
5	4"	4"	30"	6'-7"	31" x 40"	750#
10	6"	6"	36"	7'-7"	37" x 48"	900#
20	8"	8"	72"	7'-7"	84" x 84"	1600#







GLOBAL TECHNOLOGIES, INC.
MODEL 5 AND 10 VAPOR SEPARATOR MODULE
-REMOVES 95% OF ALL LIQUID DROPLETS.
-CONSTRUCTION 1/4" HOT ROLLED STEEL THROUGHOUT.
-MAXIMUM VACUUM CAPACITY -30"HG.

GLOBAL — Global Technologies, Inc. Milwaukee, Wisconsin

SCALE: NTS		CUSTOMER:		
DRAWN BY: V.L	DATE: 8-27-92	CITY, STATE:		
CHECKED:	DATE:	JOB #:	DRAWING #: VSM	REV.
APPROVED:	DATE:	SIM TO:	PAGE 1 OF 1	
TITLE: VACUUM SEPARATOR MODULE GENERAL ARRANGEMENT				

Knockout Drum Sizing – based on maximum allowable Superficial velocity for gas flow.

1) Superficial Velocity

$$V = K\sqrt{\frac{\rho_L - \rho_V}{\rho_V}}$$

V = max superficial velocity ft/s
ρ_L = liquid density lb/ft³
ρ_V = gas density lb/ft³
K = sizing factor

$$V = .20\sqrt{\frac{62.4\ \frac{lb}{ft^3} - .080703\ lb/ft^3}{.080703\ lb/ft^3}}$$

$$V = 5.56\ ft/s$$

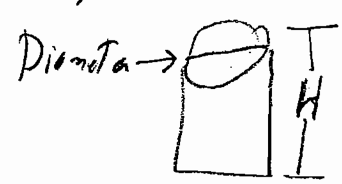
K = .20 for conservative entrainment
.10 = min entrain
.35 = normal entrain

2) Vessel Dimension

$$\text{Vessel area} = \frac{\text{Vapor Volume } ft^3/s}{V}$$

$$= \frac{\frac{1500\ CFM}{60\ s/min}\ ft^3/s}{5.56}$$

Optimum H:D



4:1 to 6:1

Vessel Area = 4.5 ft²

$$\pi\frac{D^2}{4} = 4.5\ ft^2$$

$$D = 2.4\ ft.$$

H : D	
9.6′ : 2.4′	(4:1)
12′ : 2.4′	(5:1)

3) manufacturer has cyclone design that reduces height using centrifical force. Therefore. KO Tank size is dependent on liquid volume.
Flow from Vapor wells (from well design Table) = 22 gal/min × 30 min (Hold Time) = 660 gal

Global Model #20 holds 850 gal. and is recommended by manufacturer.

Global #20 D=6′, L= 7′7″, capacity 850 gal, Flow 2000 CFM

HOLDING TANK AND SECONDARY CONTAINMENT

HOLDING TANK G. NICHOLSON 10/21/04
V102 RESING

RESIZE HOLDING TANK
PER CHANGED PARAMETERS

1. REDUCE GROUNDWATER FLOW FROM 111 GPM TO 88 GPM

REASON: a. THE 12.5 GPM FROM PERCHED WELL WILL DIMINISH AFTER ONE YEAR

b. ALSO ELIMINATE 9.5 GPM OVER PLUS

Q = 110 GPM − 12.5 GPM (NO LONGER FROM PERCHED WELLS) − 9.5 GPM (OVERPLUS)

Q = 88 GPM

1. REDUCE V102 HOLDING TIME FROM 1.36 HOURS TO 1 HOUR

REASON: WHEN LEVEL IN TANK REACHES HIGH-HIGH SIGNAL WILL BE SENT TO AIR COMPRESSOR TO TURN OFF DEEP WELL PUMPS.

$V = 88 \frac{GAL}{MIN} \times \frac{60\,MIN}{HOUR} = 5280\,GAL$

$= 704\,FT^3$

HOLDING TANK V-102 SIZING GN 10/21/04

OLD TANK SIZING

ORIGINAL TANK IS

D = 14'

h = 10'

$V = \pi (r)^2 (h) \times 7.5 \frac{GAL}{FT^3}$

$= \pi (7)^2 (10)\ FT^3 \times 7.5 \frac{GAL}{FT^3}$

= 11,539 GAL

TANK CAPACITY IS 9000 GAL SO THAT WATER IS 8' HIGH WITH 2 FOOT EMPTY SPACE ON TOP OF TANK

NEW TANK SIZING

USE $h_1 = 8'$ $h_2 = 8' - 1.5 = 6.5$ (1.5' EMPTY SPACE)

SOLVE FOR D_1

$D_1 = \sqrt{\frac{V_1}{(\pi)(h_2)}}$

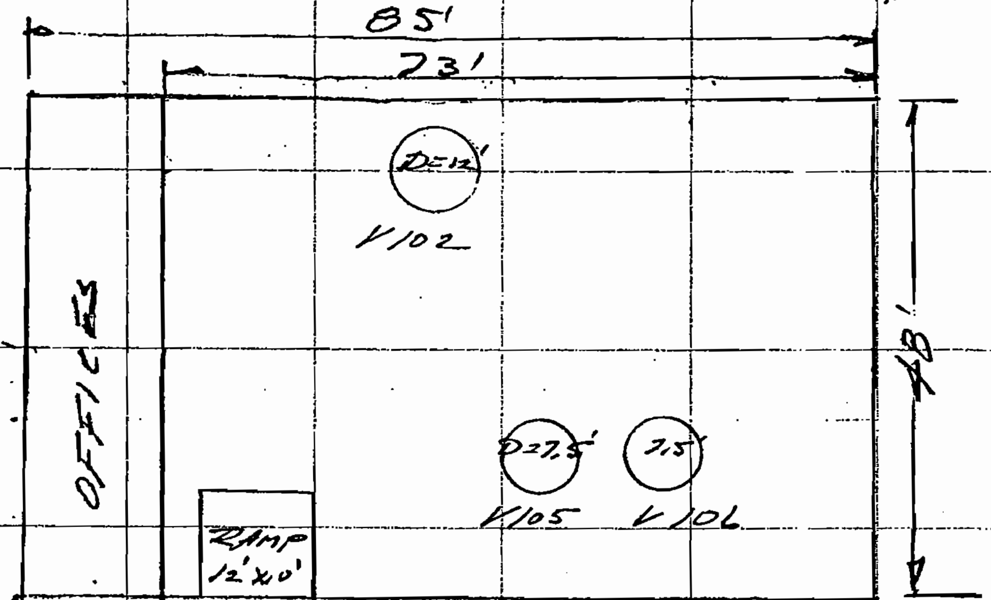
$r_1 = \sqrt{\frac{709\ FT^3}{\pi (6.5\ FT)}} = \sqrt{34.5}$

$r_1 = 6'$

$D_1 = 12'$

USE $D_1 = 12'$
$h = 8'$

CONTAINMENT WALL RESIZING C. NICHOLSON 10/21/04



CONTAINMENT VOLUME

1. WALL 6" HIGH

ASSUME SOUTH, EAST, & NORTH WALLS ARE 12" THICK

$$TOTAL\ VOL = (73'-1) \times (48'-2') \times \frac{1}{2}'$$

$$= (72)' \times 46' \times \frac{1}{2}'$$

$$= 1656\ FT^3$$

MINUS VOL OF V-102, V105, V106 & RAMP

VOL OF CONT = TOT VOL − (V102 etc)
− V105
− V106
− RAMP

CONTAINMENT GN 10/21/04
CALC SIZING

VOL OF CONT $= 1656 \text{ FT}^3 - \pi(6)^2(1/2)$
$- \pi(3.75)^2(1/2) - \pi(3.75)^2 1/2$
$- 10' \times 12' \times 1/2$

$= 1656 \text{ FT}^3 - 57 \text{ FT}^3$
$- 22.1 \text{ FT}^3 - 22.1 \text{ FT}^3$
$- 60 \text{ FT}^3$

VOL CONT $= 1656 \text{ FT}^3 - 161 \text{ FT}^3$

$= 1495 \text{ FT}^3 \times 7.5 \frac{\text{GAL}}{\text{FT}^3}$

$= 11212.5$ GAL

IF SPILL, ACTUAL VOL OF SPILL WILL BE:

ACTUAL VOL OF SPILL $= 5280 \text{ GAL} - \pi(6')^2(1/2')$
(FROM HOLDING TANK SIZING CALC 10/21/04)
$= 5280 \text{ GAL} - 57 \text{ GAL}$
$= 5223$ GAL

SINCE 11,212 GAL IS MUCH GREATER THAT 5223 GAL, TRY A 4" HIGH WALL

CONTAINMENT GN 6/21/04
WALL RE-SIZING

2. USE 4" WALL

TOTAL VOL = 72' x 46' x 1/3'

= 1103 FT³

VOL OF CONTAIN = 1103 FT³ - 161 FT³

= 941 FT³

= 7064 GAL

SINCE 7064 GAL IS GREATER THAN 5223 GAL THE 4" WALL IS OK

CHECK 3" WALL
TOTAL VOL = 828 FT³

= 621 GAL

SINCE 5223 GAL CONTAIN IS REQUIRED A 3" WALL IS ALSO OK.

HOWEVER, PREFER 4" WALL FOR OTHER EQUIPMENT VOLS

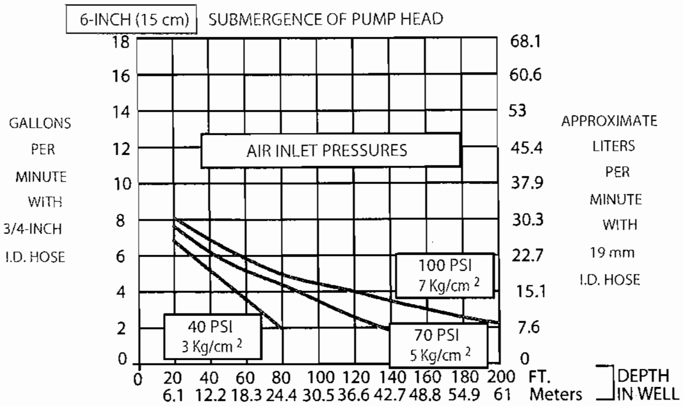
COMPRESSOR SIZING

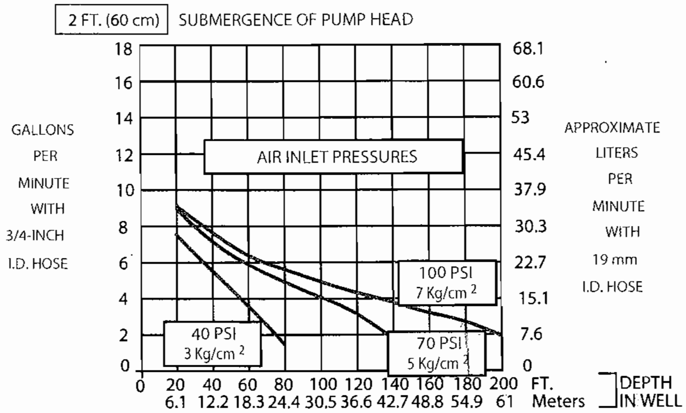
AP4B AutoPump®

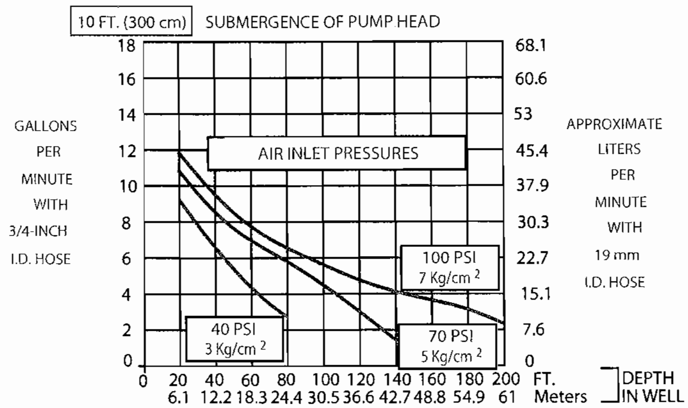
Bottom Inlet, Long

Flow Rates[1]

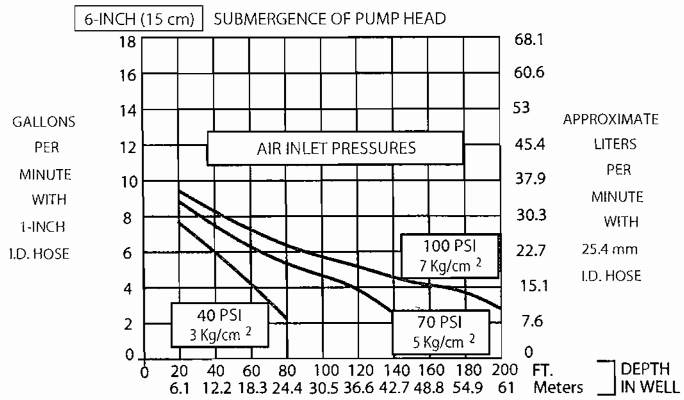
3/4 inch (19 mm)
Inside Diameter Discharge Hose
(Equivalent to 1-Inch O.D. Tubing)

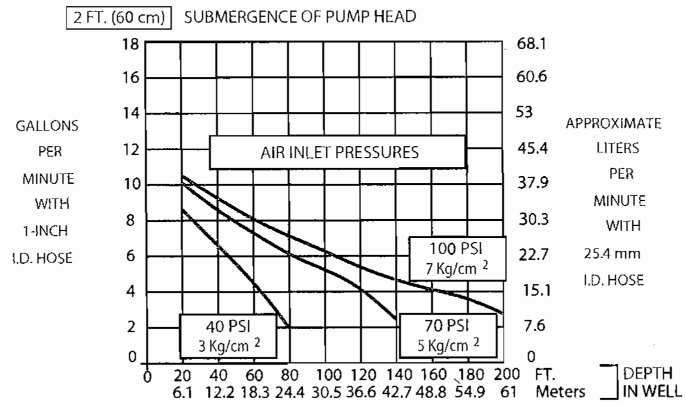


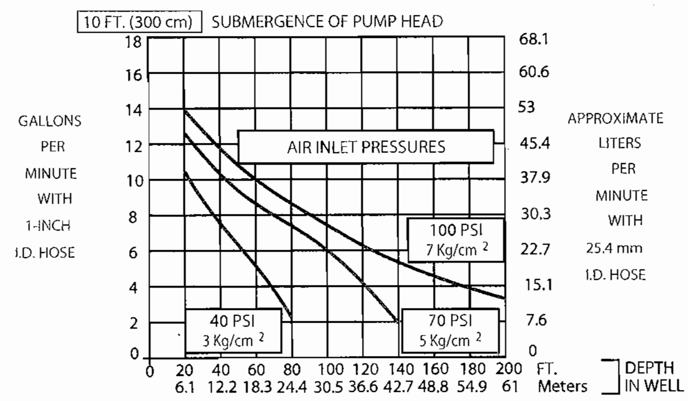




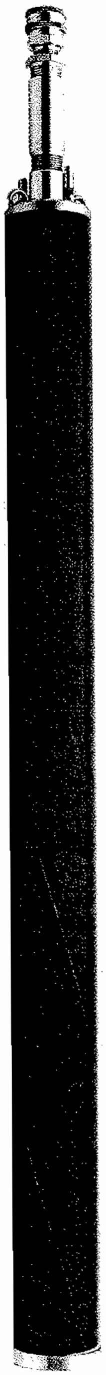
1 inch (25.4 mm)
Inside Diameter Discharge Hose
(Equivalent to 1.25-Inch O.D. Tubing)





