AIRVAC®

The World Leader in Vacuum Sewer Technology

VACUUM SEWER DESIGN SEMINAR

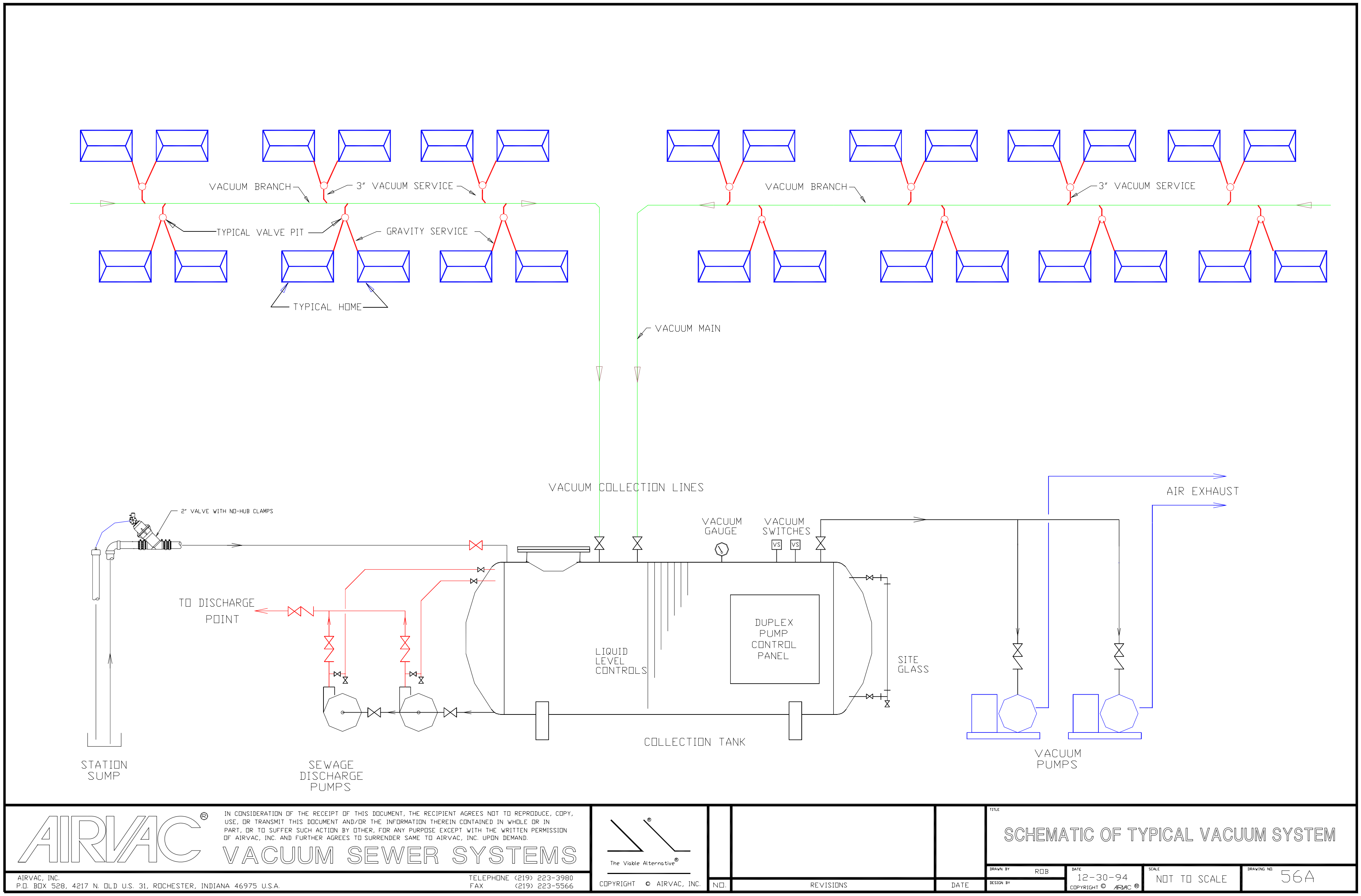
Design Seminar

- Review of Design Fundamentals
  - System schematic
- General Project Guidelines
  - Explanation of flow path
  - Explanation of “Q-Mean”
  - Sample profile
  - Summary of fundamentals

Design Seminar

- Sample Problem
  - Plan and Profile Design
  - Design Software
  - Station Calculations
- Standard Details
- Factory Collection Stations
- Questions and Answers

Schematic of Typical Vacuum System



General Guidelines for Vacuum System Design

Determine the geographical limits of the service area

- The vacuum system is a mechanical system
  - Component sizing based on total system flow
  - This is a most critical step in the analysis

Analyze topography of site to select ideal site for central vacuum station

- Locate point that utilizes as much natural ground slope as possible
  - Start with the lowest elevation in the complex
  - Optimum point is the lowest point nearest the geographical center of the site
- Review available property (other municipal works or public properties)
  - Use lowest centrally located property as guide
- Review final sewage outfall
  - Minimize forcemain length if possible

Route sewer lines along public right-of-way

- Take advantage of as much natural ground slope as possible
- Analyze approximate lift for each flow path
  - Compare ground elevation difference between the end of line and the vacuum station

    *Note the highest elevation this flow path must ascend

Route sewer lines along public right-of-way

- Using 13 Ft. as maximum static loss, the following are approximate grade elevation differences for various pipe sizes using normal lifts:

4”   = 15 Ft. (Based on 1.0‘ Lifts)

6”   = 17 Ft. (Based on 1.5’ Lifts)

8”   = 19 Ft. (Based on 1.5’ Lifts)

Additional grade elevation differences can be overcome using slightly deeper trenches and/or lower lift heights.

Determine input flow for each vacuum main or branch

- Account for the total number of:
  - Homes
  - Schools
  - Apartments
  - Commercial Businesses
  - Etc.

See Chapter 2 of 2005 Design Manual for recommended flows

- Place interface valve pits at property corners
  - Indicate gravity connections to various lots
  - To minimize gravity sewer depth
    - Use two (2) homes per valve pit as a general guideline and a maximum of four (4) homes per valve pit
- Place single, dual or other buffer tanks at appropriate high flow locations
  - Additional buffer tank limitations in Chapter 6 of 2005 Design Manual
- Analyze each vacuum line for future growth potential
  - Add this flow to existing flow
- Ideally, total peak flow for each main line entering the vacuum station should be as close to equal as possible

Determine peak design flow to vacuum collection station and calculate major station components

- Use criteria found in Chapters 2 and 3 of 2005 Design Manual

After final line routing and vacuum station site selection, line routing should be field surveyed for exact length and ground contours

- Prepare plan and profile sheets on a split or combined plan
  - Profile page using aerial photography or other techniques to locate homes, streets, right-of-ways, existing utilities, etc.
  - A scale of 1” = 50’ horizontal and 1” = 5’ vertical is typical
- Select the vacuum collection tank connection point as main line station 0+00
  - Continue outward toward main line extremities

- Where branch lines connect to main lines or each other, their connection point becomes 0+00 for that line
- Preferred direction of profile design in in the flow direction
  - It is recommended that profile design start at the end of each main line
- Starting elevation should include
  - Frost cover (as dictated by local conditions)
  - Plus the diameter of a 3” cross-over
  - Plus the invert to invert dimension of a 3” cross-over to mainline wye fitting as shown on Figure F4-8

    (normally 1’-0” minimum).

- Lifts are placed as required
  - To minimize trench depth
  - To ascend uphill grades
  - Generally speaking if ground is flat, a 1.0 foot lift at 500’ centers or a 1.5 foot lift at 750’ centers will result in an elevation equal to elevation at starting point

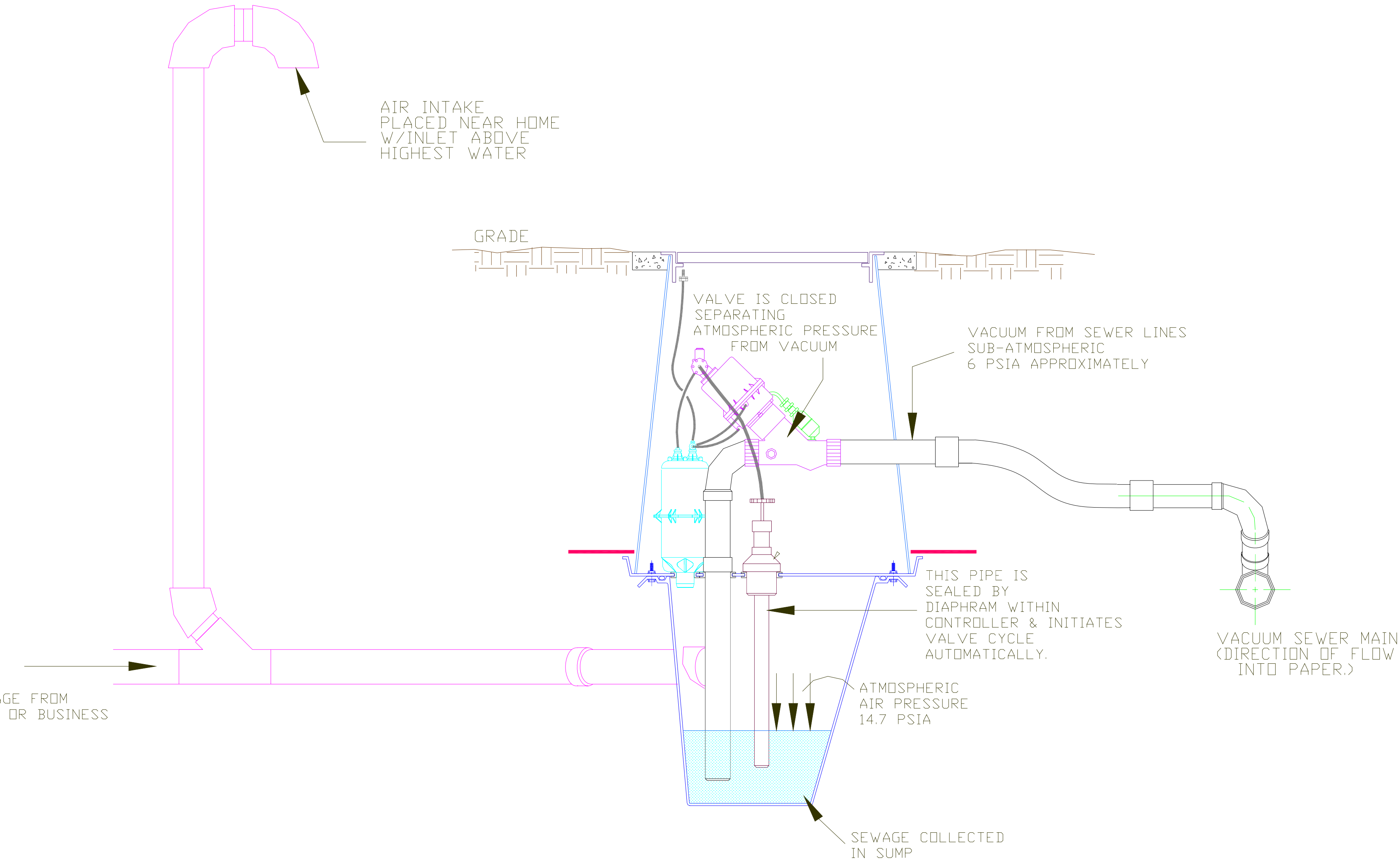
    (500 Ft. x 0.2% = 1.0 Ft. or 750 Ft. x 0.2% = 1.5 Ft.)
  - All lifts will result in a designed vacuum loss equal to the lift height minus the pipe diameter
  - The sum of all vacuum losses from the end of a “flow path” to the vacuum collection station should not exceed 13.0 Ft. without consulting AIRVAC

- Vacuum process begins at the vacuum valve and collection sump assembly
  - When the volume of sewage in sump reaches approximately 10 gallons
    - The AIRVAC valve opens
    - Differential pressure between the vacuum sewer and the atmosphere forces the 10 gallons of sewage into the vacuum main
      - While accelerating, sewage is rapidly transformed into foam
      - Soon occupies only part of the sewer pipe cross section;
        - momentum transfer from air to water takes place largely through the action of shear stresses
      - The magnitude of the propulsive forces start to decline noticeably when the AIRVAC valve closes
      - It remains important as the admitted air continues to expand
      - Eventually friction and gravity bring the sewage to rest below several lifts

- As the process continues
  - Liquid will be transported downstream by in-rushing air
  - Sewage admitted to a sewer through an AIRVAC valve initially moves in two directions.
    - 80% flows toward the collection station
    - 20% flows in the opposite direction
  - When the backsurge slows, flow moves toward the collection station (schematics follow)