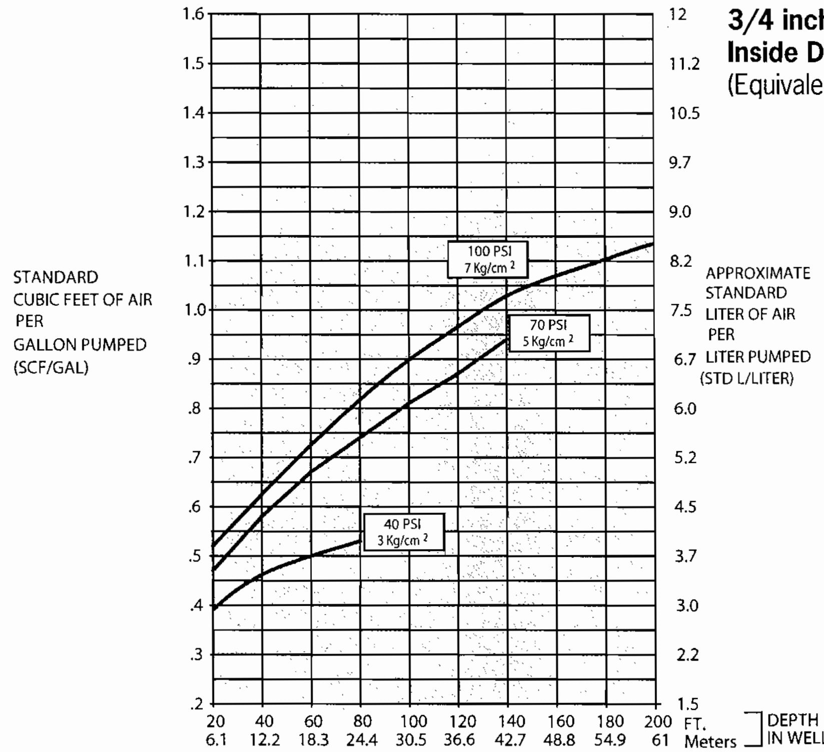


[1] FLOW RATES MAY VARY WITH SITE CONDITIONS. CALL QED FOR TECHNICAL ASSISTANCE.

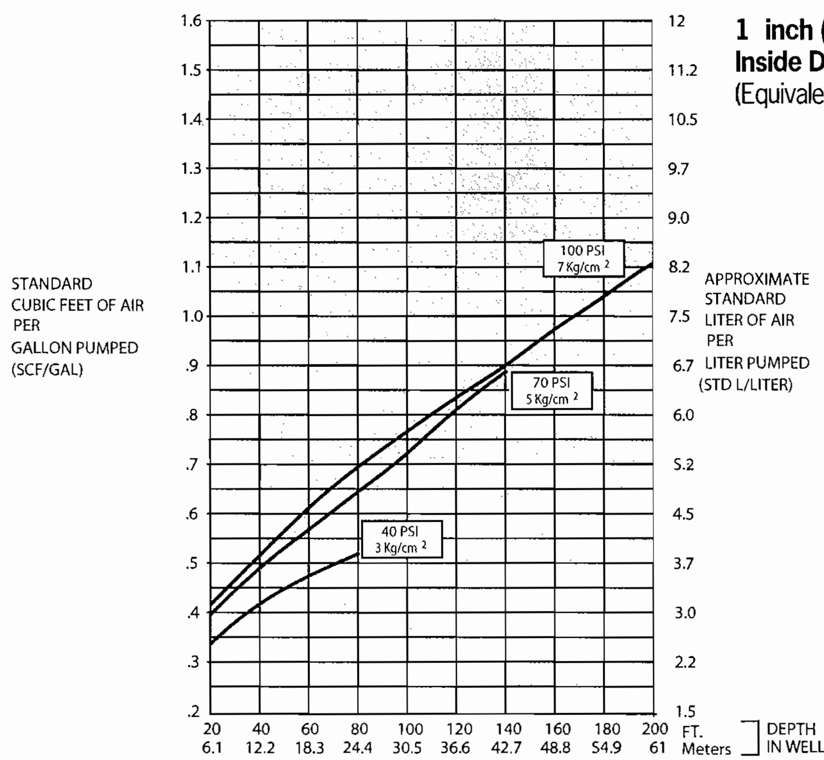


Air Consumption

3/4 inch (19 mm) Inside Diameter Discharge Hose
(Equivalent to 1-Inch O.D. Tubing)



1 inch (25.4 mm) Inside Diameter Discharge Hose
(Equivalent to 1.25-Inch O.D. Tubing)



P.O. Box 3726 Ann Arbor, MI 48106-3726 USA **1.800.624.2026** **F 1.734.995.1170** info@qedenv.com www.qedenv.com

T N & Associates, Inc.
Engineering and Science
Consulting Firm Committed to Excellence

PROJECT			REMARKS 1 OF 11
SUBJECT SIZING OF AIR HEADERS	CALC BY GN	DATE 8/26/04	
	CHK BY	DATE	

SIZING OF AIR COMPRESSOR PIPES

HEADER	NO OF WELLS	PUMP RATE		GALLONS PER HEADER
RED	10 X	2 GAL/MIN	=	20
GRAY	8 X	4 GAL/MIN	=	32
ORANGE	8 X	2 GAL/MIN	=	16
ORANGE	10 X	2 GAL/MIN	=	20
				88 GPM

$Q = 88 \text{ GPM} \times 1.15 \frac{\text{SCFM}}{\text{GAL}} = 102 \text{ SCFM}$

Q = 125 SCFM FOR 125 PSI
OR 115 SCFM FOR 100 PSI

EAST

ORANGE 16 + 20 = 36 GPM

$Q_1 = 36 \text{GPM} \times 1.15 \frac{\text{SCFM}}{\text{GAL}} = 41 \text{ SFM}$

$\% \text{ of } 125 = \frac{41}{41+60} = \frac{41}{101} \times 125 \text{ SFM}$

Q_1 = 51 SCFM FOR EAST HEADER — USE

WEST

20+32 = 52 GAL

$Q_2 = 52 \text{ GAL} \times 1.15 \frac{\text{SCFM}}{\text{GAL}} = 60 \text{ GAL}$

$\% \text{ OF } 125 = \frac{60}{41+60} =$ **74 SCFM FOR = Q_2 — USE WEST HEADER**

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PROJECT	REMARKS
	2 OF 11

SUBJECT	CALC BY	DATE	
	CHK BY	DATE	

EAST

Q_1 = 51 SCFM

USING GAS COMPUTER PROGRAM (ATTACHED)

d = 1" d = 1½" d = 2"

ΔP = .63 ΔP = .072 ΔP = .021

ASSUME

PIPING EQUIV. LENGHT IS 1000 FT
INCLUDING ELBOWS, TEES & VALVES

d = 1"

ΔP_{T_1} = 63 psi

d = 1½

ΔP_{T_2} = .072 X 10 = 7.2 PSI
TOO HIGH

d = 2"

ΔP_{T_2} = 0.021 X 10 = 2.1 PSI

USE 2" Φ HEADER
FOR EAST ROUTING

3 OF 11

Compressible Flow Pressure Loss Results	Piping, Valves, and Fittings	
Pressure Loss (psi): 0.628		
Job Number: **Client:** **Date:** **Line Number:** **Fluid:** **Nominal Pipe Size:** 1 **Pipe Schedule:** SCH 40 **Flow Rate:** 51 SCFM **Viscosity (cP):** 0.018 **Inlet Pressure (PSIG):** 125 **Temperature (F):** 200 **Pipe Roughness (ft):** 0.00015 **Actual Pipe ID (in.):** 1.049 **Fluid Velocity (ft/sec):** 18.92 **Reynolds Number:** 78239 **Flow Region:** Turbulent **Friction Factor:** 0.0248 **Pressure Loss (psi):** 0.628 **Net Expansion Factor:** 0.996 **Inlet Mach Number:** 0.015 **Outlet Mach Number:** 0.015 **Density at Inlet:** 0.572 **Specific Volume at Inlet:** 1.748 **K1:** 3153.94 **K2:** 3125.58 **Overall K:** 28.36 **Specific Heat Ratio:** 1.4 **M iterations:** 168 **Friction Factor iterations:** 4	**Piping Length (ft):** 100 **Long Radius Elbows:** 0 **Short Radius Elbows:** 0 **5 Diameter Elbows:** 0 **45 degree Elbows :** 0 **Standard 90 degreeThreaded Elbows:** 0 **45 degree Standard Elbows :** 0 **Tee Flow Through:** 0 **Tee Flow Branch :** 0 **Gate:** 0 **Globe :** 0 **Swing Check:** 0 **Lift Check :** 0	**3 Way Plug :** 0 **Ball :** 0 **Plug:** 0 **Butterfly 2in. to 8in. :** 0 **Butterfly 10in. to 14in. :** 0 **Butterfly Greater Than 14in. :** 0 **Angle Valve Flow Up:** 0 **Angle Valve Flow Down :** 0 **Pipe Entrance:** 0 **Pipe Exit :** 0 **No. of Reducers:** 0 **Reducer Outlet Size (in) :** 0 **No. of Increasers:** 0 **Increaser Outlet Size (in) :** 0

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

4 OF 11

Compressible Flow Pressure Loss Results	Piping, Valves, and Fittings	
Pressure Loss (psi): 0.072		
Job Number: **Client:** **Date:** **Line Number:** **Fluid:** **Nominal Pipe Size:** 1.5 **Pipe Schedule:** SCH 40 **Flow Rate:** 51 SCFM **Viscosity (cP):** 0.018 **Inlet Pressure (PSIG):** 125 **Temperature (F):** 200 **Pipe Roughness (ft):** 0.00015 **Actual Pipe ID (in.):** 1.61 **Fluid Velocity (ft/sec):** 8.03 **Reynolds Number:** 50977 **Flow Region:** Turbulent **Friction Factor:** 0.0243 **Pressure Loss (psi):** 0.072 **Net Expansion Factor:** 0.996 **Inlet Mach Number:** 0.006 **Outlet Mach Number:** 0.006 **Density at Inlet:** 0.572 **Specific Volume at Inlet:** 1.748 **K1:** 17534.47 **K2:** 17516.37 **Overall K:** 18.1 **Specific Heat Ratio:** 1.4 **M iterations:** 168 **Friction Factor iterations:** 4	**Piping Length (ft):** 100 **Long Radius Elbows:** 0 **Short Radius Elbows:** 0 **5 Diameter Elbows:** 0 **45 degree Elbows :** 0 **Standard 90 degreeThreaded Elbows:** 0 **45 degree Standard Elbows :** 0 **Tee Flow Through:** 0 **Tee Flow Branch :** 0 **Gate:** 0 **Globe :** 0 **Swing Check:** 0 **Lift Check :** 0	**3 Way Plug :** 0 **Ball :** 0 **Plug:** 0 **Butterfly 2in. to 8in. :** 0 **Butterfly 10in. to 14in. :** 0 **Butterfly Greater Than 14in. :** 0 **Angle Valve Flow Up:** 0 **Angle Valve Flow Down :** 0 **Pipe Entrance:** 0 **Pipe Exit :** 0 **No. of Reducers:** 0 **Reducer Outlet Size (in) :** 0 **No. of Increasers:** 0 **Increaser Outlet Size (in) :** 0

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

5 of 11

Compressible Flow Pressure Loss Results	Piping, Valves, and Fittings	
Pressure Loss (psi): 0.021		
Job Number: **Client:** **Date:** **Line Number:** **Fluid:** **Nominal Pipe Size:** 2 **Pipe Schedule:** SCH 40 **Flow Rate:** 51 SCFM **Viscosity (cP):** 0.018 **Inlet Pressure (PSIG):** 125 **Temperature (F):** 200 **Pipe Roughness (ft):** 0.00015 **Actual Pipe ID (in.):** 2.067 **Fluid Velocity (ft/sec):** 4.87 **Reynolds Number:** 39706 **Flow Region:** Turbulent **Friction Factor:** 0.0245 **Pressure Loss (psi):** 0.021 **Net Expansion Factor:** 0.99 **Inlet Mach Number:** 0.004 **Outlet Mach Number:** 0.004 **Density at Inlet:** 0.572 **Specific Volume at Inlet:** 1.748 **K1:** 47652.7 **K2:** 47638.48 **Overall K:** 14.22 **Specific Heat Ratio:** 1.4 **M iterations:** 169 **Friction Factor iterations:** 4	**Piping Length (ft):** 100 **Long Radius Elbows:** 0 **Short Radius Elbows:** 0 **5 Diameter Elbows:** 0 **45 degree Elbows :** 0 **Standard 90 degreeThreaded Elbows:** 0 **45 degree Standard Elbows :** 0 **Tee Flow Through:** 0 **Tee Flow Branch :** 0 **Gate:** 0 **Globe :** 0 **Swing Check:** 0 **Lift Check :** 0	**3 Way Plug :** 0 **Ball :** 0 **Plug:** 0 **Butterfly 2in. to 8in. :** 0 **Butterfly 10in. to 14in. :** 0 **Butterfly Greater Than 14in. :** 0 **Angle Valve Flow Up:** 0 **Angle Valve Flow Down :** 0 **Pipe Entrance:** 0 **Pipe Exit :** 0 **No. of Reducers:** 0 **Reducer Outlet Size (in) :** 0 **No. of Increasers:** 0 **Increaser Outlet Size (in) :** 0

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

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PROJECT		REMARKS
SUBJECT	CALC BY	DATE
	CHK BY	DATE

WEST

Q_2 = 74 SCFM

USING GAS COMP PROG

$d_1 = 1''$ $d_2 = 1\frac{1}{2}''$ $d_3 = 2''$

$\Delta P = 1.46$ $\Delta P = 0.17$ $\Delta P = .05$

ASSUME TOTAL EQUIV LENTH IS 1000 F

$d = 1$

ΔP_{T_1} = 146 PSI

$d = 1\frac{1}{2}$

$\Delta P_{T_2} = 0.17 \times 10$

= 17 PSI STILL TOO HIGH

$d = 2''$

$\Delta P_{T_2} = 0.05 \times 10$

= 5 PSI THIS IS OK

USE A 2" HEADER

7 OF 11

Compressible Flow Pressure Loss Results	Piping, Valves, and Fittings	
Pressure Loss (psi): 1.459		
Job Number: **Client:** **Date:** **Line Number:** **Fluid:** **Nominal Pipe Size:** 1 **Pipe Schedule:** SCH 40 **Flow Rate:** 74 SCFM **Viscosity (cP):** 0.018 **Inlet Pressure (PSIG):** 125 **Temperature (F):** 200 **Pipe Roughness (ft):** 0.00021 **Actual Pipe ID (in.):** 1.049 **Fluid Velocity (ft/sec):** 27.46 **Reynolds Number:** 113524 **Flow Region:** Turbulent **Friction Factor:** 0.0259 **Pressure Loss (psi):** 1.459 **Net Expansion Factor:** 0.995 **Inlet Mach Number:** 0.022 **Outlet Mach Number:** 0.022 **Density at Inlet:** 0.572 **Specific Volume at Inlet:** 1.748 **K1:** 1494.63 **K2:** 1463.45 **Overall K:** 31.18 **Specific Heat Ratio:** 1.4 **M iterations:** 167 **Friction Factor iterations:** 3	**Piping Length (ft):** 100 **Long Radius Elbows:** 0 **Short Radius Elbows:** 0 **5 Diameter Elbows:** 0 **45 degree Elbows :** 0 **Standard 90 degreeThreaded Elbows:** 0 **45 degree Standard Elbows :** 0 **Tee Flow Through:** 0 **Tee Flow Branch :** 0 **Gate:** 0 **Globe :** 0 **Swing Check:** 0 **Lift Check :** 0	**3 Way Plug :** 0 **Ball :** 0 **Plug:** 0 **Butterfly 2in. to 8in. :** 0 **Butterfly 10in. to 14in. :** 0 **Butterfly Greater Than 14in. :** 0 **Angle Valve Flow Up:** 0 **Angle Valve Flow Down :** 0 **Pipe Entrance:** 1 **Pipe Exit :** 1 **No. of Reducers:** 0 **Reducer Outlet Size (in) :** 0 **No. of Increasers:** 0 **Increaser Outlet Size (in) :** 0

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

8 OF 11

Compressible Flow Pressure Loss Results	Piping, Valves, and Fittings	
Pressure Loss (psi): 0.145		
Job Number: **Client:** **Date:** **Line Number:** **Fluid:** **Nominal Pipe Size:** 1.5 **Pipe Schedule:** SCH 40 **Flow Rate:** 74 SCFM **Viscosity (cP):** 0.018 **Inlet Pressure (PSIG):** 125 **Temperature (F):** 200 **Pipe Roughness (ft):** 0.00015 **Actual Pipe ID (in.):** 1.61 **Fluid Velocity (ft/sec):** 11.66 **Reynolds Number:** 73967 **Flow Region:** Turbulent **Friction Factor:** 0.0232 **Pressure Loss (psi):** 0.145 **Net Expansion Factor:** 0.997 **Inlet Mach Number:** 0.009 **Outlet Mach Number:** 0.009 **Density at Inlet:** 0.572 **Specific Volume at Inlet:** 1.748 **K1:** 8324.35 **K2:** 8307.03 **Overall K:** 17.32 **Specific Heat Ratio:** 1.4 **M iterations:** 168 **Friction Factor iterations:** 4	**Piping Length (ft):** 100 **Long Radius Elbows:** 0 **Short Radius Elbows:** 0 **5 Diameter Elbows:** 0 **45 degree Elbows :** 0 **Standard 90 degreeThreaded Elbows:** 0 **45 degree Standard Elbows :** 0 **Tee Flow Through:** 0 **Tee Flow Branch :** 0 **Gate:** 0 **Globe :** 0 **Swing Check:** 0 **Lift Check :** 0	**3 Way Plug :** 0 **Ball :** 0 **Plug:** 0 **Butterfly 2in. to 8in. :** 0 **Butterfly 10in. to 14in. :** 0 **Butterfly Greater Than 14in. :** 0 **Angle Valve Flow Up:** 0 **Angle Valve Flow Down :** 0 **Pipe Entrance:** 0 **Pipe Exit :** 0 **No. of Reducers:** 0 **Reducer Outlet Size (in) :** 0 **No. of Increasers:** 0 **Increaser Outlet Size (in) :** 0

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

9 OF 11

Compressible Flow Pressure Loss Results	Piping, Valves, and Fittings	
Pressure Loss (psi): 0.048		
Job Number: **Client:** **Date:** **Line Number:** **Fluid:** **Nominal Pipe Size:** 2 **Pipe Schedule:** SCH 40 **Flow Rate:** 74 SCFM **Viscosity (cP):** 0.018 **Inlet Pressure (PSIG):** 125 **Temperature (F):** 200 **Pipe Roughness (ft):** 0.00021 **Actual Pipe ID (in.):** 2.067 **Fluid Velocity (ft/sec):** 7.07 **Reynolds Number:** 57613 **Flow Region:** Turbulent **Friction Factor:** 0.0242 **Pressure Loss (psi):** 0.048 **Net Expansion Factor:** 0.995 **Inlet Mach Number:** 0.006 **Outlet Mach Number:** 0.006 **Density at Inlet:** 0.572 **Specific Volume at Inlet:** 1.748 **K1:** 22629.51 **K2:** 22613.97 **Overall K:** 15.54 **Specific Heat Ratio:** 1.4 **M iterations:** 169 **Friction Factor iterations:** 4	**Piping Length (ft):** 100 **Long Radius Elbows:** 0 **Short Radius Elbows:** 0 **5 Diameter Elbows:** 0 **45 degree Elbows :** 0 **Standard 90 degreeThreaded Elbows:** 0 **45 degree Standard Elbows :** 0 **Tee Flow Through:** 0 **Tee Flow Branch :** 0 **Gate:** 0 **Globe :** 0 **Swing Check:** 0 **Lift Check :** 0	**3 Way Plug :** 0 **Ball :** 0 **Plug:** 0 **Butterfly 2in. to 8in. :** 0 **Butterfly 10in. to 14in. :** 0 **Butterfly Greater Than 14in. :** 0 **Angle Valve Flow Up:** 0 **Angle Valve Flow Down :** 0 **Pipe Entrance:** 1 **Pipe Exit :** 1 **No. of Reducers:** 0 **Reducer Outlet Size (in) :** 0 **No. of Increasers:** 0 **Increaser Outlet Size (in) :** 0

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

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PROJECT			REMARKS
SUBJECT	CALC BY	DATE	
	CHK BY	DATE	

CHECK USING LB/HR TO FIND SAME ANSWER AS SCFM

$$\frac{LB}{HR} = SCFH \Big/ \frac{379}{MOL\ WT}$$

$$= \left(\frac{74\ FT^3}{MIN} \times \frac{60\ MIN}{HR}\right) \Big/ \frac{379}{29}$$

$$= \frac{4440}{13.06}$$

$$LB/HR = 340\ LB/HR$$

USING COMPUTER PROGRAM

$d = 1\frac{1}{2}$ $\quad Q = 340\ LB/HR$

$\Delta P = 0.146$

USING THE SAME PROGRAM

$d = 1\frac{1}{2}$ $\quad Q = 74\ SCFM$

$\Delta P = 0.145$

OK

11 OF 10

Compressible Flow Pressure Loss Results	Piping, Valves, and Fittings	
Pressure Loss (psi): 0.145		
Job Number:		
Client:		
Date:		
Line Number:		
Fluid:		
Nominal Pipe Size: 1.5		**3 Way Plug :** 0
Pipe Schedule: SCH 40		**Ball :** 0
Flow Rate: 74 SCFM	**Piping Length (ft):** 100	**Plug:** 0
Viscosity (cP): 0.018	**Long Radius Elbows:** 0	**Butterfly 2in. to 8in. :** 0
Inlet Pressure (PSIG): 125	**Short Radius Elbows:** 0	**Butterfly 10in. to 14in. :** 0
Temperature (F): 200	**5 Diameter Elbows:** 0	**Butterfly Greater Than 14in. :** 0
Pipe Roughness (ft): 0.00015	**45 degree Elbows :** 0	**Angle Valve Flow Up:** 0
Actual Pipe ID (in.): 1.61	**Standard 90 degreeThreaded Elbows:** 0	**Angle Valve Flow Down :** 0
Fluid Velocity (ft/sec): 11.66	**45 degree Standard Elbows :** 0	**Pipe Entrance:** 0
Reynolds Number: 73967	**Tee Flow Through:** 0	**Pipe Exit :** 0
Flow Region: Turbulent	**Tee Flow Branch :** 0	**No. of Reducers:** 0
Friction Factor: 0.0232	**Gate:** 0	**Reducer Outlet Size (in) :** 0
Pressure Loss (psi): 0.145	**Globe :** 0	**No. of Increasers:** 0
Net Expansion Factor: 0.997	**Swing Check:** 0	**Increaser Outlet Size (in) :** 0
Inlet Mach Number: 0.009	**Lift Check :** 0	
Outlet Mach Number: 0.009		
Density at Inlet: 0.572		
Specific Volume at Inlet: 1.748		
K1: 8324.35		
K2: 8307.03		
Overall K: 17.32		
Specific Heat Ratio: 1.4		
M iterations: 168		
Friction Factor iterations: 4		

'Copy and Paste' Pressure Loss or Head Loss into other applications
If any output is NaN click back button and make sure all Fluid and Piping and Valves and Fittings fields contain values, enter 0 if necessary

CONDENSATE SUMP SIZING

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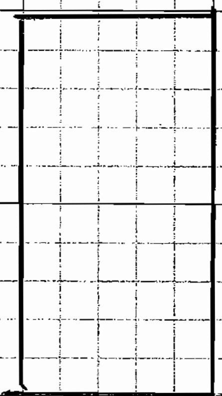
PROJECT Pemaco		REMARKS
SUBJECT Vapor Extraction Condensate Sump	CALC BY G Nicholson	DATE 7/28/04
	CHK BY	DATE

SIZING OF PVC SUMP FROM DRAWING



$1\frac{1}{2}'$

$\frac{1}{2}'$

EXISTING SUMP

50 - $V = \pi r^2 L$

$= \pi (\frac{1}{4})^2 \, 1.5$

$V = 0.294 \text{ FT}^3 \times 7.5$

$V = 2.2$ GAL

TRY 18" ΦD PVC SUMP

$V_1 = \pi r^2 L$

$= \pi (\frac{1}{2}')^2 (\frac{11''}{12})$

$= 0.72 \text{ FT}^3 \times 7.5 \frac{\text{GAL}}{\text{FT}^3}$

$V_1 = 5.4$ GAL

USE D = 12" AND L = 15"

APPENDIX F
Cost Estimate
(Prepared 2005 Cost Data)

REMEDIAL ACTION COST PROPOSAL

Pemaco Superfund Site RA Proposal
USACE - Omaha District

Format of TN&A Cost Proposal

Our Cost Proposal is divided into 2 Sections:

Section 1: A detailed breakdown of costs per Phase/Task, as listed above (as listed/defined in the RFP).

Section 2: A corresponding breakdown per Phase/Task, listing key technical assumptions, quantities, etc.

Cost Sheet Summary

Worksheet	Phase	Phase Name	Task	Task Name	Estimated Task Total
1	1	Project Management	1a	Project Planning	$ -
1	1	Project Management	1b	Overall Project Resource Planning	$ -
1	1	Project Management	1c	Overall Project Scheduling	$ -
				Task 1a-1c Subtotal	$ 71,859.18
2	1	Project Management	1d	Procurement	$ 23,800.02
3	1	Project Management	1e	Cost Control and Tracking (non-field)	$ 24,464.14
4	1	Project Management	1f	Project meetings	$ 27,009.51
5	1	Project Management	1g	Community Participation	$ 58,437.92
				Total Phase 1 - Project Management	$ 205,570.76
6	2	Project Plans	2a	Task-Specific Remedial Action Work Plans	$ 36,886.80
7	2	Project Plans	2b	Site Safety and Health Plan	$ 13,703.40
8	2	Project Plans	2c	Sampling and Analysis Plan	$ 28,963.14
9	2	Project Plans	2d	Construction Quaility Control Plan	$ 17,316.65
				Total Phase 2 - Project Plans	$ 96,870.00
10	3	Construction and O&M	3a	Mobilization/Demobilization	$ 59,907.35
11	3	Construction and O&M	3b	Well and Piping Installation - Phase 1	$ 1,244,643.56
12	3	Construction and O&M	3c	Well and Piping Installation - Phase 2	$ 350,707.88
13	3	Construction and O&M	3d	Treatment Building and Compound Construction	$ 588,981.43
14	3	Construction and O&M	3e	Treatment System Construction	$ 2,219,835.00
15	3	Construction and O&M	3f	MPE, SVE and Groundwater System Shakedown (including Source Testing)	$ 460,721.27
16	3	Construction and O&M	3g	ERH Construction	$ 2,191,767.93
17	3	Construction and O&M	3h	Monthly O&M (1 Month)	$ 127,921.46
				Monthly O&M (11 Months)	$ 1,407,136.09
18	3	Construction and O&M	3i	Validation Sampling	$ 90,936.68
19	3	Construction and O&M	3j	Project Demobilization	$ 132,965.94
				Total Phase 3 - Construction and O&M	$ 8,875,524.60
20	4	Engineering Support During Construction	4a		$ 176,078.87
				Total Phase 4 - Engineering Support During Construction	$ 176,078.87
21	5	Integration and Operation of Remedial System	5a		$ 60,276.71
				Total Phase 5 - Integration and Operation of Remedial System	$ 60,276.71
22	6	O&M Plan	6a		$ 47,037.69
				Total Phase 6 - O&M Plan	$ 47,037.69
23	7	ERH Final Technical Memorandum	7a		$ 29,629.47
				Total Phase 7- ERH Final Technical Memorandum	$ 29,629.47
24	8	Enhanced MPE Final Tech Memorandum	8a		$ 52,052.26
				Total Phase 8 - Enhanced MPE Final Tech Memorandum	$ 52,052.26
				Project Total Estimated Cost	$ 9,543,040.35