- Sewage scouring velocities of 15 to 18 feet per second are attained using the standard air/liquid ratio

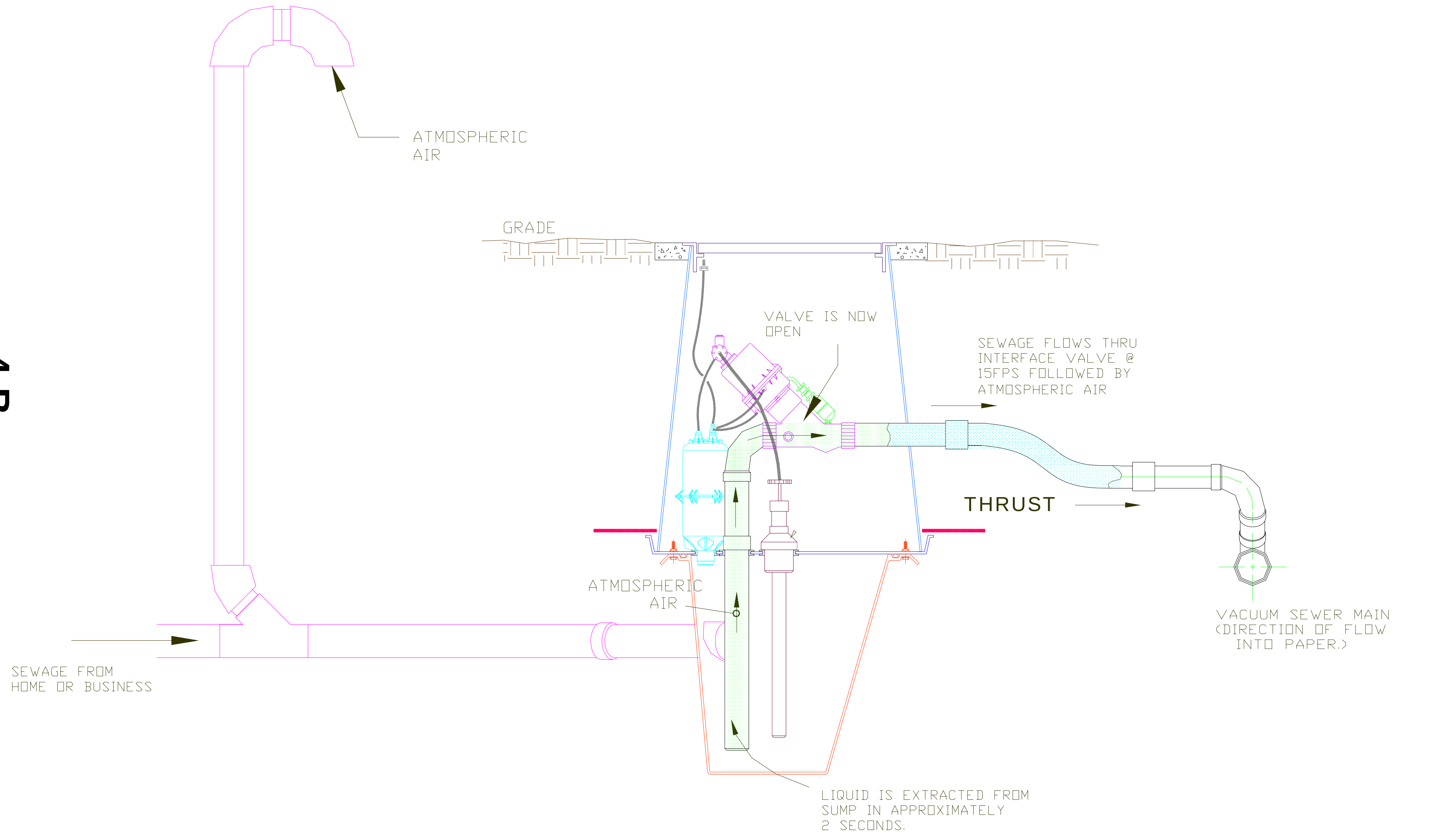
Interface Valve in Standby Position



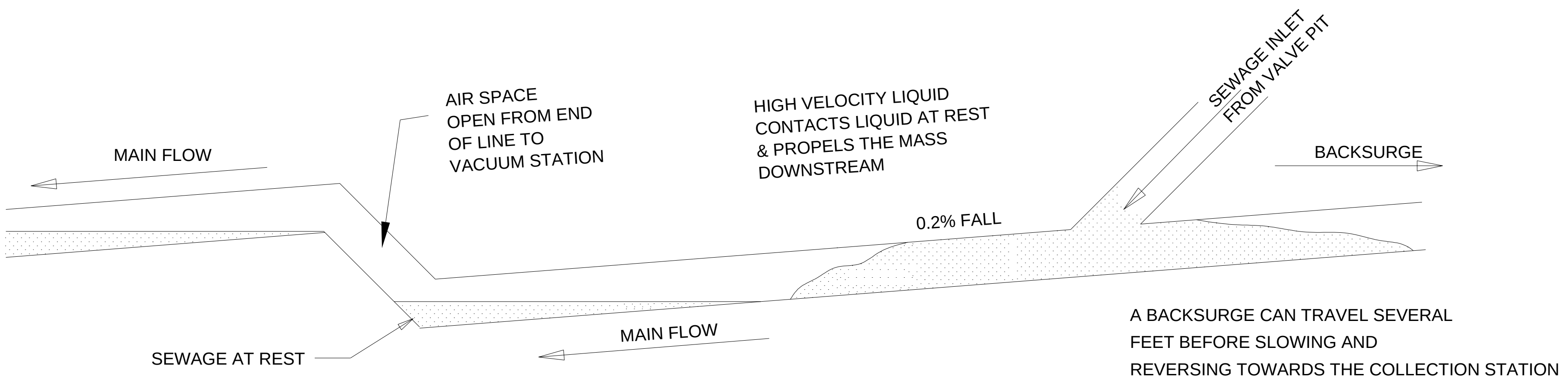
4-A

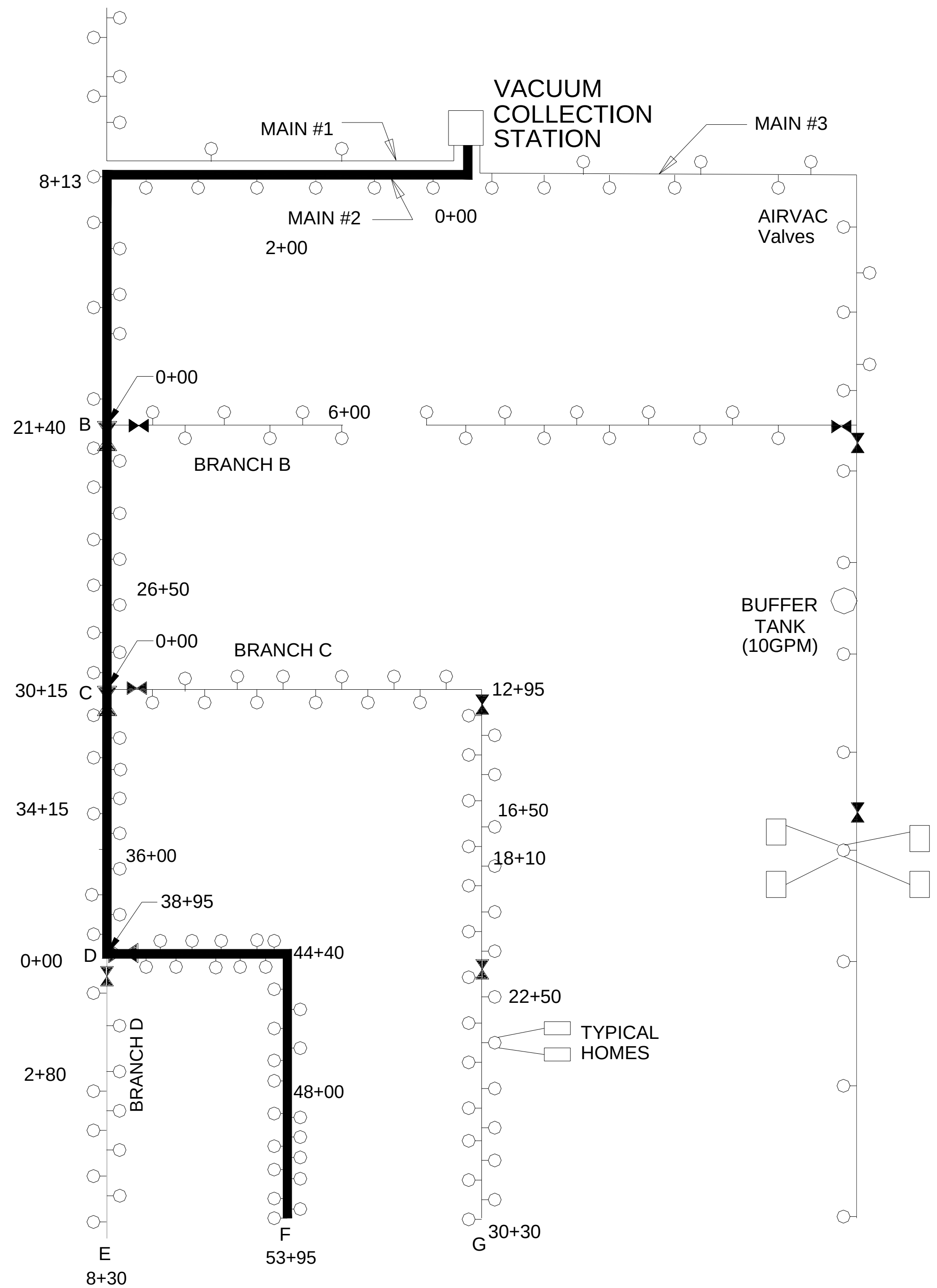
Interface Valve in Open Position

4-B



Vacuum Line Thrust





Example of Flow Path

Explanation of Q (MEAN)

To determine the friction loss for this section of vacuum main:

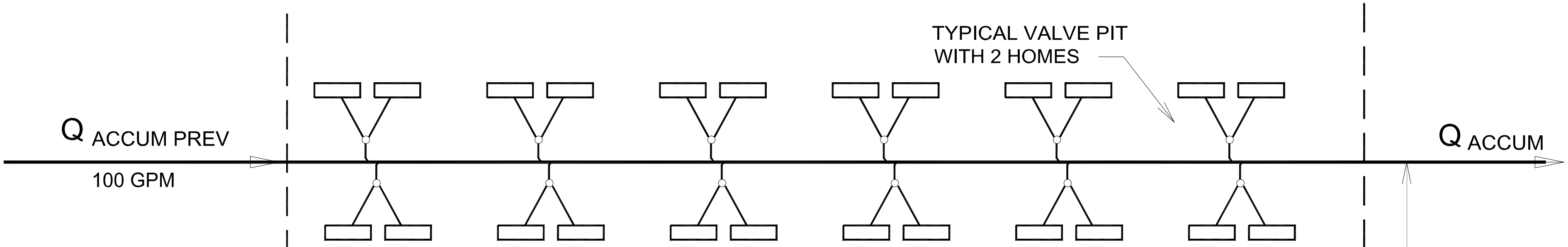
Determine the value of Q (Mean):

This is the sum of all homes along this section X $\frac{0.64 \text{ gpm}}{2}$

Plus the Total flow from all previous sections.

Using friction loss tables, find head loss per hundred feet

Multiply by the length of pipe in this section (hundreds)



$$Q\ (\text{MEAN}) = Q_{\text{ACCUM PREV}} + Q_{\text{AVERAGE FOR SECTION}}$$

$$= 100\ \text{GPM} + \frac{24\ \text{HOMES} \times 0.64\ \text{GPM}}{2}$$

$$= 100\ \text{GPM} + 7.68\ \text{GPM} = 107.68\ \text{GPM}$$

LENGTH OF PIPE FOR THIS SECTION

Branch Flow 20 GPM

Nominal Distance of 1 ft.