Pemaco Remedial Action - Cost Worksheet #1

Phase 1 - Project Management
Task 1a - Project Planning
Task 1b - Overall Project Resource Planning
Task 1c - Overall Project Scheduling

Labor	***Estimated Hours***	***Unit Cost***	***Subtotal***
Home Office Support			
Project Manager	520	$ 121.12	$ 62,984.10
Engineer (senior)	48	$ 113.63	$ 5,454.03
Engineer (mid)		$ 77.71	$ -
Chemist (senior)		$ 104.38	$ -
Chemist (mid)		$ 71.83	$ -
Hydro / Geo (senior)		$ 111.87	$ -
Hydro / Geo (mid)	24	$ 72.04	$ 1,728.96
Clerical (admin, data entry, etc.)	24	$ 48.54	$ 1,165.01
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
Laborer		$ 32.98	$ -
		Subtotal, Labor:	***$ 71,332.10***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
			$ -
			$ -
			$ -
			$ -
		Subtotal, Subcontracts:	
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
			$ -
			$ -
			$ -
			$ -
			$ -
		Subtotal, Materials/Supplies/Misc Costs:	
Equipment	***Units***	***Unit Cost***	***Subtotal***
			$ -
			$ -
			$ -
		Subtotal, Equipment:	
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel		$ -	$ -
Shipping	1	$ 266.95	$ 266.95
Copying	1	$ 260.13	$ 260.13
Other			$ -
		Subtotal, ODCs:	***$ 527.08***
Estimated Task Total:			***$ 71,859.18***

Pemaco Remedial Action - Cost Worksheet #2

Phase 1 - Project Management

Task 1d - Procurement

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	40	$ 121.12	$ 4,844.93
Engineer (senior)	8	$ 113.63	$ 909.00
Engineer (mid)	60	$ 77.71	$ 4,662.51
Chemist (senior)		$ 104.38	$ -
Chemist (mid)	60	$ 71.83	$ 4,310.04
Hydro / Geo (senior)		$ 111.87	$ -
Hydro / Geo (mid)	24	$ 72.04	$ 1,728.96
Clerical (admin, data entry, etc.)	120	$ 48.54	$ 5,825.05
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	***$ 22,280.50***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Subcontracts:	***$ -***
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Materials/Supplies/Misc Costs:	***$ -***
Equipment	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Equipment:	***$ -***
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel		$ -	$ -
Shipping	1	$ 558.00	$ 667.37
Copying	1	$ 712.50	$ 852.15
Other			$ -
		Subtotal, ODCs:	***$ 1,519.52***
		Estimated Task Total:	***$ 23,800.02***

Pemaco Remedial Action - Cost Worksheet #3

Phase 1 - Project Management

Task 1e - Cost Control and Tracking - (non-field)

Labor	***Estimated Hours***	***Unit Cost***	***Subtotal***
Home Office Support			
Project Manager	60	$ 121.12	$ 7,267.40
Engineer (senior)	40	$ 113.63	$ 4,545.02
Engineer (mid)		$ 77.71	$ -
Chemist (senior)		$ 104.38	$ -
Chemist (mid)	16	$ 71.83	$ 1,149.34
Hydro / Geo (senior)		$ 111.87	$ -
Hydro / Geo (mid)	24	$ 72.04	$ 1,728.96
Clerical (admin, data entry, etc.)	200	$ 48.54	$ 9,708.41
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	***$ 24,399.14***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Subcontracts:	***$ -***
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Materials/Supplies/Misc Costs:	***$ -***
Equipment	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Equipment:	***$ -***
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel		$ -	$ -
Shipping		$ -	$ -
Copying	1	$ 65.00	$ 65.00
Other			$ -
		Subtotal, ODCs:	***$ 65.00***
		Estimated Task Total:	***$ 24,464.14***

Pemaco Remedial Action - Cost Worksheet #4

Phase 1 - Project Management
Task 1f - Project Meetings (non-field)

Labor	***Estimated Hours***	***Unit Cost***	***Subtotal***
Home Office Support			
Project Manager	64	$ 121.12	$ 7,751.89
Engineer (senior)	64	$ 113.63	$ 7,272.03
Engineer (mid)		$ 77.71	$ -
Chemist (senior)		$ 104.38	$ -
Chemist (mid)		$ 71.83	$ -
Hydro / Geo (senior)	40	$ 111.87	$ 4,474.94
Hydro / Geo (mid)		$ 72.04	$ -
Clerical (admin, data entry, etc.)	8	$ 48.54	$ 388.34
Field Personnel			
Site Supervisor	8	$ 79.53	$ 636.25
Cost Tracker	8	$ 54.32	$ 434.53
CQC Officer	8	$ 63.84	$ 510.76
SSHO	8	$ 63.84	$ 510.76
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	***$ 21,979.49***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Subcontracts:	***$ -***
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Materials/Supplies/Misc Costs:	***$ -***
Equipment	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Equipment:	***$ -***
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel	1	$ 4,396.14	$ 4,396.14
Shipping			$ -
Copying	1	$ 633.88	$ 633.88
Other			$ -
		Subtotal, ODCs:	***$ 5,030.02***
		Estimated Task Total:	***$ 27,009.51***

Pemaco Remedial Action - Cost Worksheet #5

Phase 1 - Project Management
Task 1g - Community Participation

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	60	$ 121.12	$ 7,267.40
Engineer (senior)	60	$ 113.63	$ 6,817.53
Engineer (mid)	60	$ 77.71	$ 4,662.51
Chemist (senior)		$ 104.38	$ -
Chemist (mid)	16	$ 71.83	$ 1,149.34
Hydro / Geo (senior)	60	$ 111.87	$ 6,712.41
Hydro / Geo (mid)	120	$ 72.04	$ 8,644.82
Clerical (admin, data entry, etc.)	40	$ 48.54	$ 1,941.68
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	*$ 37,195.69*
Subcontracts	*Units*	*Unit Cost*	*Subtotal*
Translation Services	4	$ 1,543.95	$ 6,175.80
Graphics Services	2	$ 2,573.25	$ 5,146.50
		Subtotal, Subcontracts:	*$ 11,322.30*
Materials/Supplies/Misc Costs	*Units*	*Unit Cost*	*Subtotal*
Misc.	1	$ 1,196.00	$ 1,196.00
		Subtotal, Materials/Supplies/Misc Costs:	*$ 1,196.00*
Equipment	*Units*	*Unit Cost*	*Subtotal*
		Subtotal, Equipment:	*$ -*
ODCs	*Units*	*Unit Cost*	*Subtotal*
Travel	1	$ 4,089.42	$ 4,089.42
Shipping			$ -
Copying	1	$ 4,634.50	$ 4,634.50
Other			$ -
		Subtotal, ODCs:	*$ 8,723.92*
		Estimated Task Total:	*$ 58,437.92*

Pemaco Remedial Action - Cost Worksheet #6

Phase 2 - Project Plans

Task 2a - Task-Specific Remedial Action Work Plans

Labor	***Estimated Hours***	***Unit Cost***	***Subtotal***
Home Office Support			
Project Manager	8	$ 121.12	$ 968.99
Engineer (senior)	120	$ 113.63	$ 13,635.06
Engineer (mid)	160	$ 77.71	$ 12,433.36
Chemist (senior)		$ 104.38	$ -
Chemist (mid)		$ 71.83	$ -
Hydro / Geo (senior)	12	$ 111.87	$ 1,342.48
Hydro / Geo (mid)	24	$ 72.04	$ 1,728.96
Clerical (admin, data entry, etc.)	48	$ 48.54	$ 2,330.02
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	***$ 32,438.88***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Subcontracts:	***$ -***
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Materials/Supplies/Misc Costs:	***$ -***
Equipment	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Equipment:	***$ -***
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel	1	$ 1,380.18	$ 1,380.18
Shipping	1	$ 556.14	$ 556.14
Copying	1	$ 2,511.60	$ 2,511.60
Other			$ -
		Subtotal, ODCs:	***$ 4,447.92***
		Estimated Task Total:	***$ 36,886.80***

Pemaco Remedial Action - Cost Worksheet #7

Phase 2 - Project Plans

Task 2b - Site Safety and Health Plans

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	4	$ 121.12	$ 484.49
Engineer (senior)	40	$ 113.63	$ 4,545.02
Engineer (mid)	80	$ 77.71	$ 6,216.68
Chemist (senior)		$ 104.38	$ -
Chemist (mid)		$ 71.83	$ -
Hydro / Geo (senior)		$ 111.87	$ -
Hydro / Geo (mid)	4	$ 72.04	$ 288.16
Clerical (admin, data entry, etc.)	16	$ 48.54	$ 776.67
Field Personnel			
Site Supervisor	4	$ 79.53	$ 318.12
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	$ 12,629.15
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Subcontracts:	$ -
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Materials/Supplies/Misc Costs:	$ -
Equipment	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Equipment:	$ -
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel		$ -	$ -
Shipping	1	$ 266.95	$ 266.95
Copying	1	$ 807.30	$ 807.30
Other			$ -
		Subtotal, ODCs:	$ 1,074.25
Estimated Task Total:			$ 13,703.40

Pemaco Remedial Action - Cost Worksheet #8

Phase 2 - Project Plans

Task 2c - Sampling and Analysis Plan

Labor	***Estimated Hours***	***Unit Cost***	***Subtotal***
Home Office Support			
Project Manager	12	$ 121.12	$ 1,453.48
Engineer (senior)	24	$ 113.63	$ 2,727.01
Engineer (mid)	24	$ 77.71	$ 1,865.00
Chemist (senior)	16	$ 104.38	$ 1,670.01
Chemist (mid)	160	$ 71.83	$ 11,493.44
Hydro / Geo (senior)	40	$ 111.87	$ 4,474.94
Hydro / Geo (mid)		$ 72.04	$ -
Clerical (admin, data entry, etc.)	24	$ 48.54	$ 1,165.01
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	***$ 24,848.90***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Subcontracts:	***$ -***
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Materials/Supplies/Misc Costs:	***$ -***
Equipment	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Equipment:	***$ -***
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel	1	$ 1,380.18	$ 1,380.18
Shipping	1	$ 222.46	$ 222.46
Copying	1	$ 2,511.60	$ 2,511.60
Other			$ -
		Subtotal, ODCs:	***$ 4,114.24***
		Estimated Task Total:	***$ 28,963.14***

Pemaco Remedial Action - Cost Worksheet #9

Phase 2 - Project Plans

Task 2d - Construction Quality Control Plan

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	8	$ 121.12	$ 968.99
Engineer (senior)	40	$ 113.63	$ 4,545.02
Engineer (mid)	100	$ 77.71	$ 7,770.85
Chemist (senior)		$ 104.38	$ -
Chemist (mid)	4	$ 71.83	$ 287.34
Hydro / Geo (senior)		$ 111.87	$ -
Hydro / Geo (mid)	16	$ 72.04	$ 1,152.64
Clerical (admin, data entry, etc.)	24	$ 48.54	$ 1,165.01
Field Personnel			
Site Supervisor	8	$ 79.53	$ 636.25
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	*$ 16,526.10*
Subcontracts	*Units*	*Unit Cost*	*Subtotal*
		Subtotal, Subcontracts:	*$ -*
Materials/Supplies/Misc Costs	*Units*	*Unit Cost*	*Subtotal*
		Subtotal, Materials/Supplies/Misc Costs:	*$ -*
Equipment	*Units*	*Unit Cost*	*Subtotal*
		Subtotal, Equipment:	*$ -*
ODCs	*Units*	*Unit Cost*	*Subtotal*
Travel		$ -	$ -
Shipping	1	$ 222.46	$ 222.46
Copying	1	$ 568.10	$ 568.10
Other			$ -
		Subtotal, ODCs:	*$ 790.56*
		Estimated Task Total:	*$ 17,316.65*

Pemaco Remedial Action - Cost Worksheet #10

Phase 3 - Contruction and O&M
Task 3a - Project Mobilization

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	12	$ 121.12	$ 1,453.48
Engineer (senior)	16	$ 113.63	$ 1,818.01
Engineer (mid)	40	$ 77.71	$ 3,108.34
Chemist (senior)		$ 104.38	$ -
Chemist (mid)	5	$ 71.83	$ 359.17
Hydro / Geo (senior)		$ 111.87	$ -
Hydro / Geo (mid)	60	$ 72.04	$ 4,322.41
Clerical (admin, data entry, etc.)	12	$ 48.54	$ 582.50
Field Personnel			
Site Supervisor	100	$ 79.53	$ 7,953.10
Cost Tracker	48	$ 54.32	$ 2,607.15
CQC Officer		$ 63.84	$ -
SSHO	48	$ 63.84	$ 3,064.55
Env. Technician (senior)	24	$ 54.32	$ 1,303.58
Env. Technician (jr/mid)	48	$ 45.19	$ 2,169.11
		Subtotal, Labor:	***$ 28,741.39***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
Note: subcontractor mobilization costs are estimated at ~$27,000; costs shown under respective construction subtask	0	$ -	$ -
		Subtotal, Subcontracts:	***$ -***
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
Field Office Materials/Supplies, etc.	8	$ 717.60	$ 5,740.80
Dumpster/Waste Removal	8	$ 448.50	$ 3,588.00
			$ -
			$ -
		Subtotal, Materials/Supplies/Misc Costs:	***$ 9,328.80***
Equipment	***Units***	***Unit Cost***	***Subtotal***
Field Trailer and Storage (8 months)	8	$ 1,196.00	$ 9,568.00
Temporary Fencing	8	$ 358.80	$ 2,870.40
Other (Porta-toilet, H&S, etc.)	8	$ 358.80	$ 2,870.40
		Subtotal, Equipment:	***$ 15,308.80***
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel	1	$ 6,372.89	$ 6,372.89
Shipping		$ -	$ -
Copying	1	$ 155.48	$ 155.48
Other			$ -
		Subtotal, ODCs:	***$ 6,528.37***
		Estimated Task Total:	***$ 59,907.35***

Pemaco Remedial Action - Cost Worksheet #11

Phase 3 - Contruction and O&M

Task 3b - Well and Piping Installation - Phase 1 ("Park Area")

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager		$ 121.12	$ -
Engineer (senior)		$ 113.63	$ -
Engineer (mid)		$ 77.71	$ -
Chemist (senior)		$ 104.38	$ -
Chemist (mid)	40	$ 71.83	$ 2,873.36
Hydro / Geo (senior)	40	$ 111.87	$ 4,474.94
Hydro / Geo (mid)	400	$ 72.04	$ 28,816.05
Clerical (admin, data entry, etc.)	16	$ 48.54	$ 776.67
Field Personnel			
Site Supervisor	510	$ 79.53	$ 40,560.80
Cost Tracker	510	$ 54.32	$ 27,700.97
CQC	250	$ 63.84	$ 15,961.17
SSHO	250	$ 63.84	$ 15,961.17
Env. Technician (senior)	255	$ 54.32	$ 13,850.49
Env. Technician (jr/mid)	510	$ 45.19	$ 23,046.76
		Subtotal, Labor:	*$ 174,022.39*
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
Well Installation "Park" (lump sum)	1	$ 273,282.34	$ 273,282.34
Trench and Pipe (lump sum)	1	$ 671,371.22	$ 671,371.22
Soil Removal/Disposal (c.y.)	345	$ 67.93	$ 23,437.16
Site Security (days)	60	$ 185.27	$ 11,116.44
Geophysical Survey (lump)	1	$ 3,602.55	$ 3,602.55
Construction Surveyor (day)	3	$ 1,543.95	$ 4,631.85
Traffic Control (flagmen) (day)	14	$ 257.33	$ 3,602.55
		Subtotal, Subcontracts:	*$ 991,044.11*
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
H&S	1	$ 657.80	$ 657.80
Sampling	160	$ 29.90	$ 4,784.00
Misc. marking, staking, flagging	1	$ 299.00	$ 299.00
Visqeen Plastic (soil cover)	6	$ 119.60	$ 717.60
		Subtotal, Materials/Supplies/Misc Costs:	*$ 6,458.40*
Equipment	***Units***	***Unit Cost***	***Subtotal***
Baker Tank Rental	1	$ 777.40	$ 777.40
Bin Rental (17 bins for 90 days)	1530	$ 5.98	$ 9,149.40
Equipment Rental (generator, etc.)	1	$ 2,990.00	$ 2,990.00
PID (VOC monitor)	1	$ 1,315.60	$ 1,315.60
Aerosol monitor	1	$ 598.00	$ 598.00
Horiba U-10 (well development)	1	$ 598.00	$ 598.00
Walter level indicator	1	$ 179.40	$ 179.40
Misc. Hand Tools	1	$ 179.40	$ 179.40
		Subtotal, Equipment:	*$ 15,787.20*
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel	1	$ 52,511.58	$ 52,511.58
Shipping	1	$ 4,664.40	$ 4,664.40
Copying	1	$ 155.48	$ 155.48
Other			$ -
		Subtotal, ODCs:	*$ 57,331.46*
		Estimated Task Total:	*$ 1,244,643.56*

Pemaco Remedial Action - Cost Worksheet #12

Phase 3 - Contruction and O&M

Task 3c - Well and Piping Installation - Phase 2 (60th Street)

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager		$ 121.12	$ -
Engineer (senior)		$ 113.63	$ -
Engineer (mid)		$ 77.71	$ -
Chemist (senior)		$ 104.38	$ -
Chemist (mid)	20	$ 71.83	$ 1,436.68
Hydro / Geo (senior)	40	$ 111.87	$ 4,474.94
Hydro / Geo (mid)	140	$ 72.04	$ 10,085.62
Clerical (admin, data entry, etc.)	16	$ 48.54	$ 776.67
Field Personnel			
Site Supervisor	310	$ 79.53	$ 24,654.61
Cost Tracker	310	$ 54.32	$ 16,837.85
CQC Officer	155	$ 63.84	$ 9,895.93
SSHO	155	$ 63.84	$ 9,895.93
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)	140	$ 45.19	$ 6,326.56
		Subtotal, Labor:	*$ 84,384.78*
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
Well Installation 60th Street (lump)	1	$ 39,675.29	$ 39,675.29
Trench and Pipe (lump)	1	$ 160,351.56	$ 160,351.56
Soil Removal/Disposal (c. y.)	64	$ 49.41	$ 3,162.01
Site Security (day)	55	$ 185.27	$ 10,190.07
Geophysical Survey (lump)	1	$ 2,573.25	$ 2,573.25
Construction Surveyor (day)	2	$ 1,543.95	$ 3,087.90
Traffic Control (flagmen) (day)	31	$ 257.33	$ 7,977.08
		Subtotal, Subcontracts:	*$ 227,017.16*
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
H&S	5	$ 299.00	$ 1,495.00
Traffic Control/Safety Equipment	1	$ 2,392.00	$ 2,392.00
Misc. marking, staking, flagging	1	$ 299.00	$ 299.00
Visqeen Plastic (soil cover)	6	$ 119.60	$ 717.60
Drums (55 gallon)	32	$ 45.45	$ 1,454.34
		Subtotal, Materials/Supplies/Misc Costs:	*$ 6,357.94*
Equipment	***Units***	***Unit Cost***	***Subtotal***
Bin Rental (5 bins for 90 days)	150	$ 5.98	$ 897.00
Equipment Rental (generator, etc.)	1	$ 2,990.00	$ 2,990.00
PID (VOC monitor)	1	$ 1,315.60	$ 1,315.60
Aerosol monitor	1	$ 598.00	$ 598.00
Horiba U-10 (well development)	1	$ 598.00	$ 598.00
Equipment Rental (generator, etc.)	1	$ 2,392.00	$ 2,392.00
Walter level indicator	1	$ 179.40	$ 179.40
Sampling pump	1	$ 1,196.00	$ 1,196.00
		Subtotal, Equipment:	*$ 10,166.00*
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel	1	$ 22,626.53	$ 22,626.53
Shipping			$ -
Copying	1	$ 155.48	$ 155.48
Other			$ -
		Subtotal, ODCs:	*$ 22,782.01*
		Estimated Task Total:	*$ 350,707.88*

Pemaco Remedial Action - Cost Worksheet #13

Phase 3 - Contruction and O&M
Task 3d - Treatment Building and Compound Construction

Labor	***Estimated Hours***	***Unit Cost***	***Subtotal***
Home Office Support			
Project Manager	16	$ 121.12	$ 1,937.97
Engineer (senior)		$ 113.63	$ -
Engineer (mid)		$ 77.71	$ -
Chemist (senior)		$ 104.38	$ -
Chemist (mid)		$ 71.83	$ -
Hydro / Geo (senior)	0	$ 111.87	$ -
Hydro / Geo (mid)		$ 72.04	$ -
Clerical (admin, data entry, etc.)	16	$ 48.54	$ 776.67
Field Personnel			
Site Supervisor	200	$ 79.53	$ 15,906.20
Cost Tracker	200	$ 54.32	$ 10,863.13
CQC Officer	100	$ 63.84	$ 6,384.47
SSHO	100	$ 63.84	$ 6,384.47
Env. Technician (senior)	100	$ 54.32	$ 5,431.56
Env. Technician (jr/mid)	100	$ 45.19	$ 4,518.97
		Subtotal, Labor:	***$ 52,203.44***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
External Elec.Connections-Incl. ERH	1	$ 138,955.50	$ 138,955.50
Building Construction	1	$ 59,699.40	$ 59,699.40
Concrete Pads and Access Ways	1	$ 169,834.50	$ 169,834.50
Transformer T1 (Drawing E-2)	1	$ 33,966.90	$ 33,966.90
Fencing & Gates	1	$ 13,380.90	$ 13,380.90
Elec. Switches Panel, Stepdown trans.	1	$ 32,937.60	$ 32,937.60
Interior/Exterior Wiring and Lighting	1	$ 44,259.90	$ 44,259.90
Site Security (day)	20	$ 185.27	$ 3,705.48
Alarm System	1	$ 12,351.60	$ 12,351.60
		Subtotal, Subcontracts:	***$ 509,091.78***
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
Misc. Hardware/Fittings, etc.	1	$ 1,435.20	$ 1,435.20
Misc. exterior lights and wiring	1	$ 1,913.60	$ 1,913.60
Misc. paints and coatings	1	$ 4,186.00	$ 4,186.00
H&S	1	$ 299.00	$ 299.00
		Subtotal, Materials/Supplies/Misc Costs:	***$ 7,833.80***
Equipment	***Units***	***Unit Cost***	***Subtotal***
Small Tools	1	$ 598.00	$ 598.00
Equipment Rental (generator, etc.)	1	$ 2,392.00	$ 2,392.00
Paint/Coating Sprayer	1	$ 418.60	$ 418.60
			$ -
		Subtotal, Equipment:	***$ 3,408.60***
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel	1	$ 16,288.32	$ 16,288.32
Shipping			$ -
Copying	1	$ 155.48	$ 155.48
Other			$ -
		Subtotal, ODCs:	***$ 16,443.80***
		Estimated Task Total:	***$ 588,981.43***

Pemaco Remedial Action - Cost Worksheet #14

Phase 3 - Contruction and O&M
Task 3e- Treatment System Construction

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	16	$ 121.12	$ 1,937.97
Engineer (senior)		$ 113.63	$ -
Engineer (mid)		$ 77.71	$ -
Chemist (senior)		$ 104.38	$ -
Chemist (mid)		$ 71.83	$ -
Hydro / Geo (senior)		$ 111.87	$ -
Hydro / Geo (mid)		$ 72.04	$ -
Clerical (admin, data entry, etc.)	12	$ 48.54	$ 582.50
Field Personnel			
Site Supervisor	300	$ 79.53	$ 23,859.30
Cost Tracker	300	$ 54.32	$ 16,294.69
CQC Officer	150	$ 63.84	$ 9,576.70
SSHO	150	$ 63.84	$ 9,576.70
Env. Technician (senior)	300	$ 54.32	$ 16,294.69
Env. Technician (jr/mid)	600	$ 45.19	$ 27,113.84
		Subtotal, Labor:	$ 105,236.40
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
Specialized Technicians	1	$ 16,211.48	$ 16,211.48
Site Security (day)	38	$ 185.27	$ 7,040.41
		Subtotal, Subcontracts:	$ 23,251.89
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
Misc. Hardware/Fittings, etc.	1	$ 2,990.00	$ 2,990.00
Misc. int. wiring and connections	1	$ 1,435.20	$ 1,435.20
Misc. paints and labels	1	$ 2,152.80	$ 2,152.80
H&S - PPE, respiratory	1	$ 1,076.40	$ 1,076.40
Misc. Office Furniture/Shelves	1	$ 3,827.20	$ 3,827.20
Emergency Response - spill/fire	1	$ 3,229.20	$ 3,229.20
		Subtotal, Materials/Supplies/Misc Costs:	$ 14,710.80
Equipment	***Units***	***Unit Cost***	***Subtotal***
Multi-phase Extraction System	1	$ 189,447.54	$ 189,447.54
Influent Water Conditioning	1	$ 20,560.56	$ 20,560.56
Carbon Adsorber	2	$ 32,709.11	$ 65,418.21
Vapor Conditioning	2	$ 17,555.17	$ 35,110.34
Flameless Thermal Oxidizer	1	$ 603,874.75	$ 603,874.75
Piping Materials	1	$ 110,032.00	$ 110,032.00
Valves for Water Filters	16	$ 299.00	$ 4,784.00
Vapor Valving and Gauges	1	$ 56,212.00	$ 56,212.00
Instrumentation, PLC, meters	1	$ 81,328.00	$ 81,328.00
Well Pumps and Assemblies	36	$ 5,212.43	$ 187,647.54
Water Conveyance and Tanks	1	$ 16,071.25	$ 16,071.25
Water Filtration	10	$ 2,796.31	$ 27,963.08
Flow Totalizers and Indicators	1	$ 1,495.00	$ 1,495.00
Air Compressor	1	$ 18,881.49	$ 18,881.49
UV Oxidizer System	1	$ 598,000.00	$ 598,000.00
Forklift rental	1	$ 1,435.20	$ 1,435.20
Interior lighting	1	$ 33,488.00	$ 33,488.00
Drum dolly rental	1	$ 299.00	$ 299.00
		Subtotal, Equipment:	$ 2,052,047.95
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel	1	$ 24,432.49	$ 24,432.49
Shipping			$ -
Copying	1	$ 155.48	$ 155.48
Other			$ -
		Subtotal, ODCs:	$ 24,587.97
		Estimated Task Total:	$ 2,219,835.00

Pemaco Remedial Action - Cost Worksheet #15

Phase 3 - Contruction and O&M

Task 3f - MPE, SVE, and Groundwater System Shakedown (including Sou

Labor	Estimated Hours	Unit Cost	Subtotal
Home Office Support			
Project Manager	16	$ 121.12	$ 1,937.97
Engineer (senior)	200	$ 113.63	$ 22,725.11
Engineer (mid)	120	$ 77.71	$ 9,325.02
Chemist (senior)	8	$ 104.38	$ 835.01
Chemist (mid)	80	$ 71.83	$ 5,746.72
Hydro / Geo (senior)	8	$ 111.87	$ 894.99
Hydro / Geo (mid)	40	$ 72.04	$ 2,881.61
Clerical (admin, data entry, etc.)	32	$ 48.54	$ 1,553.35
Field Personnel			
Site Supervisor	240	$ 79.53	$ 19,087.44
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO	40	$ 63.84	$ 2,553.79
Env. Technician (senior)	400	$ 54.32	$ 21,726.25
Env. Technician (jr/mid)	400	$ 45.19	$ 18,075.89
		Subtotal, Labor:	$ 107,343.14
Subcontracts	**Units**	**Unit Cost**	**Subtotal**
Analytical	1	$ 112,780.40	$ 112,780.40
Source Testing	1	$ 102,930.00	$ 102,930.00
Liquid waste disposal	1	$ 874.91	$ 874.91
		Subtotal, Subcontracts:	$ 216,585.31
Materials/Supplies/Misc Costs	**Units**	**Unit Cost**	**Subtotal**
Misc. lubricants	1	$ 119.60	$ 119.60
H&S Sample Collection	1	$ 657.80	$ 657.80
55-gallon drums	6	$ 45.45	$ 272.69
Electrical Costs (month)	1	$ 36,597.60	$ 36,597.60
Water (month)	1	$ 2,750.80	$ 2,750.80
Sewer (month)	1	$ 418.60	$ 418.60
Gas (month)	1	$ 19,674.20	$ 19,674.20
Sodium Hydroxide (month)	1	$ 6,099.60	$ 6,099.60
Peroxide	1	$ 2,511.60	$ 2,511.60
		Subtotal, Materials/Supplies/Misc Costs:	$ 69,102.49
Equipment	**Units**	**Unit Cost**	**Subtotal**
Baker Tank	1	$ 777.40	$ 777.40
Misc. gages and meters	1	$ 1,435.20	$ 1,435.20
Misc controlls	1	$ 2,511.60	$ 2,511.60
Vapor Monitoring Equip.	1	$ 9,328.80	$ 9,328.80
Water Monitoring Equip.	1	$ 6,578.00	$ 6,578.00
Misc. hardware	1	$ 299.00	$ 299.00
Dioxin/Furan samp. collect. train	1	$ 23,794.27	$ 23,794.27
		Subtotal, Equipment:	$ 44,724.27
ODCs	**Units**	**Unit Cost**	**Subtotal**
Travel	1	$ 22,810.59	$ 22,810.59
Shipping			$ -
Copying	1	$ 155.48	$ 155.48
Other			$ -
		Subtotal, ODCs:	$ 22,966.07
		Estimated Task Total:	$ 460,721.27