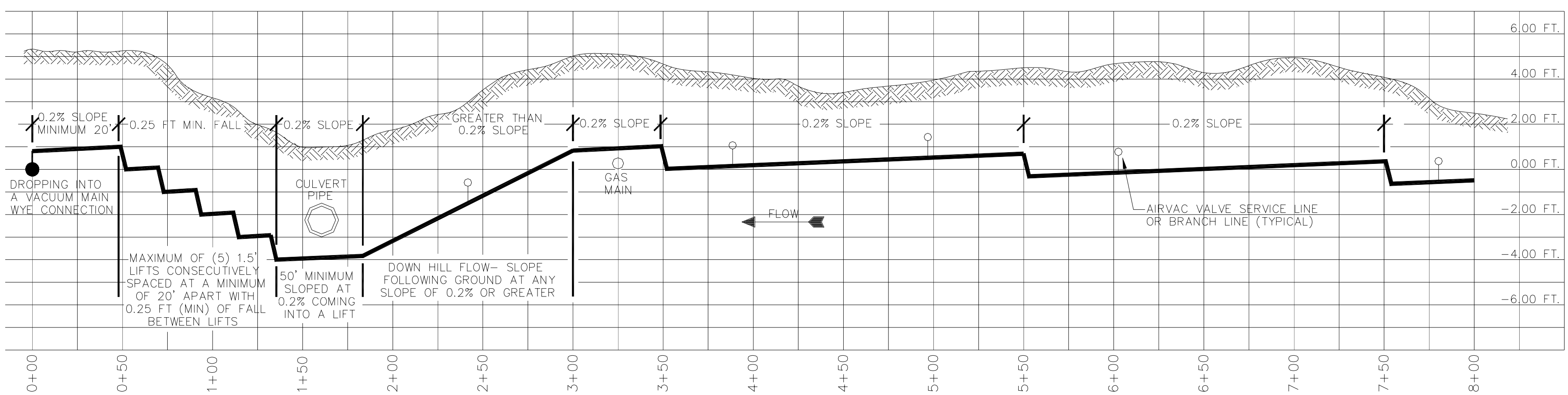
$$Q_{\text{ACCUM}} = Q_{\text{ACCUM PREV}} + Q_{\text{ACCUM THIS SECTION}} + Q_{\text{BRANCH FLOW}}$$

$$= 100\ \text{GPM} + (24 \times 0.64\ \text{GPM}) + 20\ \text{GPM} = 135.36\ \text{GPM}$$

Vacuum Main Profile Design Example

PROFILE DESIGNED FOR 4" OR LARGER VACUUM MAINS

P:\DC\STD_DET\COMMON\44B.DWG



LEVEL AND UPGRADE TRANSPORT

MINIMUM FALL BETWEEN LIFTS:

PIPE DIA.	MIN. FALL	0.2% OF DISTANCE
3"	0.20'	0.2% 100' ▲
4"	0.25'	0.2% 125' ▲
6"	0.25'	0.2% 125' ▲
8"	0.25'	0.2% 125' ▲
10"	0.25'	0.2% 125' ▲

USE WHICHEVER SLOPE IS GREATER BETWEEN ANY 2 LIFTS.
▲ –ABOVE THIS LENGTTH IN DISTANCE, THE 0.2% SLOPE IS GREATER. ANYTHING SHORTER THAN THIS DISTANCE SHOULD USE MIN. FALL INDICATED. WHEN NOT BETWEEN TWO LIFTS, USE 0.2% SLOPE.

3" SERVICE LATERAL PROFILE DESIGN

3" VALVE SERVICE LINE– MAXIMUM LENGTH 300', 1 VALVE PIT FLOW LIMIT.
USE SCHEDULE 40 OR SDR 21 PVC PIPE.

4" OR LARGER MAIN PROFILE DESIGN

4" VACUUM MAIN– MAXIMUM LENGTH 2000'; 38 GPM MAXIMUM FLOW.
6" VACUUM MAIN– NO MAXIMUM LENGTH; 106 GPM MAXIMUM FLOW.
8" VACUUM MAIN– NO MAXIMUM LENGTH; 210 GPM MAXIMUM FLOW.
10" VACUUM MAIN– NO MAXIMUM LENGTH; 375 GPM MAXIMUM FLOW.
–4" AND ABOVE, USE SDR 21 PVC PIPE.

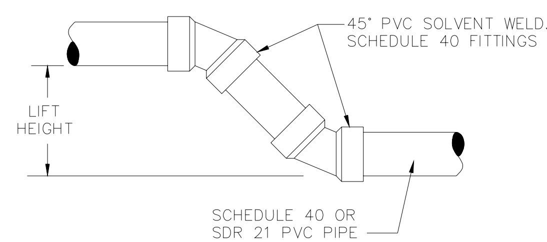
LEVEL AND UPGRADE TRANSPORT

PROFILE CHANGES

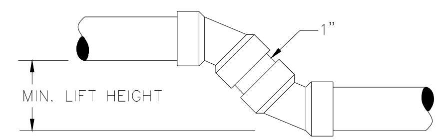
USE 1' LIFTS WHENEVER POSSIBLE. FOR 6" OR LARGER VACUUM LINES, USE 1.5' LIFTS IN ANY SERIES OF LIFTS, OTHERWISE 1' LIFTS ARE RECOMMENDED. CONSULT AIRVAC REGARDING LIFTS ABOVE 3'.

PROFILE CHANGE CONSTRUCTION

STATIC LIFT FOR CALCULATING LINE LOSSES= LIFT HEIGHT MINUS PIPE DIAMETER, FOR ALL PIPE SIZES.



MINIMUM LIFT HEIGHT	
3" PIPE	.42 FT
4" PIPE	.45 FT
6" PIPE	.71 FT
8" PIPE	.86 FT
10" PIPE	1.07 FT



AIRVAC® VACUUM SEWER SYSTEMS

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The Viable Alternative®

NO.	REVISIONS	DATE
2	REVISED MINIMUM FALL	2/08/00
1	REVISED PROFILE CHANGE TABLE	7/10/98

TITLE: VACUUM MAIN PROFILE DESIGN EXAMPLES

AIRVAC - STANDARD

DRAWN BY	DATE	SCALE	DRAWING NO.
	1/04/99	3/16" = 1'-0"	44B

DESIGN BY

Summary of Vacuum Piping Design Fundamentals

- SLOPES
  - Use natural ground slope if greater than 0.2%
  - Use 0.2% slope for flat terrain
  - Use saw tooth profile for uphill transport
  - Use 0.2% slope at 50’ minimum prior to first lift in any series

Summary of Vacuum Piping Design Fundamentals

- FALL BETWEEN LIFTS
  - Use larger of two values
  - 0.2% x Length
  - 0.20 Ft. fall for 3” service laterals if lifts are closer than 100 Ft. apart
  - 0.25 Ft. minimum fall for ALL vacuum mains and branches 4” and larger if lifts are closer than 125 Ft. apart

Summary of Vacuum Piping Design Fundamentals

- LIFTS
  - Use 1’-0” for 3” or 4” pipe
  - Use 1’-6” for 6” or larger pipe
  - Static loss = Lift height – Pipe diameter
  - Maximum vacuum loss due to lifts from any AIRVAC valve to the collection station = (13 Ft. Static Loss + 5 Ft. Friction Loss)
  - Maximum series of lifts = 5 at 20 Ft. centers
  - First lift on a branch minimum 20 Ft. from connection to main

Summary of Vacuum Piping Design Fundamentals

- CONNECTIONS
  - Use wye connectors for all branch and lateral connectors
    - Wye may be vertical or at 45° angle
  - Use long sweep 90° ell for 3” service connectors ONLY
  - Use 45° ells for 4” and larger connectors and any directional change
  - Recommended minimum Invert to Invert elevation difference for connections:

4 x 3 = .73 Ft.	6 x 3 = .80 Ft.	8 x 3 = .99 Ft.	10 x 3 = 1.08 Ft.
4 x 4 = .71 Ft.	6 x 4 = .78 Ft.	8 x 4 = 1.05 Ft.	10 x 4 = 1.18 Ft.

Summary of Vacuum Piping Design Fundamentals

- FLOW LIMITS
  - Maximum Friction Loss not to exceed 5 feet

  3” = 4 homes or equivalent

  4” = 38 GPM

  6” = 106 GPM

  8” = 210 GPM

  10”= 375 GPM

Summary of Vacuum Piping Design Fundamentals

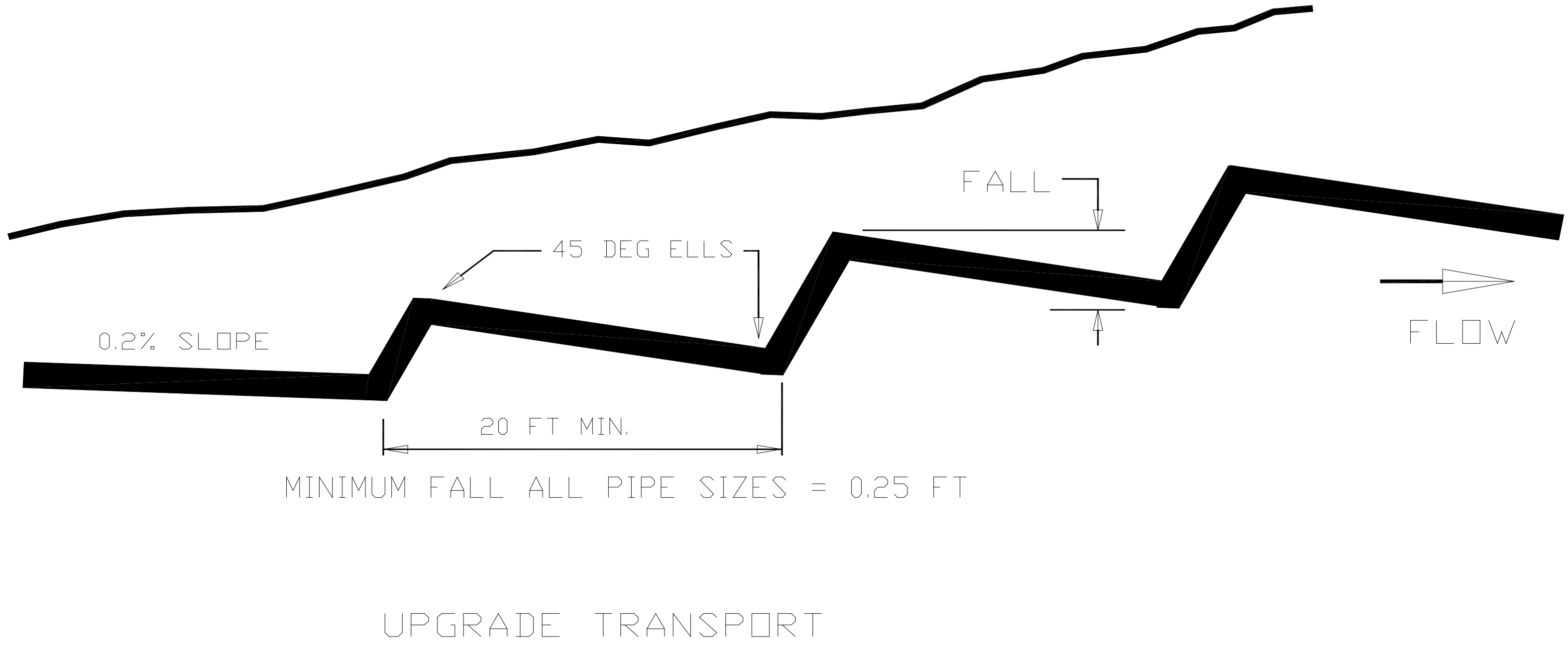
- MAXIMUM LINE LENGTHS

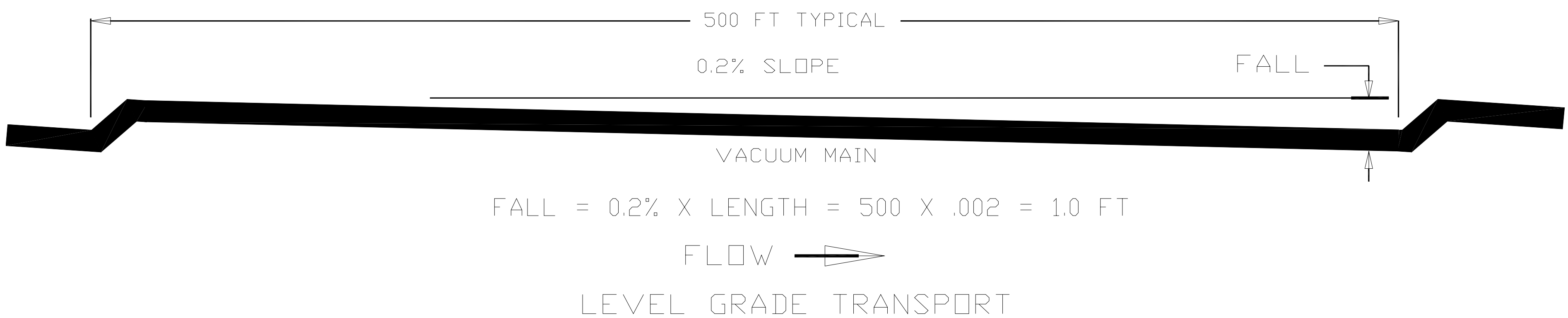
  3” = 300 Ft.