Pemaco Remedial Action - Cost Worksheet #16

Phase 3 - Contruction and O&M
Task 3g - ERH Construction

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	6	$ 121.12	$ 726.74
Engineer (senior)	40	$ 113.63	$ 4,545.02
Engineer (mid)	60	$ 77.71	$ 4,662.51
Chemist (senior)		$ 104.38	$ -
Chemist (mid)	20	$ 71.83	$ 1,436.68
Hydro / Geo (senior)		$ 111.87	$ -
Hydro / Geo (mid)	100	$ 72.04	$ 7,204.01
Clerical (admin, data entry, etc.)	6	$ 48.54	$ 291.25
Field Personnel			
Site Supervisor	120	$ 79.53	$ 9,543.72
Cost Tracker	30	$ 54.32	$ 1,629.47
CQC Officer	60	$ 63.84	$ 3,830.68
SSHO	60	$ 63.84	$ 3,830.68
Env. Technician (senior)	40	$ 54.32	$ 2,172.63
Env. Technician (jr/mid)	80	$ 45.19	$ 3,615.18
		Subtotal, Labor:	*$ 43,488.57*
Subcontracts	*Units*	*Unit Cost*	*Subtotal*
ERH Construction and Operation	1	$ 2,058,600.00	$ 2,058,600.00
Drilling (SVE Wells in ERH Area)	8	$ 7,431.55	$ 59,452.37
		Subtotal, Subcontracts:	*$ 2,118,052.37*
Materials/Supplies/Misc Costs	*Units*	*Unit Cost*	*Subtotal*
Sampling Equipment	100	$ 29.90	$ 2,990.00
Well Vaults and Well Head Assembly	8	$ 598.00	$ 4,784.00
		Subtotal, Materials/Supplies/Misc Costs:	*$ 7,774.00*
Equipment	*Units*	*Unit Cost*	*Subtotal*
Fencing	1	$ 14,950.00	$ 14,950.00
		Subtotal, Equipment:	*$ 14,950.00*
ODCs	*Units*	*Unit Cost*	*Subtotal*
Travel	1	$ 7,425.25	$ 7,425.25
Shipping			$ -
Copying	1	$ 77.74	$ 77.74
Other			$ -
		Subtotal, ODCs:	*$ 7,502.99*
		Estimated Task Total:	*$ 2,191,767.93*

Pemaco Remedial Action - Cost Worksheet #17

Phase 3 - Contruction and O&M

Task 3h - Monthly O&M

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	2	$ 121.12	$ 242.25
Engineer (senior)	24	$ 113.63	$ 2,727.01
Engineer (mid)	32	$ 77.71	$ 2,486.67
Chemist (senior)	4	$ 104.38	$ 417.50
Chemist (mid)	14	$ 71.83	$ 1,005.68
Hydro / Geo (senior)	4	$ 111.87	$ 447.49
Hydro / Geo (mid)	8	$ 72.04	$ 576.32
Clerical (admin, data entry, etc.)	24	$ 48.54	$ 1,165.01
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)	160	$ 54.32	$ 8,690.50
Env. Technician (jr/mid)	80	$ 45.19	$ 3,615.18
		Subtotal, Labor:	*$ 21,373.62*
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
Analytical (month)	1	$ 22,696.07	$ 22,696.07
Carbon Sampling/Disposal	0.0833	$ 7,874.15	$ 655.92
Sludge disposal	1	$ 257.33	$ 257.33
Dumpster/Waste Removal	8	$ 385.99	$ 3,087.90
		Subtotal, Subcontracts:	*$ 26,697.21*
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
Bag Filters	104	$ 38.57	$ 4,011.38
Vapor Phase Carbon Replace.	0.0833	$ 14,950.00	$ 1,245.34
Electrical Costs (month)	1	$ 36,597.60	$ 36,597.60
Water (month)	1	$ 2,750.80	$ 2,750.80
Sewer (month)	1	$ 418.60	$ 418.60
Gas (month)	1	$ 19,674.20	$ 19,674.20
Sodium Hydroxide (month)	1	$ 6,099.60	$ 6,099.60
Peroxide	1	$ 2,511.60	$ 2,511.60
Misc. lubricants	1	$ 119.60	$ 119.60
Cleaning/Maintenance supplies	1	$ 119.60	$ 119.60
Ice	1	$ 299.00	$ 299.00
PPE, Spill, H&S	1	$ 328.90	$ 328.90
Calibration gasses/fluids	1	$ 71.76	$ 71.76
		Subtotal, Materials/Supplies/Misc Costs:	*$ 74,247.98*
Equipment	***Units***	***Unit Cost***	***Subtotal***
Air Monitoring Equip.	1	$ 299.00	$ 299.00
Misc. Replacement Parts	1	$ 1,435.20	$ 1,435.20
Misc. piping, valves, fittings	1	$ 986.70	$ 986.70
		Subtotal, Equipment:	*$ 2,720.90*
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel	1	$ 2,726.28	$ 2,726.28
Shipping			$ -
Copying	1	$ 155.48	$ 155.48
Other			$ -
		Subtotal, ODCs:	*$ 2,881.76*
		Estimated Task Total:	*$ 127,921.46*

Pemaco Remedial Action - Cost Worksheet #18

Phase 3 - Contruction and O&M

Task 3i - Validation Sampling

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	6	$ 121.12	$ 726.74
Engineer (senior)	24	$ 113.63	$ 2,727.01
Engineer (mid)	24	$ 77.71	$ 1,865.00
Chemist (senior)		$ 104.38	$ -
Chemist (mid)	60	$ 71.83	$ 4,310.04
Hydro / Geo (senior)	32	$ 111.87	$ 3,579.95
Hydro / Geo (mid)	120	$ 72.04	$ 8,644.82
Clerical (admin, data entry, etc.)	24	$ 48.54	$ 1,165.01
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)	120	$ 45.19	$ 5,422.77
		Subtotal, Labor:	*$ 28,441.34*
Subcontracts	*Units*	*Unit Cost*	*Subtotal*
Drilling	1	$ 56,611.50	$ 56,611.50
		Subtotal, Subcontracts:	*$ 56,611.50*
Materials/Supplies/Misc Costs	*Units*	*Unit Cost*	*Subtotal*
Miscellaneous	1	$ 657.80	$ 657.80
		Subtotal, Materials/Supplies/Misc Costs:	*$ 657.80*
Equipment	*Units*	*Unit Cost*	*Subtotal*
		Subtotal, Equipment:	*$ -*
ODCs	*Units*	*Unit Cost*	*Subtotal*
Travel	1	$ 5,070.56	$ 5,070.56
Shipping			$ -
Copying	1	$ 155.48	$ 155.48
Other			$ -
		Subtotal, ODCs:	*$ 5,226.04*
		Estimated Task Total:	*$ 90,936.68*

Pemaco Remedial Action - Cost Worksheet #19

Phase 3 - Contruction and O&M
Task 3j - Project Demobilization

Labor	***Estimated Hours***	***Unit Cost***	***Subtotal***
Home Office Support			
Project Manager	4	$ 121.12	$ 484.49
Engineer (senior)		$ 113.63	$ -
Engineer (mid)		$ 77.71	$ -
Chemist (senior)		$ 104.38	$ -
Chemist (mid)		$ 71.83	$ -
Hydro / Geo (senior)		$ 111.87	$ -
Hydro / Geo (mid)		$ 72.04	$ -
Clerical (admin, data entry, etc.)	12	$ 48.54	$ 582.50
Field Personnel			
Site Supervisor	80	$ 79.53	$ 6,362.48
Cost Tracker	50	$ 54.32	$ 2,715.78
CQC Officer	24	$ 63.84	$ 1,532.27
SSHO	10	$ 63.84	$ 638.45
Env. Technician (senior)		$ 63.84	$ -
Env. Technician (jr/mid)	80	$ 45.19	$ 3,615.18
		Subtotal, Labor:	***$ 15,931.16***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
Analytical	0	$ 23,159.25	$ -
Liquid waste disposal	8	$ 257.33	$ 2,058.60
Dumpster/Waste Removal	7	$ 385.99	$ 2,701.91
Equipment Moving (FTO and Carb	1	$ 32,937.60	$ 32,937.60
Industrial Cleaning	1	$ 10,087.14	$ 10,087.14
Remove Overhead lines to ERH	1	$ 60,214.05	$ 60,214.05
Utility Lockout	0	$ 13,895.55	$ -
		Subtotal, Subcontracts:	***$ 107,999.30***
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
H&S - PPE, respiratory	1	$ 1,076.40	$ 1,076.40
Misc. Cleaning materials	1	$ 657.80	$ 657.80
		Subtotal, Materials/Supplies/Misc Costs:	***$ 1,734.20***
Equipment	***Units***	***Unit Cost***	***Subtotal***
Steam Cleaner	1	$ 299.00	$ 299.00
Forklift	1	$ 1,435.20	$ 1,435.20
Flatbed	5	$ 448.50	$ 2,242.50
		Subtotal, Equipment:	***$ 3,976.70***
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel	1	$ 3,169.10	$ 3,169.10
Shipping			$ -
Copying	1	$ 155.48	$ 155.48
Other			$ -
		Subtotal, ODCs:	***$ 3,324.58***
		Estimated Task Total:	***$ 132,965.94***

Pemaco Remedial Action - Cost Worksheet #20

Phase 4 - Engineering Support during Construction

Task 4a - Engineering Support During Construction

Labor	**Estimated Hours**	**Unit Cost**	**Subtotal**
Home Office Support			
Project Manager	6	$ 121.12	$ 726.74
Engineer (senior)	700	$ 113.63	$ 79,537.88
Engineer (mid)	700	$ 77.71	$ 54,395.97
Chemist (senior)	6	$ 104.38	$ 626.25
Chemist (mid)	60	$ 71.83	$ 4,310.04
Hydro / Geo (senior)	80	$ 111.87	$ 8,949.88
Hydro / Geo (mid)	40	$ 72.04	$ 2,881.61
Clerical (admin, data entry, etc.)	32	$ 48.54	$ 1,553.35
Field Personnel			
Site Supervisor		$ 51.91	$ -
Cost Tracker		$ 35.45	$ -
CQC Officer		$ 41.67	$ -
SSHO		$ 41.67	$ -
Env. Technician (senior)		$ 35.45	$ -
Env. Technician (jr/mid)		$ 29.49	$ -
		Subtotal, Labor:	*$ 152,981.71*
Subcontracts	**Units**	**Unit Cost**	**Subtotal**
		Subtotal, Subcontracts:	*$ -*
Materials/Supplies/Misc Costs	**Units**	**Unit Cost**	**Subtotal**
		Subtotal, Materials/Supplies/Misc Costs:	*$ -*
Equipment	**Units**	**Unit Cost**	**Subtotal**
		Subtotal, Equipment:	*$ -*
ODCs	**Units**	**Unit Cost**	**Subtotal**
Travel	1	$ 21,740.89	$ 21,740.89
Shipping	1	$ 333.68	$ 333.68
Copying	1	$ 1,022.58	$ 1,022.58
Other			$ -
		Subtotal, ODCs:	*$ 23,097.15*
		Estimated Task Total:	*$ 176,078.87*

Pemaco Remedial Action - Cost Worksheet #21

Phase 5 - Integration and Operation of Remedial Systems

Task 5a - Integration and Operation of Remedial Systems

Labor	***Estimated Hours***	***Unit Cost***	***Subtotal***
Home Office Support			
Project Manager		$ 121.12	$ -
Engineer (senior)	240	$ 113.63	$ 27,270.13
Engineer (mid)	400	$ 77.71	$ 31,083.41
Chemist (senior)		$ 104.38	$ -
Chemist (mid)		$ 71.83	$ -
Hydro / Geo (senior)		$ 111.87	$ -
Hydro / Geo (mid)		$ 72.04	$ -
Clerical (admin, data entry, etc.)		$ 48.54	$ -
Field Personnel			
Site Supervisor		$ 111.82	$ -
Cost Tracker		$ 76.37	$ -
CQC Officer		$ 89.77	$ -
SSHO		$ 89.77	$ -
Env. Technician (senior)		$ 76.37	$ -
Env. Technician (jr/mid)		$ 63.54	$ -
		Subtotal, Labor:	***$ 58,353.54***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Subcontracts:	***$ -***
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Materials/Supplies/Misc Costs:	***$ -***
Equipment	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Equipment:	***$ -***
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel			$ -
Shipping	1	$ 667.37	$ 667.37
Copying	1	$ 1,255.80	$ 1,255.80
Other			$ -
		Subtotal, ODCs:	***$ 1,923.17***
		Estimated Task Total:	***$ 60,276.71***

Pemaco Remedial Action - Cost Worksheet #22

Phase 6 - O&M Plan
Task 6a - O&M Plan

Labor	***Estimated Hours***	***Unit Cost***	***Subtotal***
Home Office Support			
Project Manager	6	$ 121.12	$ 726.74
Engineer (senior)	80	$ 113.63	$ 9,090.04
Engineer (mid)	200	$ 77.71	$ 15,541.71
Chemist (senior)	4	$ 104.38	$ 417.50
Chemist (mid)	80	$ 71.83	$ 5,746.72
Hydro / Geo (senior)	80	$ 111.87	$ 8,949.88
Hydro / Geo (mid)	40	$ 72.04	$ 2,881.61
Clerical (admin, data entry, etc.)	32	$ 48.54	$ 1,553.35
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO	8	$ 63.84	$ 510.76
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	***$ 45,418.30***
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Subcontracts:	***$ -***
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Materials/Supplies/Misc Costs:	***$ -***
Equipment	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Equipment:	***$ -***
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel		$ -	$ -
Shipping	1	$ 333.68	$ 333.68
Copying	1	$ 1,285.70	$ 1,285.70
Other			$ -
		Subtotal, ODCs:	***$ 1,619.38***
		Estimated Task Total:	***$ 47,037.69***