  4” = 2,000 Ft.

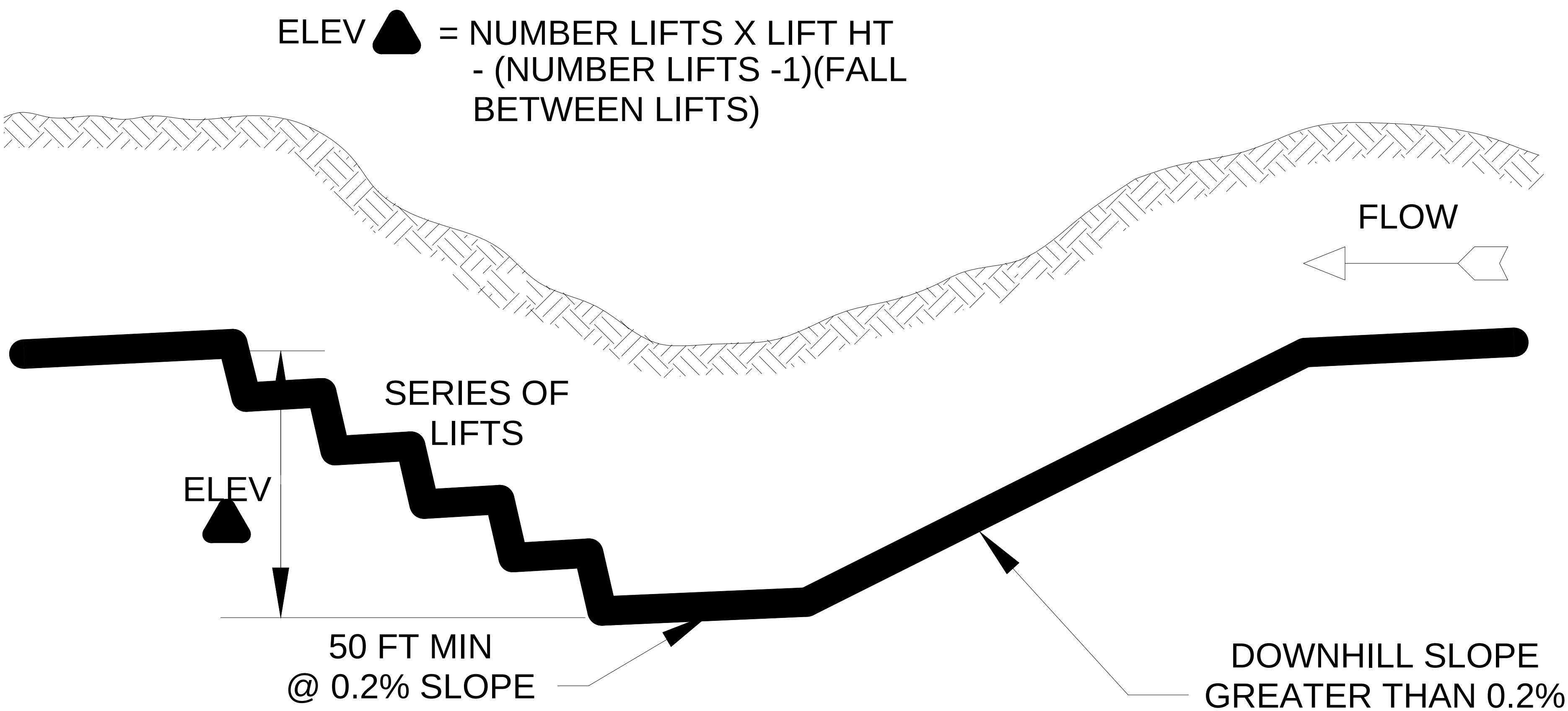
  6” & Larger determined by static limits or friction

Minimum Slopes



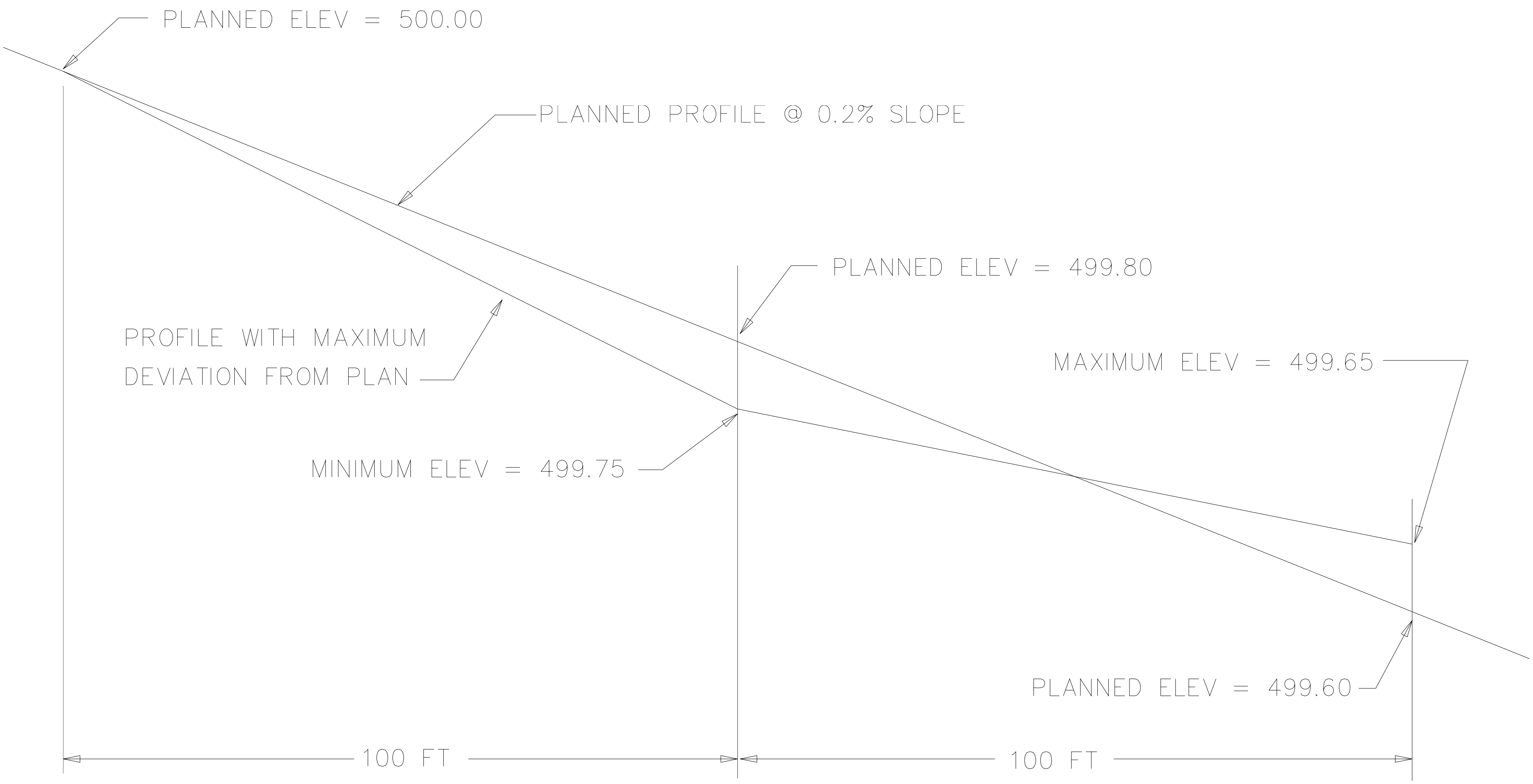


50’ @ 0.2% Rule

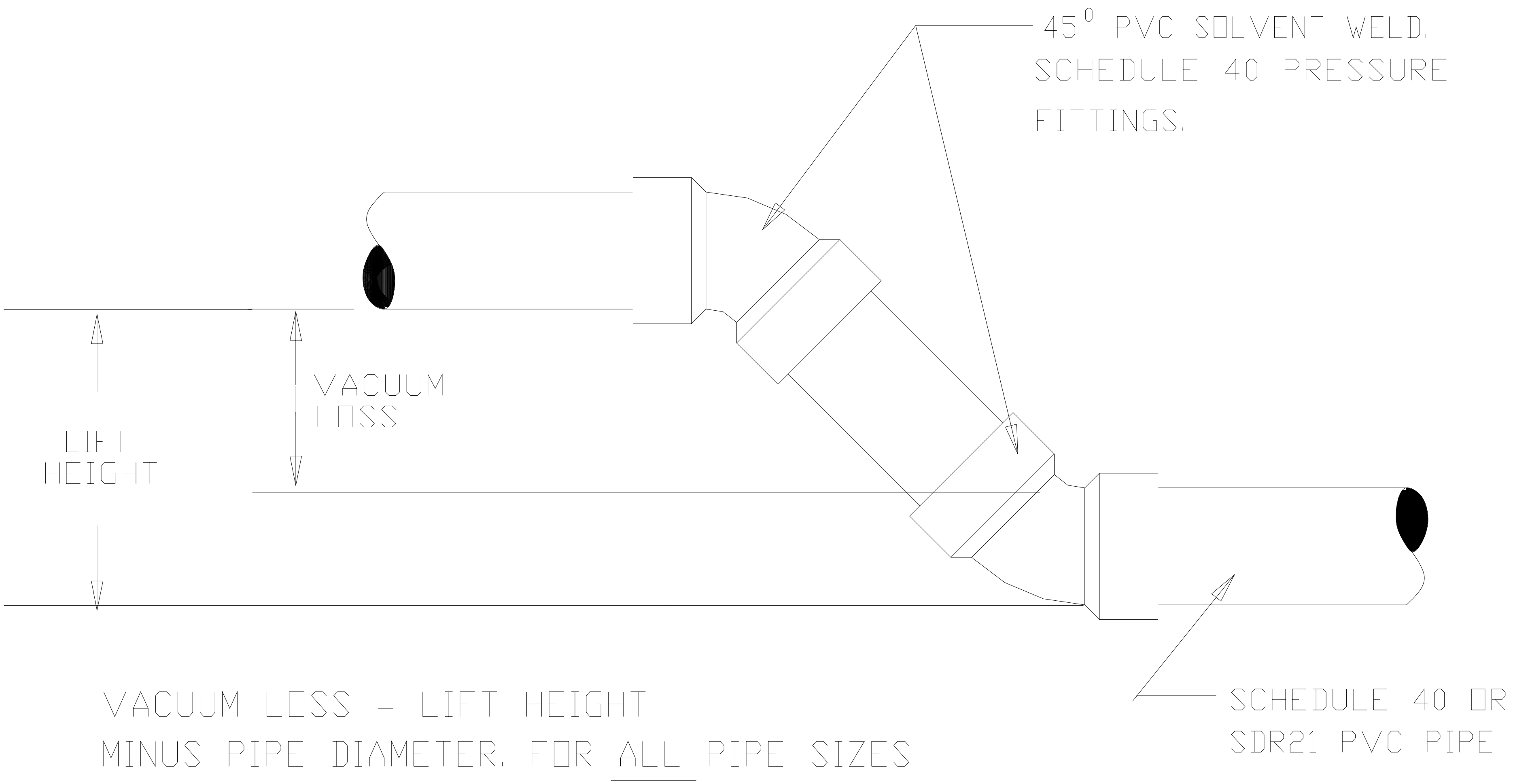

ELEV = NUMBER LIFTS X LIFT HT
- (NUMBER LIFTS -1)(FALL
BETWEEN LIFTS)
FLOW
SERIES OF
LIFTS
ELEV
50 FT MIN
@ 0.2% SLOPE
DOWNHILL SLOPE
GREATER THAN 0.2%