Pemaco Remedial Action - Cost Worksheet #23

Phase 7 - ERH Final Tech Memo
Task 7a - ERH Final Tech Memo

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	6	$ 121.12	$ 726.74
Engineer (senior)	80	$ 113.63	$ 9,090.04
Engineer (mid)	80	$ 77.71	$ 6,216.68
Chemist (senior)		$ 104.38	$ -
Chemist (mid)	24	$ 71.83	$ 1,724.02
Hydro / Geo (senior)	40	$ 111.87	$ 4,474.94
Hydro / Geo (mid)	80	$ 72.04	$ 5,763.21
Clerical (admin, data entry, etc.)	24	$ 48.54	$ 1,165.01
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	*$ 29,160.64*
Subcontracts	*Units*	*Unit Cost*	*Subtotal*
		Subtotal, Subcontracts:	*$ -*
Materials/Supplies/Misc Costs	*Units*	*Unit Cost*	*Subtotal*
		Subtotal, Materials/Supplies/Misc Costs:	*$ -*
Equipment	*Units*	*Unit Cost*	*Subtotal*
		Subtotal, Equipment:	*$ -*
ODCs	*Units*	*Unit Cost*	*Subtotal*
Travel		$ -	$ -
Shipping	1	$ 222.46	$ 222.46
Copying	1	$ 246.38	$ 246.38
Other			$ -
		Subtotal, ODCs:	*$ 468.83*
		Estimated Task Total:	*$ 29,629.47*

Pemaco Remedial Action - Cost Worksheet #24

Phase 8 - Enhanced MPE Final Tech Memo

Task 8a - MPE, SVE, and Groundwater System Technical Memorandum

Labor	*Estimated Hours*	*Unit Cost*	*Subtotal*
Home Office Support			
Project Manager	8	$ 121.12	$ 968.99
Engineer (senior)	40	$ 113.63	$ 4,545.02
Engineer (mid)	160	$ 77.71	$ 12,433.36
Chemist (senior)	24	$ 104.38	$ 2,505.02
Chemist (mid)	200	$ 71.83	$ 14,366.80
Hydro / Geo (senior)	40	$ 111.87	$ 4,474.94
Hydro / Geo (mid)	120	$ 72.04	$ 8,644.82
Clerical (admin, data entry, etc.)	60	$ 48.54	$ 2,912.52
Field Personnel			
Site Supervisor		$ 79.53	$ -
Cost Tracker		$ 54.32	$ -
CQC Officer		$ 63.84	$ -
SSHO		$ 63.84	$ -
Env. Technician (senior)		$ 54.32	$ -
Env. Technician (jr/mid)		$ 45.19	$ -
		Subtotal, Labor:	*$ 50,851.47*
Subcontracts	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Subcontracts:	*$ -*
Materials/Supplies/Misc Costs	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Materials/Supplies/Misc Costs:	*$ -*
Equipment	***Units***	***Unit Cost***	***Subtotal***
		Subtotal, Equipment:	*$ -*
ODCs	***Units***	***Unit Cost***	***Subtotal***
Travel		$ -	$ -
Shipping	1	$ 333.68	$ 333.68
Copying	1	$ 867.10	$ 867.10
Other		$ -	$ -
		Subtotal, ODCs:	*$ 1,200.78*
		Estimated Task Total:	*$ 52,052.26*

Technical Assumptions and ODC Breakdown

Phase 1 - Project Management

Tasks 1a, b and c - Project Planning, Resource Scheduling and Overall Scheduling

Technical Assumptions for Tasks 1a, b and c:

1. Meeting attendance is included in Task 1f.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	0	$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00	0	$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	0			$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00	0			$ -
Subtotal Travel							$ -
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60	12					$ 223
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 223
Copying							
8 1/2 x 11	$ 0.13	500					$ 65
D-Size	$ 7.00	20					$ 140
Color 8 1/2 x 11	$ 0.25	50					$ 13
Subtotal Copying							$ 218

Technical Assumptions and ODC Breakdown
Phase 1 - Project Management
Tasks 1d - Procurement

No technical assumptions to add.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	0	$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00	0	$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	0			$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00	0			$ -
Subtotal Travel							$ -
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60	30					$ 558
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 558
Copying							
8 1/2 x 11	$ 0.13	2500					$ 325
D-Size	$ 7.00	50					$ 350
Color 8 1/2 x 11	$ 0.25	150					$ 38
Subtotal Copying							$ 713

Technical Assumptions and ODC Breakdown
Phase 1 - Project Management
Tasks 1d - Procurement

No technical assumptions to add.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	0	$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00	0	$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	0			$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00	0			$ -
Subtotal Travel							$ -
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60	30					$ 558
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 558
Copying							
8 1/2 x 11	$ 0.13	2500					$ 325
D-Size	$ 7.00	50					$ 350
Color 8 1/2 x 11	$ 0.25	150					$ 38
Subtotal Copying							$ 713

Technical Assumptions and ODC Breakdown
Phase 1 - Project Management
Task 1e - Cost Control and Tracking (non-field)

Technical Assumptions for Task 1e:

1. Includes cost tracking on overall project basis, review of subcontractor invoices and tracking/comparison with field data.
2. Daily construction cost tracking included in Tasks 3a-3f.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95		$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00				$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ -
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	500					$ 65
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 65

Technical Assumptions and ODC Breakdown
Phase 1 - Project Management
Task 1g - Community Participation

Technical Assumptions for Task 1g:
1. Assumes 1 "full" community meeting and 5 meetings with communtiy focus groups.
2. Assumes preparation and translation of 1 Fact Sheet.
3. Assumes Fact Sheet postage paid by EPA

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	15	$ 1,154
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	15			$ 2,265
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 3,419
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	2500					$ 325
D-Size	$ 7.00	150					$ 1,050
Color 8 1/2 x 11	$ 0.25	10000					$ 2,500
Subtotal Copying							$ 3,875

Technical Assumptions and ODC Breakdown
Phase 1 - Project Management
Tasks 1f - Project Meetings

Technical Assumptions for Task 1f:

1. Includes 2 trips for 2 people to San Francisco. 6 trips for PM to project site (see table below).
2. Attendence of weekly field meetings during construction by Site Manage and Lead Engineers are bugeted in Phase 3 tasks and in Task 4a.
3. Attendence of Community meetings budgeted in Task 1g.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	6	$ 462
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00	4	$ 1,600
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	6			$ 906
San Francisco, California	$ 126.00	$ 51.00	$ 177.00	4			$ 708
Subtotal Travel							$ 3,676
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00	50					$ 350
Color 8 1/2 x 11	$ 0.25	200					$ 50
Subtotal Copying							$ 530

Technical Assumptions and ODC Breakdown
Phase 2 - Project Plans
Task 2a - Task-Specific Work Plans

Technical Assumptions for Task 2a:

1. TN&A will coordinate Work Plan production with the US EPA and USACE to assure that the content and presentation meet or exceed expectations.
2. Cost for possible Work Plans to address supplementary insitu technologies; e.g., ISCO or EISB, have not been included.
3. Costs are included to develop individual and/or composite Work Plans for separate construction phases, if necessary to meet project schedule.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95		$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00	2	$ 800
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00				$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00	2			$ 354
Subtotal Travel							$ 1,154
Other ODC's	Unit Cost	Estimated Units					
Shipping		10.00					
Fedex (Binder size)	$ 18.60	25.00					$ 465
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 465
Copying							
8 1/2 x 11	$ 0.13	5000					$ 650
D-Size	$ 7.00	200					$ 1,400
Color 8 1/2 x 11	$ 0.25	200					$ 50
Subtotal Copying							$ 2,100

Technical Assumptions and ODC Breakdown
Phase 2 - Project Plans
Task 2b - Site Safey and Health Plan

Technical Assumptions for Task 2b:

1. TN&A will coordinate Site Safety and Health Plan production with the US EPA and USACE to assure that content and presentation meets or exceeds expectations.
2. Assumes one Site Safety and Health Plan for the entire project and separate AHA chapters/addenda for various project phases/tasks.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95		$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00				$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ -
Other ODC's	Unit Cost	Estimated Units					
Shipping		10.00					
Fedex (Binder size)	$ 18.60	12.00					$ 223
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 223
Copying							
8 1/2 x 11	$ 0.13	4000					$ 520
D-Size	$ 7.00	20					$ 140
Color 8 1/2 x 11	$ 0.25	60					$ 15
Subtotal Copying							$ 675

Technical Assumptions and ODC Breakdown
Phase 2 - Project Plans
Task 2c - Sampling and Analysis Plan

Technical Assumptions for Task 2c:

1. TN&A will coordinate SAP production with the US EPA and USACE to assure that content and presentation meets or exceeds expectations.
2. Assume SAP preparation treatment system processs monitoring, remediation progress monitoring, and verification sampling.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95		$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00	2	$ 800
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00				$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00	2			$ 354
Subtotal Travel							$ 1,154
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60	10.00					$ 186
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 186
Copying							
8 1/2 x 11	$ 0.13	5000					$ 650
D-Size	$ 7.00	200					$ 1,400
Color 8 1/2 x 11	$ 0.25	200					$ 50
Subtotal Copying							$ 2,100

Technical Assumptions and ODC Breakdown
Phase 2 - Project Plans
Task 2d - Construction Quality Control Plan

Technical Assumptions for Task 2d:

1. TN&A will coordinate CQC Plan production with the US EPA and USACE to assure that the content and presentation meet or exceed expectations.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95		$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00				$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ -
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60	10					$ 186
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 186
Copying							
8 1/2 x 11	$ 0.13	1500					$ 195
D-Size	$ 7.00	40					$ 280
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 475

Technical Assumptions and ODC Breakdown
Phase 3 - Construction and O&M
Task 3a - Project Mobilization

Technical Assumptions for Task 3a:

1. Subcontractor mobilization costs are estimated at ~$27,000 and are not shown under this Task. Costs for subcontractor mobilizations are shown under respective construction tasks (Tasks 3b-3g).
2. Mobilization charges shown include mobilize construction facilities, manage utility connections and locating/marking, facilitate equipment and material deliveries, facilitate subcontractor mobilizations and coordinate transitions with park construction activities.
3. Note: While the RFP listed this initial Task as Mobilization/Demobilization, Demobilization was also listed as a separate Task. In this cost estimate, demobilization costs are included in Task 3J, Project Demobilization.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	30	$ 2,309
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	20			$ 3,020
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 5,329
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 130

Technical Assumptions and ODC Breakdown
Phase 3 - Construction and O&M
Task 3b - Well and Piping Installation - Phase 1

Technical Assumptions for Task 3b:

1 It is assumed that the proposed Walker Avenue and 59th Place pipe and trench network will cross over existing water, gas and sewer pipelines. The "As Built" depth of these networks cannot be confirmed from available drawings, therefore it is anticipated that some design/build decisions will be made in the field regarding final pipeline depth.
2 It is assumed that traffic control and safety equipment, including: cover plates, cones, temporary fencing, construction signs and barriers are included in the lump-sum total for "Trench and Pipe."
3 It is assumed that 345 c.y. of trench spoils requires disposal as "non-hazardous waste" at a Class I disposal facility.
4 Estimate includes analytical sampling from 12 wells in and surrounding the ERH area, averaging 12 samples per well using an Encore sampler.
5 The health and safety oversight and quality control oversight will be performed by the same person.
6 The estimate includes all wells, vaults, and wellhead assemblies for "Park Area."
7 The park area includes all wells within the park boundary plus all wells on 59th Place and Walker Ave.
8 Since the park grading activity and former use has compacted the site, a minimal amount of compaction testing will be required for trench floors.
9 A "one-sack sand slurry" will be used to backfill pipes to 6 inches above the pipe, the remainder of the trench will be backfilled with trench spoils.
10 Trench plates will be used in all Streets.
11 The costs of removal or relocation of any utilities is not included.
12 Excavations less than 5 ft in depth and in which a competent person examines and determines there to be no potential for cave-in do not require protective systems. Trench shoring will be used, as needed, in accordance with ACE and OSHA requirements.
13 Asphalt will be replaced to the same specification as it was found.
14 Asphalt will be replaced to the same specification as exists currently.
15 Well Installation and Trenching/Piping Sucontractor costs based on initial quotes from several candidate subcontractors.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	80	$ 6,156
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	250			$ 37,750
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 43,906
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00	20					$ 3,900
Subtotal Shipping							$ 3,900
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 130

Technical Assumptions and ODC Breakdown
Phase 3 - Construction and O&M
Task 3c - Well and Piping Installation - Phase 2

Technical Assumptions for task 3c:

1. The drilling estimate includes all wells planned for 60th St. (shown on RD Drawing C-2). The total number of wells is 8 for Phase 2.
2. It is assumed that the proposed 60th St. pipe and trench network will cross over numerous existing water, gas, and sewer pipelines. The "As Built" depth of these networks cannot be confirmed from available drawings, therefore it is anticipated that some design/build decisions will be made in the field regarding final pipeline depth.
3. It is assumed that traffic control and safety equipment, including: cover plates, cones, temporary fencing, construction signs and barriers are included in the lump-sum total for "Trench and Pipe."
4. It is assumed that 64 c.y. of soil will be recycled as waste soil.
5. The health and safety oversight and quality control oversight will be performed by the same person.
6. The estimate includes all wells, vaults, and wellhead assemblies for "Park Area."
7. The park area includes all wells within the park boundary plus all wells on 59th Place and Walker Ave.
8. Since the park grading activity and former use has compacted the site, a minimal amount of compaction testing will be required for trench floors.
9. A "one-sack sand slurry" will be used to backfill pipes to 6 inches above the pipe, the remainder of the trench will be backfilled with trench spoils.
10. Trench plates will be used in all streets.
11. The costs of removal or relocation of any utilities is not included.
12. Excavations less than 5 ft in depth and in which a competent person examines and determines there to be no potential for cave-in do not require protective systems. Trench shoring will be used, as needed, in accordance with ACE and OSHA requirements.
13. Asphalt will be replaced to the same specification as exists currently.
14. Well Installation and Trenching/Piping Sucontractor costs based on initial quotes from several candidate subcontractors.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	30	$ 2,309
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	110			$ 16,610
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 18,919
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 130