Slope to Tolerance

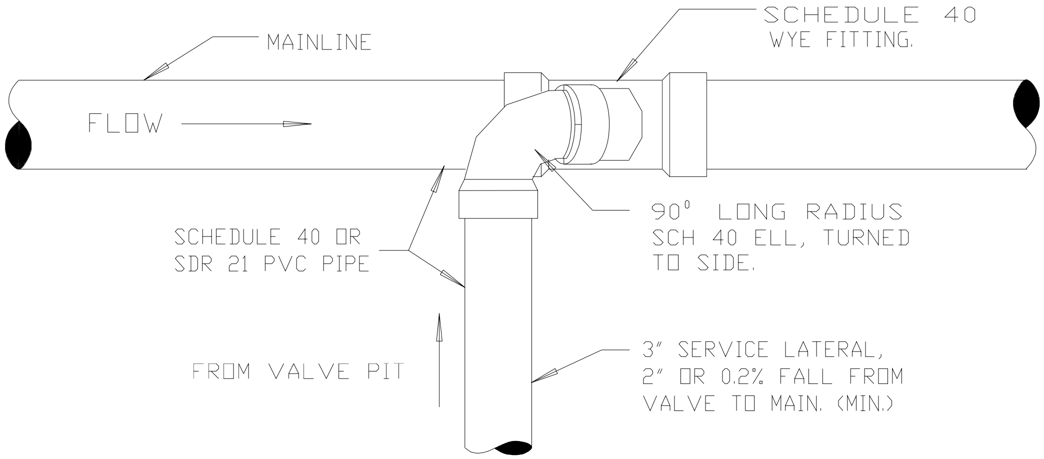
SAMPLE PROFILE SHOWING TOLERANCE FROM PLANNED ELEVATION @ 0.05 FT PER 100 FT



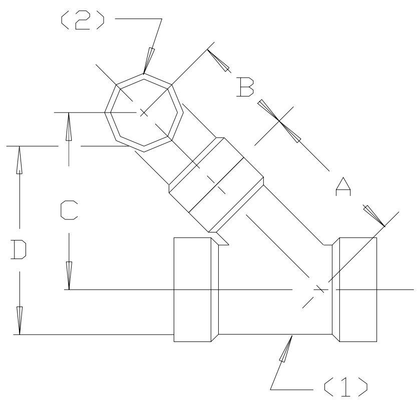
Static Loss Diagram



Service Connections



VALVE PIT TO MAIN CONNECTIONS

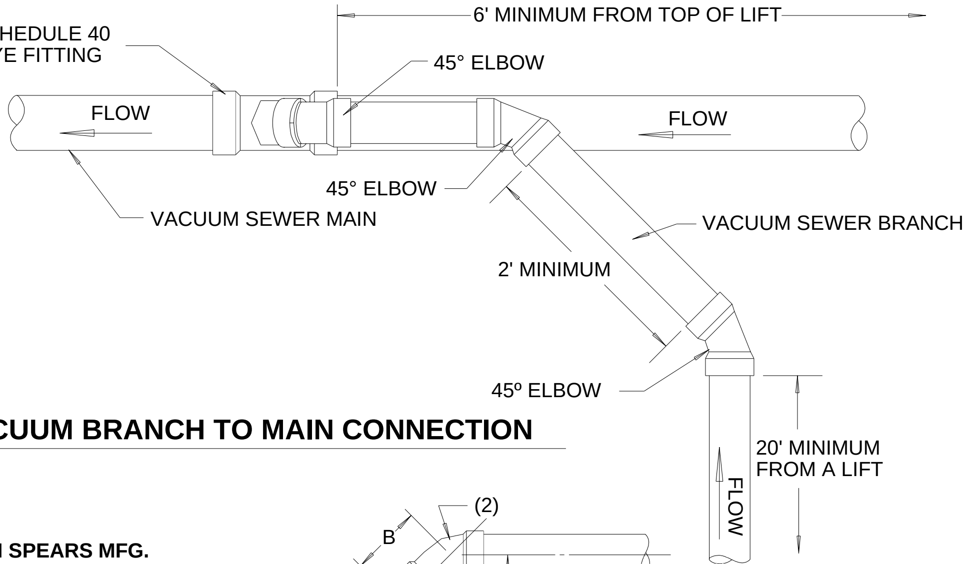


BASED ON SPEARS MFG PVC
SCH 40 PRESSURE FITTINGS

(1) SCH 40 WYE SOLVENT WELD
(2) SCH 40 X 90° ELL SOLVENT WELD.

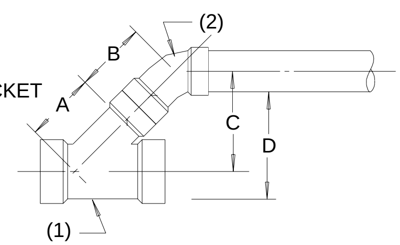
WYE SIZE	A	B	C	D- INVERT
4 x 4 x 3	9 1/4″	3 25/32″	9.32″	0.78′
6 x 6 x 3	10 1/2″	3 25/32″	10.21″	O.85′
8 x 8 x 3	13″	3 25/32″	11.86″	1.00′
10 x 10 x 3	14 3/8″	3 25/32″	12.84″	1.10′

Branch Connections



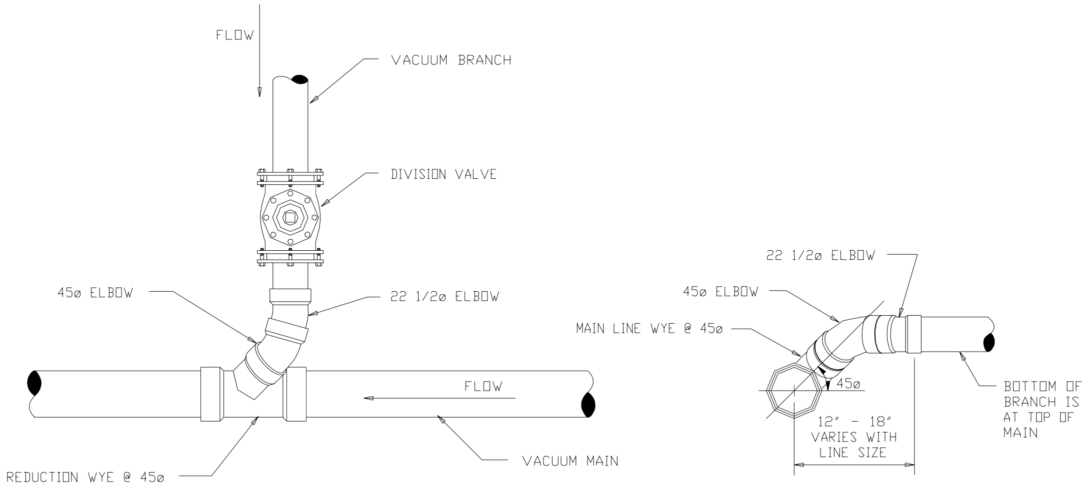
VACUUM BRANCH TO MAIN CONNECTION

BASED ON SPEARS MFG.
(1) 45° WYE, SOCKET x SOCKET x SOCKET
(2) 45° ELL, SOCKET x SOCKET

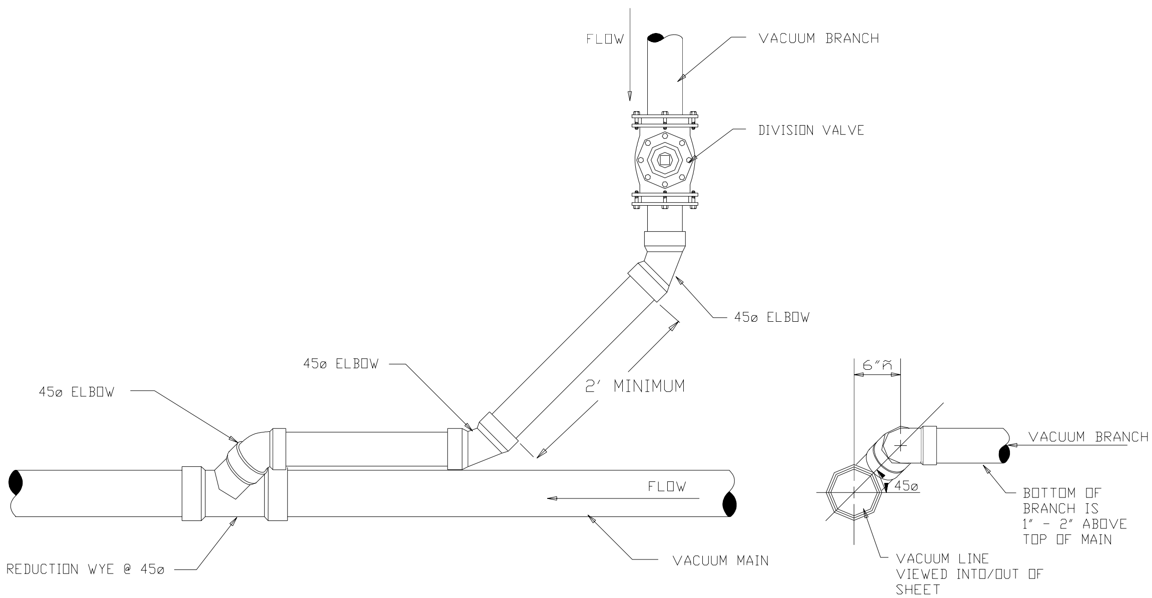


WYE SIZE	A	B	C	D - INVERT
4 x 4 x 4	8 3/4"	3 5/16"	8.53"	0.71'
4 x 4 x 3	9 1/4"	3 1/16"	8.70"	0.73'
6 x 6 x 6	12 1/8"	5 9/16"	12.5"	1.04'
6 x 6 x 4	10"	3 5/16"	9.41"	0.78'
6 x 6 x 3	10 1/2"	3 1/16"	9.59"	0.80'
8 x 8 x 8	18 3/4"	6 13/16"	18.07"	1.52'
8 x 8 x 6	16 1/4"	6 3/8"	15.42"	1.30'
8 x 8 x 4	14 1/4"	3 5/16"	12.42"	1.05'
8 x 8 x 3	13"	3 1/16"	11.36"	0.99'
10 x 10 x 10	22 3/8"	8 19/32"	21.90"	1.89'
10 x 10 x 8	20 1/4"	6 13/16"	19.13"	1.61'
10 x 10 x 6	17 3/4"	5 9/16"	16.48"	1.42'
10 x 10 x 4	15 3/4"	3 5/16"	13.48"	1.18'
10 x 10 x 3	14 3/4"	3 1/16"	12.33"	1.08'

Alternate Connections



ALTERNATE VACUUM BRANCH TO MAIN LINE CONNECTION



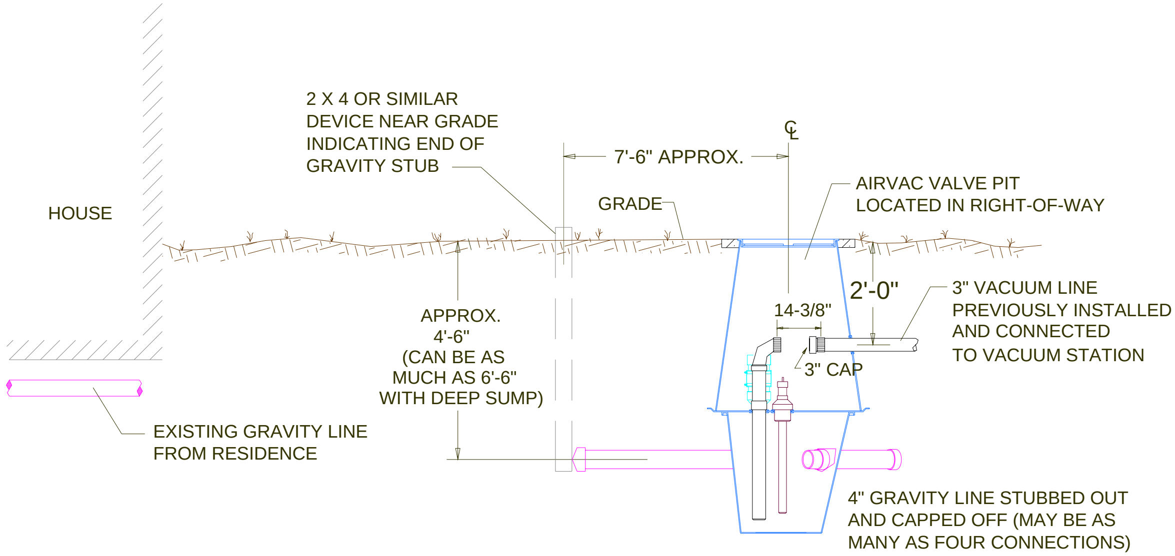


FIGURE 3-2 VALVE PIT PRIOR TO HOME CONNNECTION

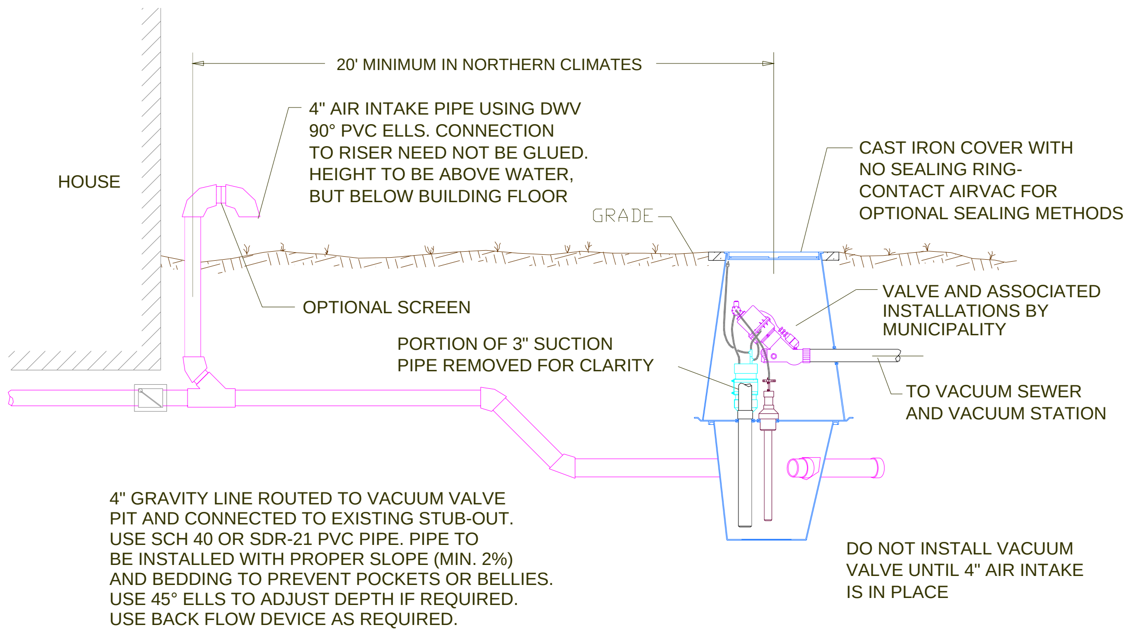
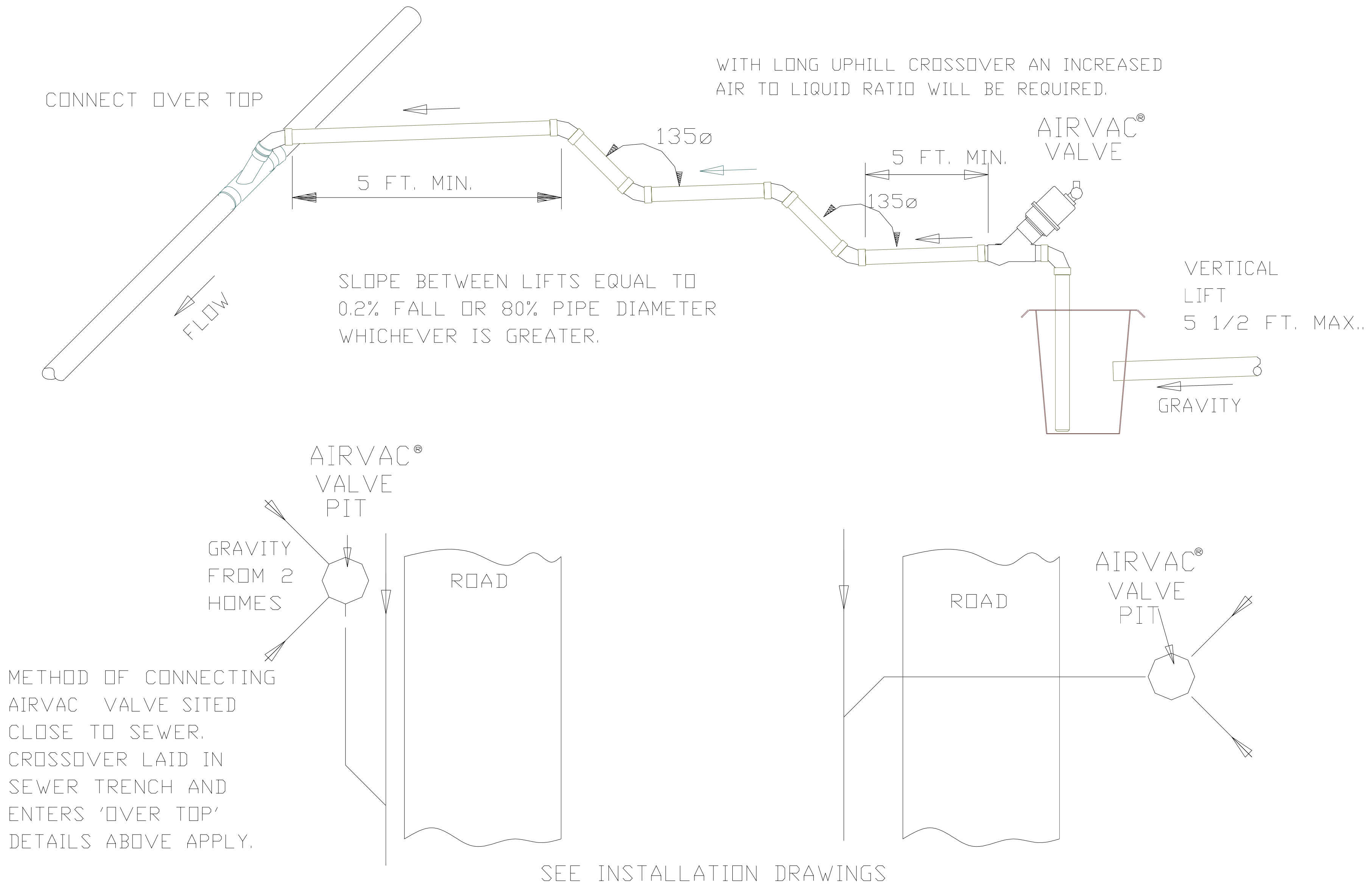


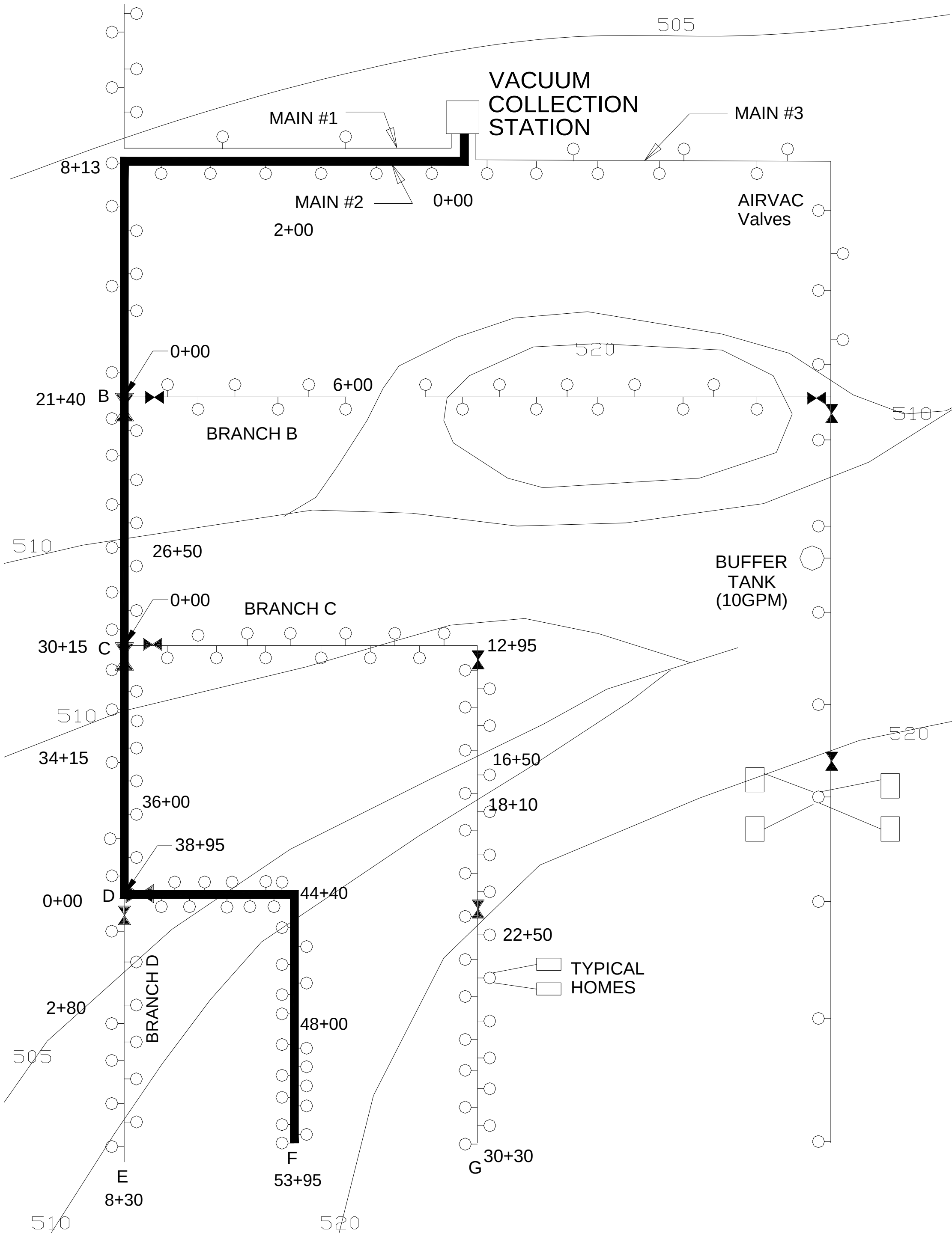
FIGURE 3-3 VALVE PIT WITH HOME CONNNECTED

Gravity Connections

3” Service Line Lifts



Design Example Layout



Design Example

- Consider vacuum sewer layout
  - Locations of collection station, sewers and AIRVAC valves selected in accordance with requirements of AIRVAC 2005 Design Manual
    - Locate sewers to
      - Minimize lift
      - Minimize length
      - Equalize flows on each sewer (where possible)
  - Locate AIRVAC valves to serve two or more homes per valve
    - See Chapter 5

Design Example

- Assumptions
  - Each AIRVAC valve to serve two (2) homes
  - Peak flow per home .64 GPM or 1.28 GPM / AIRVAC valve installation
- To efficiently serve the areas in the design example layout
  - Three (3) main sewers required
  - Each main connected directly to vacuum tank at collection station
  - Sewers are not joined together into bus main outside the station

Design Example

- Division valves located to isolate areas of sewer network for troubleshooting purposes
- Profiles prepared for Main #2
  - Profiles for Branches, Main #1 and Main #3 would be similar

Design Example

- Location of AIRVAC valves and branch sewer connection points follow principles in Chapters 4 and 5
- Buffer tank valve installation on Branch C
  - Represents high flow user (ex: laundromat or school)
  - Ten (10) GPM used as inflow rate for this location
- Main #3 represents sewer main laid in alley way
  - Allows up to four (4) homes to be connected to each AIRVAC valve installation