Technical Assumptions and ODC Breakdown
Phase 3 - Construction and O&M
Task 3d - Treatment Building and Compound Construction

Technical Assumptions for Task 3d:

1. Subcontract costs shown are based on initial quotes from candidate subcontractors. Gates and alarm system from R.S. Means.
2. The external electrical connections include approx. $75,000 for high voltage cables to connect S.C. Edison lines to the ERH compound. Additional installation costs are from all electrical connector & conveyance equipment (6 poles to ERH area, 2 poles to main compound) necessary to bring power to both the main treatment compound and the ERH area.
3. The pre-engineered steel building design will be compatible with the concrete sections shown in drawing C-10. Structure will not require any additional permits.
4. Concrete Pad includes items shown in Drawings C-9 and C-10 plus (1) 20-foot wide asphalt access road from 60th Steet to the compound.
5. The transformer T1 is for the main compound only. The transformer will be provided by SCE and the cost may vary based on availability.
6. All interior electical components and recepticles are included.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	20	$ 1,539
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	80			$ 12,080
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 13,619
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 130

Technical Assumptions and ODC Breakdown
Phase 3 - Construction and O&M
Task 3e - Treatment System Construction

Technical Assumptions for Task 3e:

1. Task 3e includes installation of all interior manifolds and conveyance piping for water and vapor treatment systems. All treatment equipment shown in the General P&ID drawing M-1 are included.
2. Specialized technician (shown under Subcontracts) may be multiple subcontractors required for integration of systems, control refinement, etc.
3. System appurtunances such as flowmeters and gauges will be installed as per design.
4. Includes purchase of specified FTO and UV/Oxidation treatment units based initial vendor quotes.
5. Post-FTO vapor conditioning and carbon treatment system included.
6. Does not include carbon treatment system for water treatment.
7. The MPE system line item (under Equipment) includes: high vac pumps (P-101 and P-102); moisture seperator (V-101); control systems; inlet filters (F-101, F-102); transfer pump (P-201); exhaust filters (F-103, F-104); gauges and meters (influent and effluent); etc.
8. Includes all downhole well pumps, assemblies and controls. Unit cost of $4,358.22 is weighted average of heat-tolerant pumps required for ERH area and regular pumps for wells outside ERH area; based on initial vendor quote.
9. Treatment system installation does not include supplementary insitu technologies; e.g., ISCO or EISB.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	30	$ 2,309
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	120			$ 18,120
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 20,429
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 130

Technical Assumptions and ODC Breakdown
Phase 3 - Construction and O&M
Task 3f - MPE, SVE and Groundwater System Shakedown (including Source Testing)

Technical Assumptions for Task 3f:

1. Volatile Organic for air matrix list includes 1,4-Dioxane.
2. Estimated cost for sampling train/equipment for dioxin and furan analysis by method EPA 23 is $13,500.
3. Estimated cost for sampling/train equipment for dioxin and furan analysis by method TO-9 is $5,050.
4. Only a very limited "baseline sampling" from new wells is included (30 total water analyses for shakedown period - includes influent and effluent testing). Other baseline lab data could be provided by CLP at no direct cost to project.
5. Estimate for Source Testing (must be independent 3rd party) based on discussions with EPA. Assumes dioxin testing is required.
6. Assumes limited ambient air sampling program (see quantities below).

Analyte Group	Matrix	Analytical Method	Number of Analyses	Unit Price	Estimated Total
Volatile Organics	air (exhaust)	TO-15	120	$ 295.000	$ 35,400.00
Total Hydrocarbons	air (exhaust)	TO-3M	120	$ 85.000	$ 10,200.00
Fixed Gases	air (exhaust)	ASTM D-1946	20	$ 85.000	$ 1,700.00
Dioxins and Furans	air (exhaust)	EPA 23	20	$ 1,210.000	$ 24,200.00
Particulates (PM10)	air (exhaust)	ASTM D-1946	20	$ 85.000	$ 1,700.00
Volatile Organics	air (ambient)	TO-15SIM	30	$ 480.000	$ 14,400.00
Dioxins and Furans	air (ambient)	EPA 23	9	$ 1,000.000	$ 9,000.00
Volatile Organics	water	SW8260B	30	$ 100.000	$ 3,000.00
Chemical Oxygen Demand	water	EPA410.4	10	$ 20.000	$ 200.00
Tot. Dissolved Solids	water	EPA160.1	10	$ 15.000	$ 150.00
Tot.Suspended Solids	water	EPA160.2	10	$ 15.000	$ 150.00
CAM 17 Metals	water	SW6010/7000	10	$ 140.000	$ 1,400.00
Semivolatile Organics	water	SW8260C	10	$ 250.000	$ 2,500.00
Nonhalogenated Volatile Organics	water	SW8015M	10	$ 90.000	$ 900.00
Sulfide	water	EPA376.2	10	$ 25.000	$ 250.00
Cyanide	water	EPA335.2	10	$ 40.000	$ 400.00
Pesticides and Polychlorinated Biphenyl	water	SW8081/8082	10	$ 120.000	$ 1,200.00
Tot. Recoverable Hydrocarbons	water	EPA418.1	10	$ 50.000	$ 500.00
Thiosulfate	water	CSLAC 260A	10	$ 52.000	$ 520.00
Ammonia	water	EPA350.2	10	$ 35.000	$ 350.00
Mercaptans	water	CSLAC 258	10	$ 70.000	$ 700.00
Fluoride	water	EPA340.2	10	$ 25.000	$ 250.00
Surfactants	water	EPA425.1	10	$ 50.000	$ 500.00
				Task 3F, Total Analytical:	**$ 109,570.00**

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	32	$ 2,462
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	110			$ 16,610
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 19,072
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 130

Technical Assumptions and ODC Breakdown
Phase 3 - Construction and O&M
Task 3g - ERH Construction

Technical Assumptions for Task 3g:

1. Per RFP, a $2M Subcontractor cost is assumed.
2. ERH contractor will include all costs associated with the ERH program with the exception of SVE well installation and operation.
3. All ERH construction, operation, maintenance, sampling, utility/energy and mobilization/demobilization costs are included in this task.
4. Assumes installation of 8 additional VE wells in the ERH area to 90 ft bg.
5. Assumes soil sampling of additional 8 wells, 12 samples per well. Lab analysis by CLP (analytical cost not included).

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	12	$ 923
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	35			$ 5,285
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 6,208
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	500					$ 65
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 65

Technical Assumptions and ODC Breakdown
Phase 3 - Construction and O&M
Task 3h - Monthly O&M

Technical Assumptions for Task 3h:

1 Estimated cost for sampling equipment for dioxin and furan analysis by method EPA 23 is $13,500.
2 Estimated cost for sampling equipment for dioxin and furan analysis by method TO-9 is $5,050.
3 No continous monitoring is included.
4 Costs for ERH O&M not included - they are included in the $2M lump sum under ERH construction (Task 3g)
5 Assumed that UV/Ox system will be primary water treatment unit for first year of operation. No carbon costs included.
6 Note: Most of the electrical costs estimated for O&M ($30,600/mo) are associated with operation of the UV/Ox system.
7 Gas costs for FTO were provided by vendor and are contingent on contaminant loading.
8 Labor level of effort was weighted over a 1 year period (more intensive the first 4 months). Includes all sampling and general maintenance/repair.

Analyte Group	Matrix	Analytical Method	Number of Analyses	Unit Price	Estimated Total
Volatile Organics	air (exhaust)	TO-15	340	$ 295.000	$ 100,300.00
Total Hydrocarbons	air (exhaust)	TO-3M	12	$ 85.000	$ 1,020.00
Fixed Gases	air (exhaust)	ASTM D-1946	12	$ 85.000	$ 1,020.00
Dioxins and Furans	air (exhaust)	EPA 23	104	$ 1,210.000	$ 125,840.00
Particulates (PM10)	air (exhaust)	ASTM D-1946	12	$ 85.000	$ 1,020.00
Volatile Organics	air (ambient)	TO-15SIM	20	$ 600.000	$ 12,000.00
Volatile Organics	water	SW8260B	208	$ 100.000	$ 20,800.00
Chemical Oxygen Demand	water	EPA410.4	52	$ 20.000	$ 1,040.00
Tot. Dissolved Solids	water	EPA160.1	52	$ 15.000	$ 780.00
Tot.Suspended Solids	water	EPA160.2	52	$ 15.000	$ 780.00
				Task 3H, Total Analytical (for 12 months):	**$ 264,600.00**

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	10	$ 770
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	10			$ 1,510
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 2,280
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 130

Technical Assumptions and ODC Breakdown
Phase 3 - Construction and O&M
Task 3i - Validation Sampling

Technical Assumptions for Task 3i:

1. Validation sampling program for ERH area only.
2. Assumes 2 rounds of CPT MIP sampling in the ERH area
3. Does not include analytical costs (other than MIP). Assumed soil vapor sampling will be covered as part of O&M program. Assumed that any "fixed lab" analyses for *in situ* soil, groundwater or vapor sampling will be by CLP lab.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	8	$ 616
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	24			$ 3,624
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 4,240
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 130

Technical Assumptions and ODC Breakdown
Phase 3 - Construction and O&M
Task 3j - Project Demobilization

Technical Assumptions for Task 3j:

1. General construction demobilization included.
2. Main tasks include complete utility demob. of ERH area (main components of system included in ERH subcontractor bid; however, utility abandonment will still be required). This will require removal of 6 electrical poles and high voltage electrical lines, connections, and meters.
3. No well abandonment or analytical testing included.
4. Includes removal of FTO and conversion of MPE vapor treatment system to carbon. Includes transport of FTO to EPA designated CA storage location.
5. No park restoration included. No restoration of hardscape or landscape.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	5	$ 385
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	15			$ 2,265
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 2,650
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60						$ -
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ -
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25						$ -
Subtotal Copying							$ 130

Technical Assumptions and ODC Breakdown
Phase 4 - Engineering Support During Construction
Task 4a - Engineering Support During Construction

Technical Assumptions for Task 4a:
1. Task 4a includes all engineering support hours for the following construction tasks: Task 3b (Well Piping and Installation - Phase I), Task 3c (Well Piping and Installation - Phase 2), Task 3d (Treatment Building and Compound Construction), and Task 3e (Treatment System Construction).
2. Assume all engineering support hours are necessary for the elimination of down time and to facilitate field implementation of the design intent.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95	40	$ 3,078
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00	100			$ 15,100
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ 18,178
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60	15					$ 279
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 279
Copying							
8 1/2 x 11	$ 0.13	1000					$ 130
D-Size	$ 7.00	100					$ 700
Color 8 1/2 x 11	$ 0.25	100					$ 25
Subtotal Copying							$ 855

Technical Assumptions and ODC Breakdown
Phase 5 -Integration and Operation of Remedial Systems
Task 5a - Integration and Operation of Remedial Systems

Technical Assumptions for Task 5a:

1. Task 5a includes all engineering support hours for integration and optimization of the treatment systems. The are no hours for this task placed under Task 4a (Engineering Support During Construction).
2. Assumes the three major treatment networks; namely vapor extraction, conveyance, and treatment system, the groundwater extraction, conveyance, and treatment system, and the ERH heating system are integrated and balanced through system interlocks, fail-safe control, and process logic controls to operate efficiently, effectively, and safely.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95		$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00				$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ -
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60	30					$ 558
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 558
Copying							
8 1/2 x 11	$ 0.13	2500					$ 325
D-Size	$ 7.00	100					$ 700
Color 8 1/2 x 11	$ 0.25	100					$ 25
Subtotal Copying							$ 1,050

Technical Assumptions and ODC Breakdown
Phase 6 - O&M Plan
Task 6a - O&M Plan

Technical Assumptions for Task 6a:

1. Assume O&M Plan will provide manufacturer recommended maintenance schedules for all major pieces of equipment.
2. Estimate does not include andy O&M plans for ERH.
3. O&M plan will not contain decomissioning procedures.
4. O&M Plan will address all requirements outlined in the RFP and applicable USEPA and USACE guidance documents.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95		$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00				$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ -
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60	15					$ 279
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 279
Copying							
8 1/2 x 11	$ 0.13	2500					$ 325
D-Size	$ 7.00	100					$ 700
Color 8 1/2 x 11	$ 0.25	200					$ 50
Subtotal Copying							$ 1,075

Technical Assumptions and ODC Breakdown
Phase 7 - ERH Technical Memorandum
Task 7a - ERH Technical Memoradum

Technical Assumptions for Task 7a:

1. Assumes an ERH Technical Memo will be provided by the ERH contractor. TN&A will augment with sudsidiary data and provide an evaluation (discussion section) and project conclusions.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95		$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00				$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ -
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60	10					$ 186
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 186
Copying							
8 1/2 x 11	$ 0.13	1200					$ 156
D-Size	$ 7.00						$ -
Color 8 1/2 x 11	$ 0.25	200					$ 50
Subtotal Copying							$ 206

Technical Assumptions and ODC Breakdown
Phase 8 - MPE, SVE and Groundwater System Technical Memorandum
Task 8a - MPE, SVE and Groundwater System Technical Memorandum

Technical Assumptions for Task 8a:

1. TN&A will prepare the MPE, SVE and Groundwater System Technical Memorandum per the requirements stated in the RFP, and to meet US EPA and USACE requirements.

Travel	Total Round Trip Miles	Air Travel	Misc. Travel (Taxi)	Mileage Rate	Unit Cost Per Trip	Estimated No. Trips	Subtotal
Destination (Origin: Ventura, California)							
Maywood, California	190	$ -	$ -	$ 0.405	$ 76.95		$ -
San Francisco, California	NA	$ 350.00	$ 50.00	$ -	$ 400.00		$ -
FY 2005 Domestic Per Diem Rates	Max Lodging Rate	M&IE Rate	Unit Cost Per Day	Estimated No. of Days			
Per Diem Rates by Destination							
Maywood, California	$ 100.00	$ 51.00	$ 151.00				$ -
San Francisco, California	$ 126.00	$ 51.00	$ 177.00				$ -
Subtotal Travel							$ -
Other ODC's	Unit Cost	Estimated Units					
Shipping							
Fedex (Binder size)	$ 18.60	15					$ 279
Fedex (Cooler size - e.g. samples)	$ 195.00						$ -
Subtotal Shipping							$ 279
Copying							
8 1/2 x 11	$ 0.13	2500					$ 325
D-Size	$ 7.00	50					$ 350
Color 8 1/2 x 11	$ 0.25	200					$ 50
Subtotal Copying							$ 725