Design Example Layout

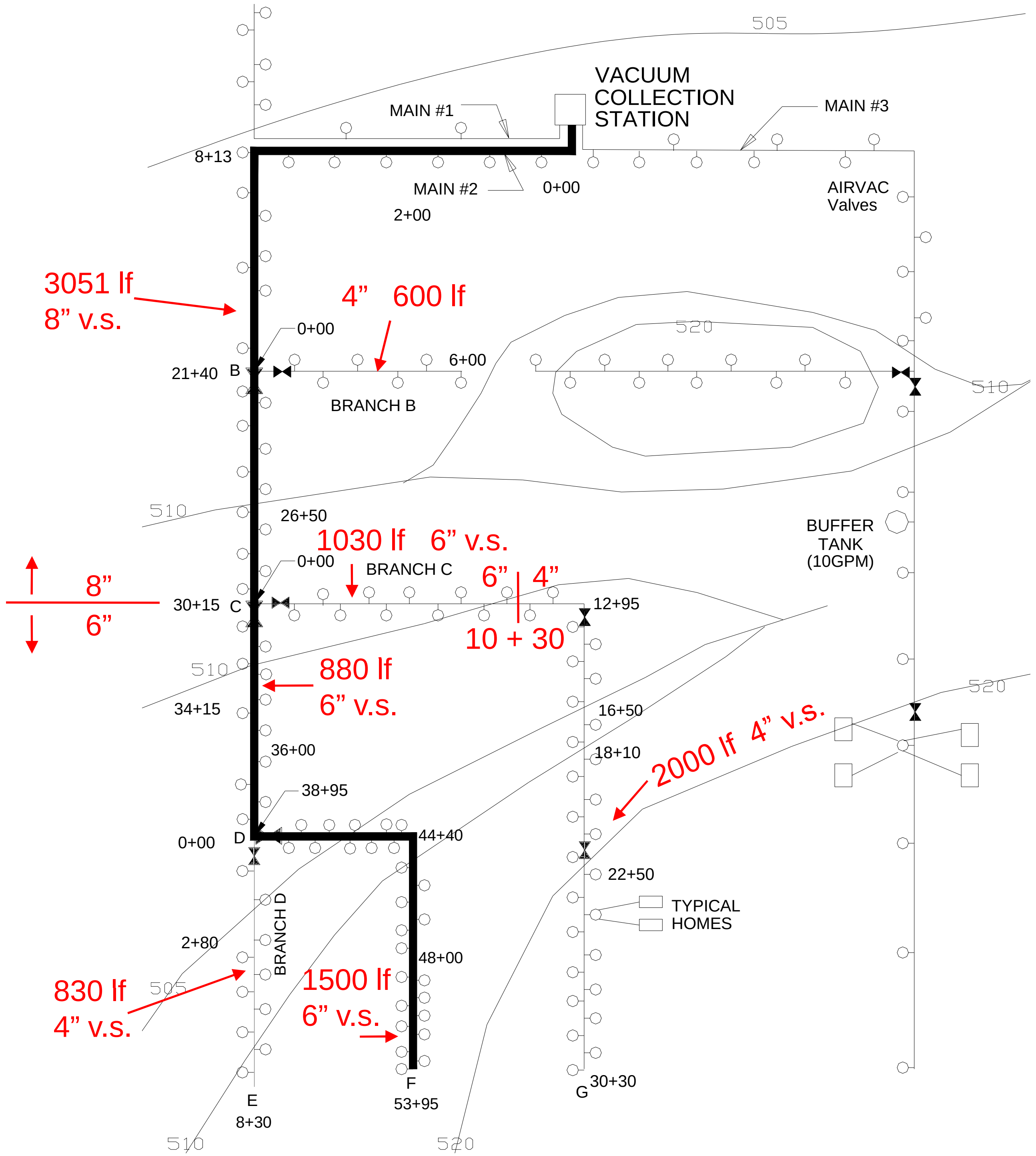


Figure F4-17 – Piping Calculation Sheet

PROJECT: Design Example   STATION NUMBER: 1

DATE: 6/25/03   Peak Flow Rate per Home = .64 gpm

LINE	4” PIPE	6” PIPE	8” PIPE	10” PIPE	PEAK	# SVCE LATERALS	# AIRVAC VALVES	HOMES (or EDUS)
1	2400	1400			79.4	62	62	124
2								
3	3700	2200			49.9	10	32	78
TOTALS								

Average Service Lateral Length	
Total 3” Pipe	

VOLUME OF PIPEWORK (BASED ON SDR-21 PVC PIPE)

Vp = (.0547 x Length 3”) + (.0904 x Length 4”) + (.1959 x Length 6”) + (.3321 x Length 8”) = (.5095 x QTY 10”) FT^3

Vp = (_____ + _____ + _____ + ____ + _____) FT^3

Vp = 7.5 (____) GALLONS

Vp = ______ GALLONS

$^2/_3$ Vp = _____ GALLONS

Figure F4-17 – Piping Calculation Sheet

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DATE: 6/25/03 Peak Flow Rate per Home = .64 gpm

LINE	4" PIPE	6" PIPE	8" PIPE	10" PIPE	PEAK	# SVCE LATERALS	# AIRVAC VALVES	HOMES (or EDUS)
1	2400	1400			79.4	62	62	124
2	3430	3410	3015		145.9	114	114	228
3	3700	2200			49.9	10	32	78
TOTALS	9530	7010	3015		275.2	186	208	430

Average Service Lateral Length	20'
Total 3" Pipe	3720

VOLUME OF PIPEWORK (BASED ON SDR-21 PVC PIPE)

Vp = (.0547 x Length 3") + (.0904 x Length 4") + (.1959 x Length 6") + (.3321 x Length 8") = (.5095 x QTY 10") FT^3

Vp = (_____ + _____ + _____ + ____ + _____) FT^3

Vp = 7.5 (____) GALLONS

Vp = ______ GALLONS

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VOLUME OF PIPEWORK (BASED ON SDR-21 PVC PIPE)

Vp = (.0547 x Length 3") + (.0904 x Length 4") + (.1959 x Length 6") + (.3321 x Length 8") = (.5095 x QTY 10") FT^3

Vp = (203 + 861 + 1373 + 1001 + --) FT^3 = 3438 FT^3

Vp = 7.5 (3438) GALLONS (7.5 gal / FT^3)

Vp = 25,785 GALLONS TOTAL PIPE VOLUME (Sewage & Vacuum)

$^2/_3$ Vp = 17,018 GALLONS VACUUM ONLY

Example Problem

PROJECT: Example Problem

Project No.: 951075

Station Number: 1

Date: 6/25/03

Peak Flow (Qmax) — Qmax = gpm

Average Flow (Qa) = $\frac{Qmax}{Peak\ Factor}$ = $\frac{\_\_\_}{3.5}$ — Qa = gpm

Minimum Flow (Qmin) = $\frac{Qa}{2}$ = $\frac{\_\_\_}{2}$ — Qmin = gpm

Vacuum Pump Capacity Required (Qvp) = $\frac{A^* \text{ x Qmax c.f.m.}}{7.5 \text{ gal/ft}^3}$ = $\frac{\text{x c.f.m.}}{7.5 \text{ gal/ft}^3}$ — Qvp = a.c.f.m (use 300 c.f.m.)

*Longest Line Length			(A)
0'	-	5,000'	6
5001'	-	7.000'	7
7001'	-	10,000'	8
10,001'		12,000'	9
12,001'		15,000'	11

Discharge Pump Capacity (Qdp) = Qmax — Qmax = gpm

Collection Tank Operating Volume (Vo) = $\frac{15\ Qmin}{Qdp}$ (Qdp-Qmin) — Vo = gal

(for 15 min. cycle at Qmin)

Vo =1.84 Qmax for 3.5 Peak Factor

=1.64 Qmax for 4.0 Peak Factor

Total Volume Collection Tank (Vct) = ____Vo = 3 Vo — Vct = gal

INCLUDE 400 Gallons for Reserve Tank

Vacuum Reservoir/Moisture Removal Tank

(Vrt) (If separate vessel is desired) — Vrt = gal (include in Vct)

(Recommended Volume Vrt-= 400 gal)

System Pump Down Time for Operating Range of 16" to 20" Hg Vacuum (t) = $\frac{\text{(0.045 cfm min)}}{\text{gal}}$ $\frac{\text{(2/3 Vp+(Vct-Vo)+Vrt) gal}}{\text{Qvp cfm}}$

"t" should be 1 to 3 mins.

if over 3, increase Qvp / if under 1, increase Vrt

= $\frac{(0.045\ (\quad) + (\quad - \quad) + (\quad)}{\text{cfm}}$ — t = mins.

Example Problem

PROJECT: Example Problem PROJECT #: 951075

STATION #: 1 DATE: 6/25/03

Peak Flow					Qmax	=	275.2 gpm
Average Flow (Qa)	=	$\frac{\text{Qmax}}{\text{Peak Factor}}$	=	$\frac{\text{Qmax}}{3.5}$	Qa	=	78.6 gpm
Minimum Flow (Qmin)	=	$\frac{\text{Qa}}{2}$	=	$\frac{78.6}{2}$	Qmin	=	39.3 gpm
Vacuum Pump Capacity Required (Qvp)	=	$\frac{\text{A* x Qmax c.f.m}}{7.5\ \text{gal/ft}^3}$	=	$\frac{\text{7 x 275.2 c.f.m.}}{7.5\ \text{gal/ft}^3}$	Qvp	=	256.8 a.c.f.m. (use 300 c.f.m.)

*Longest Line Length			(A)	
0’	-	5,000’	6	
5,001’	-	7,000’	7	(6045)
7,001’	-	10,000’	8	
10,001’	-	12,000’	9	
12,001’	-	15,000’	11	

Example Problem

PROJECT: Example Problem

PROJECT #: 951075

STATION #: 1

DATE: 6/25/03

Discharge Pump Capacity (Qdp)	=	Qmax			Qmax	=	275.2 gpm
Collection Tank Operating Volume (Vo*) (for 15 min. cycle at Qmin)	=	$\frac{15\ Qmin\ (Qdp-Qmin)}{Qdp}$			Vo	=	506.3 gal
Total Volume Collection Tank (Vct) -INCLUDE 400 gallons for Reserve Tank	=	______ Vo	=	3 Vo	Vct	=	1519 gal
Vacuum Reservoir / Moisture Removal Tank (Vrt) (if separate vessel is desired)		-Recommended Volume Vrt = 400 gal 1519 + 400 = 1919 use 2000 gal			Vrt	=	0 gal (include in Vct)

* Vo

= 1.84 Qmax for 3.5 Peak Factor

= 1.64 Qmax for 4.0 Peak Factor

Example Problem

PROJECT: Example Problem

PROJECT #: 951075

STATION #: 1

DATE: 6/25/03

System Pump Down Time for Operating Range of 16" to 20" Hg Vacuum (t) -(t) should be 1 to 3 mins - if over 3, increase Qvp -If under 1, increase Vrt	$\frac{(0.045 \text{ cfm min})}{\text{gal}} \quad \frac{(2/3\ Vp + (Vct - Vo) + Vrt)\ \text{gal}}{Qvp\ \text{cfm}}$ $\frac{(0.045\ (17{,}018) + (2{,}000 - 506) + (0))}{455\ \text{cfm}}$	t	=	1.83 mins

Example Problem

PROJECT: Example Problem **Project No.:** 951075

Station Number: 1 **Date:** 6/25/03

Peak Flow (Qmax)					Qmax	=	gpm
Average Flow (Qa)	=	Qmax / Peak Factor	=	___ / 3.5	Qa	=	gpm
Minimum Flow (Qmin)	=	Qa / 2	=	___ / 2	Qmin	=	gpm
Vacuum Pump Capacity Required (Qvp)	=	A* x Qmax c.f.m. / 7.5 gal/ft^3	=	x c.f.m. / 7.5 gal/ft^3	Qvp	=	a.c.f.m (use 300 c.f.m.)

*Longest Line Length			(A)
0'	-	5,000'	6
5001'	-	7.000'	7
7001'	-	10,000'	8
10,001'		12,000'	9
12,001'		15,000'	11

Discharge Pump Capacity (Qdp)	=	Qmax			Qmax	=	gpm
Collection Tank Operating Volume (Vo) (for 15 min. cycle at Qmin) Vo =1.84 Qmax for 3.5 Peak Factor =1.64 Qmax for 4.0 Peak Factor	=	15 Qmin (Qdp-Qmin) / Qdp			Vo	=	gal
Total Volume Collection Tank (Vct) *INCLUDE 400 Gallons for Reserve Tank*	=	____Vo	=	3 Vo	Vct	=	gal
Vacuum Reservoir/Moisture Removal Tank (Vrt) (If separate vessel is desired) (Recommended Volume Vrt-= 400 gal)					Vrt	=	gal (include in Vct)

System Pump Down Time for Operating Range of 16" to 20" Hg Vacuum (t)

= (0.045 cfm min) / gal × (2/3 Vp+(Vct-Vo)+Vrt) gal / Qvp cfm

"t" should be 1 to 3 mins.

if over 3, increase Qvp / if under 1, increase Vrt

= (0.045 (   ) + (-   ) + (   )) / cfm   t = mins.

E x a m p l e   P r o b l e m

PROJECT: Example Problem

Project No.: 951075

Station Number: 1

Date: 6/25/03

Peak Flow (Qmax) — Qmax = **275.2** gpm

Average Flow (Qa) $= \frac{Qmax}{Peak\ Factor} = \frac{Qmax}{3.5}$ — Qa = **78.6** gpm

Minimum Flow (Qmin) $= \frac{Qa}{2} = \frac{78.6}{2}$ — Qmin = **39.3** gpm

Vacuum Pump Capacity Required (Qvp) $= \frac{A^* \times Qmax\ c.f.m.}{7.5\ gal/ft^3} = \frac{7 \times 275.2\ c.f.m.}{7.5\ gal/ft^3}$ — Qvp = **256.8** a.c.f.m (use 300 c.f.m.)

*Longest Line Length			(A)
0'	-	5,000'	6
5001'	-	7.000'	7
7001'	-	10,000'	8
10,001'		12,000'	9
12,001'		15,000'	11

----- 6045

Discharge Pump Capacity (Qdp) = Qmax — Qmax = 275.2 gpm

Collection Tank Operating Volume (Vo) $= \frac{15\ Qmin\ (Qdp-Qmin)}{Qdp}$ — Vo = 506.3 gal

(for 15 min. cycle at Qmin)

Vo =1.84 Qmax for 3.5 Peak Factor

=1.64 Qmax for 4.0 Peak Factor

Total Volume Collection Tank (Vct) = ____Vo = 3 Vo — Vct = 1519 gal

INCLUDE 400 Gallons for Reserve Tank

Vacuum Reservoir/Moisture Removal Tank

(Vrt) (If separate vessel is desired) — Vrt = 0 gal (include in Vct)

(Recommended Volume Vrt-= 400 gal)

1519 + 400 = 1919 - use 2000 gal.

System Pump Down Time for Operating Range of 16" to 20" Hg Vacuum (t)

$$= \frac{(0.045\ cfm\ min)}{gal} \cdot \frac{(2/3\ Vp+(Vct-Vo)+Vrt)\ gal}{Qvp\ cfm}$$

"t" should be 1 to 3 mins.

if over 3, increase Qvp / if under 1, increase Vrt

$$= \frac{(0.045\ (\ 17{,}018\ ) + (\ 2000\ -\ 506\ ) + (\ 0\ )}{455\ cfm}$$

t = 1.83 mins.

E x a m p l e P r o b l e m

PROJECT: Example Problem

Station Number: 1

Project No.: 951075

Date: 6/25/03

Peak Flow (Qmax) Qmax = 275.2 gpm

Average Flow (Qa) = $\frac{Qmax}{Peak\ Factor}$ = $\frac{Qmax}{3.5}$ Qa = 78.6 gpm

Minimum Flow (Qmin) = $\frac{Qa}{2}$ = $\frac{78.6}{2}$ Qmin = 39.3 gpm

Vacuum Pump Capacity Required (Qvp) = $\frac{A^* \times Qmax\ c.f.m.}{7.5\ gal/ft^3}$ = $\frac{7 \times 275.2\ c.f.m.}{7.5\ gal/ft^3}$ Qvp = 256.8 a.c.f.m (use 300 c.f.m.)

*Longest Line Length			(A)
0'	-	5,000'	6
5001'	-	7.000'	7
7001'	-	10,000'	8
10,001'		12,000'	9
12,001'		15,000'	11

----- 6045

Discharge Pump Capacity (Qdp) = Qmax Qmax = 275.2 gpm

Collection Tank Operating Volume (Vo) = $\frac{15\ Qmin}{Qdp}$ (Qdp-Qmin) Vo = 506.3 gal

(for 15 min. cycle at Qmin)

Vo =1.84 Qmax for 3.5 Peak Factor

=1.64 Qmax for 4.0 Peak Factor

Total Volume Collection Tank (Vct) = ____Vo = 3 Vo Vct = 1519 gal

INCLUDE 400 Gallons for Reserve Tank

Vacuum Reservoir/Moisture Removal Tank

(Vrt) (If separate vessel is desired) Vrt = 0 gal (include in Vct)

(Recommended Volume Vrt-= 400 gal)

1519 + 400 = 1919 - use 2000 gal.

System Pump Down Time for Operating Range of 16" to 20" Hg Vacuum (t) = $\frac{(0.045\ cfm\ min)}{gal}\ \frac{(2/3\ Vp+(Vct-Vo)+Vrt)\ gal}{Qvp\ cfm}$

"t" should be 1 to 3 mins.

if over 3, increase Qvp / if under 1, increase Vrt

= $\frac{(0.045\ (\ 17{,}018\ ) + (\ 2000\ -\ 506\ ) + (\ 0\ )}{455\ cfm}$ t = 1.83 mins.

Example Problem

PROJECT: Example Problem

Project No.: 951075

Station Number: 1

Date: 6/25/03

Peak Flow (Qmax) — Qmax = 275.2 gpm

Average Flow (Qa) = $\frac{Qmax}{\text{Peak Factor}}$ = $\frac{Qmax}{3.5}$ — Qa = 78.6 gpm

Minimum Flow (Qmin) = $\frac{Qa}{2}$ = $\frac{78.6}{2}$ — Qmin = 39.3 gpm

Vacuum Pump Capacity Required (Qvp) = $\frac{\text{A* x Qmax c.f.m.}}{7.5\ \text{gal/ft}^3}$ = $\frac{\text{7 x 275.2 c.f.m.}}{7.5\ \text{gal/ft}^3}$ — Qvp = 256.8 a.c.f.m (use 300 c.f.m.)

*Longest Line Length			(A)
0'	-	5,000'	6
5001'	-	7.000'	7
7001'	-	10,000'	8
10,001'		12,000'	9
12,001'		15,000'	11

----- 6045

Discharge Pump Capacity (Qdp) = Qmax — Qmax = 275.2 gpm

Collection Tank Operating Volume (Vo) = $\frac{15\ Qmin}{Qdp}$ (Qdp-Qmin) — Vo = 506.3 gal

(for 15 min. cycle at Qmin)

Vo =1.84 Qmax for 3.5 Peak Factor

=1.64 Qmax for 4.0 Peak Factor

Total Volume Collection Tank (Vct) = ____Vo = 3 Vo — Vct = 1519 gal

INCLUDE 400 Gallons for Reserve Tank

Vacuum Reservoir/Moisture Removal Tank

(Vrt) (If separate vessel is desired) — Vrt = 0 gal (include in Vct)

(Recommended Volume Vrt-= 400 gal)

1519 + 400 = 1919 - use 2000 gal.

System Pump Down Time for Operating Range of 16" to 20" Hg Vacuum (t) = $\frac{\text{(0.045 cfm min)}}{\text{gal}}\ \frac{\text{(2/3 Vp+(Vct-Vo)+Vrt) gal}}{\text{Qvp cfm}}$

"t" should be 1 to 3 mins.

if over 3, increase Qvp / if under 1, increase Vrt

= $\frac{(0.045\ (17{,}018) + (2000 - 506) + (0))}{455\ \text{cfm}}$ — t = 1.83 mins.

Design Example: Hydloss Spreadsheet

(R)

AIRVAC

Vacuum Sewer Systems

hydloss2.xls

PROJECT	Design Example	PROJECT NUMBER	
STATION	1		
LINE	Main #2	MAX FLOW	.64 GPM/HM
DATE	1/20/2006		

STREET OR OTHER NOTES	STATION TO STATION	LINE LENGTH	PIPE SIZE	HOMES	Q MEAN	Q ACC'M	HL/ 100'	HEAD LOSS LINE	TOTAL STATIC LIFT	NUMBER LIFTS	STATIC LOSS	SUB TOTAL FRICTION	SUB TOTAL STATIC	PIPE SIZE 3"	4"	6"	8"	10"	NUMBER AIRVAC VALVES
			4		0.00	0.00	0.0000	0.0000			0.00	0.0000	5.7667		0				0
			4		0.00	0.00	0.0000	0.0000			0.00	0.0000	5.7667		0				0
E.O.L. Main #2	53+95 - 44+40	955	6	32	10.24	20.48	0.0034	0.0324			0.00	0.0324	5.7667			955			16
	44+40 - 38+95	545	6	20	26.88	33.28	0.0203	0.1104	1.5	1	1.00	0.1428	5.7667			545			10
CONN. BRANCH D	38+95 - 38+94	1	6	20	39.68	46.08	0.0416	0.0004			0.00	0.1432	4.7667			1			10
	38+94 - 30+15	879	6	22	53.12	60.16	0.0714	0.6277	4.5	3	3.00	0.7710	4.7667			879			11
8X6 REDUCER	30+15 - 30+10	5	8	0	60.16	60.16	0.0249	0.0012			0.00	0.7722	1.7667				5		0
CONN. BRANCH C	30+10 - 30+09	1	8	74	83.84	107.52	0.0459	0.0005			0.00	0.7727	1.7667				1		37
	30+09 - 21+40	869	8	22	114.56	121.60	0.0818	0.7111	1.5	1	0.83	1.4838	1.7667				869		11
CONN. BRANCH B	21+40 - 21+39	1	8	12	125.44	129.28	0.0968	0.0010			0.00	1.4848	0.9333				1		6
	21+39 - 8+13	1326	8	14	133.76	138.24	0.1090	1.4453			0.00	2.9301	0.9333				1326		7
CONN. @ V.C.STN.	8+13 - 0+00	813	8	12	142.08	145.92	0.1219	0.9908	1.6	1	0.93	3.9209	0.9333				813		6
			4		145.92	145.92	3.0366	0.0000			0.00	3.9209	0.0000		0				0
			4		145.92	145.92	3.0366	0.0000			0.00	3.9209	0.0000		0				0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
			6		145.92	145.92	0.4631	0.0000			0.00	3.9209	0.0000			0			0
TOTALS		**5395**		**228**		**145.92**		**3.9209**	**9.1**	**6**	**5.77**	**3.9209**		**0**	**0**	**2380**	**3015**	**0**	**114**

The AIRVAC Hydloss spreadsheet shown is one example of a hydraulic analysis of Main #2 in the Design Seminar Example.

Design Example: Hydloss Spreadsheet

Microsoft Excel Worksheet

The AIRVAC Hydloss spreadsheet shown is one example of a hydraulic analysis of Main #2 in the Design Seminar Example.

Figure F6-3 Sample Profile

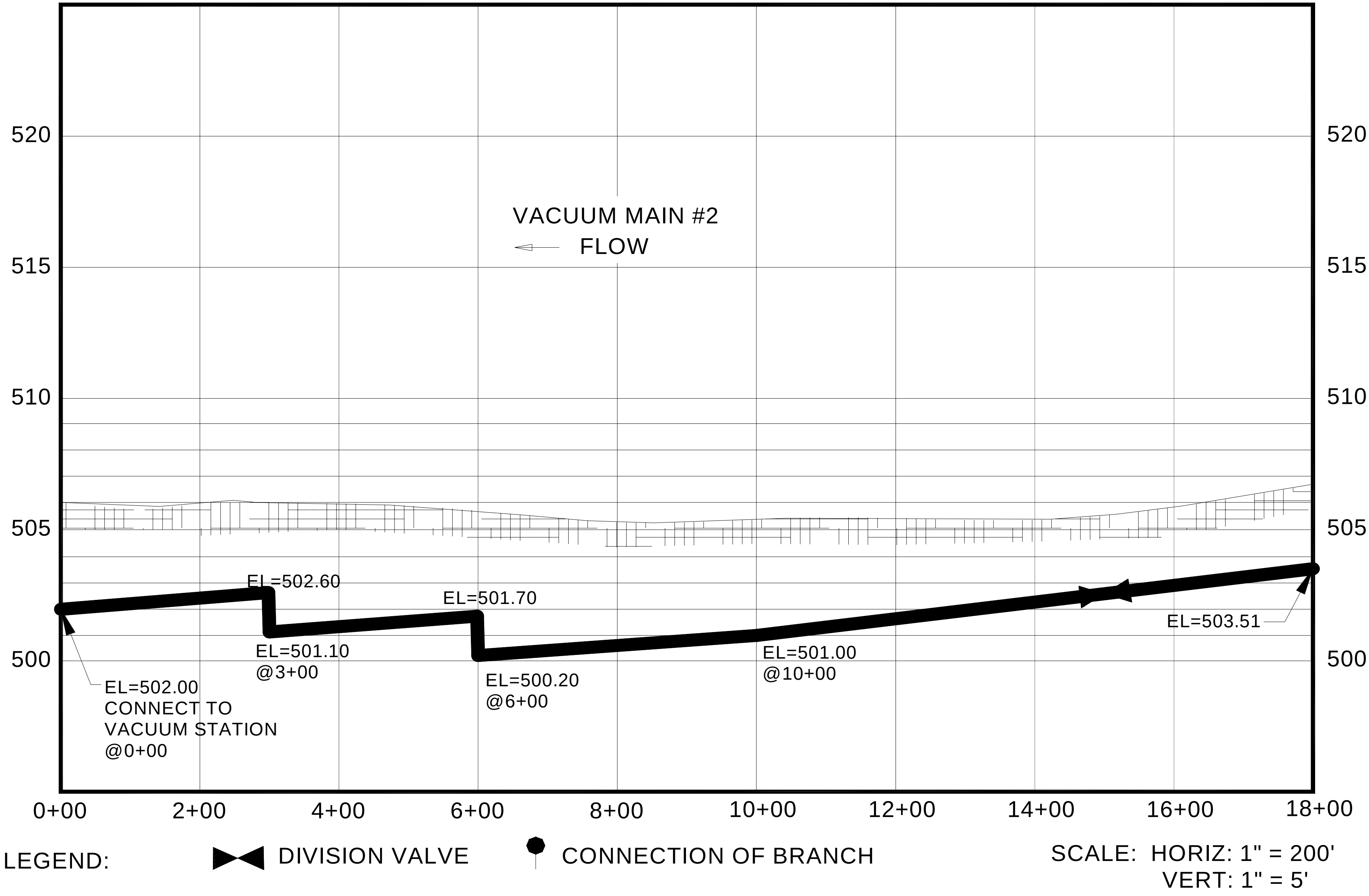


Figure F6-4 Sample Profile

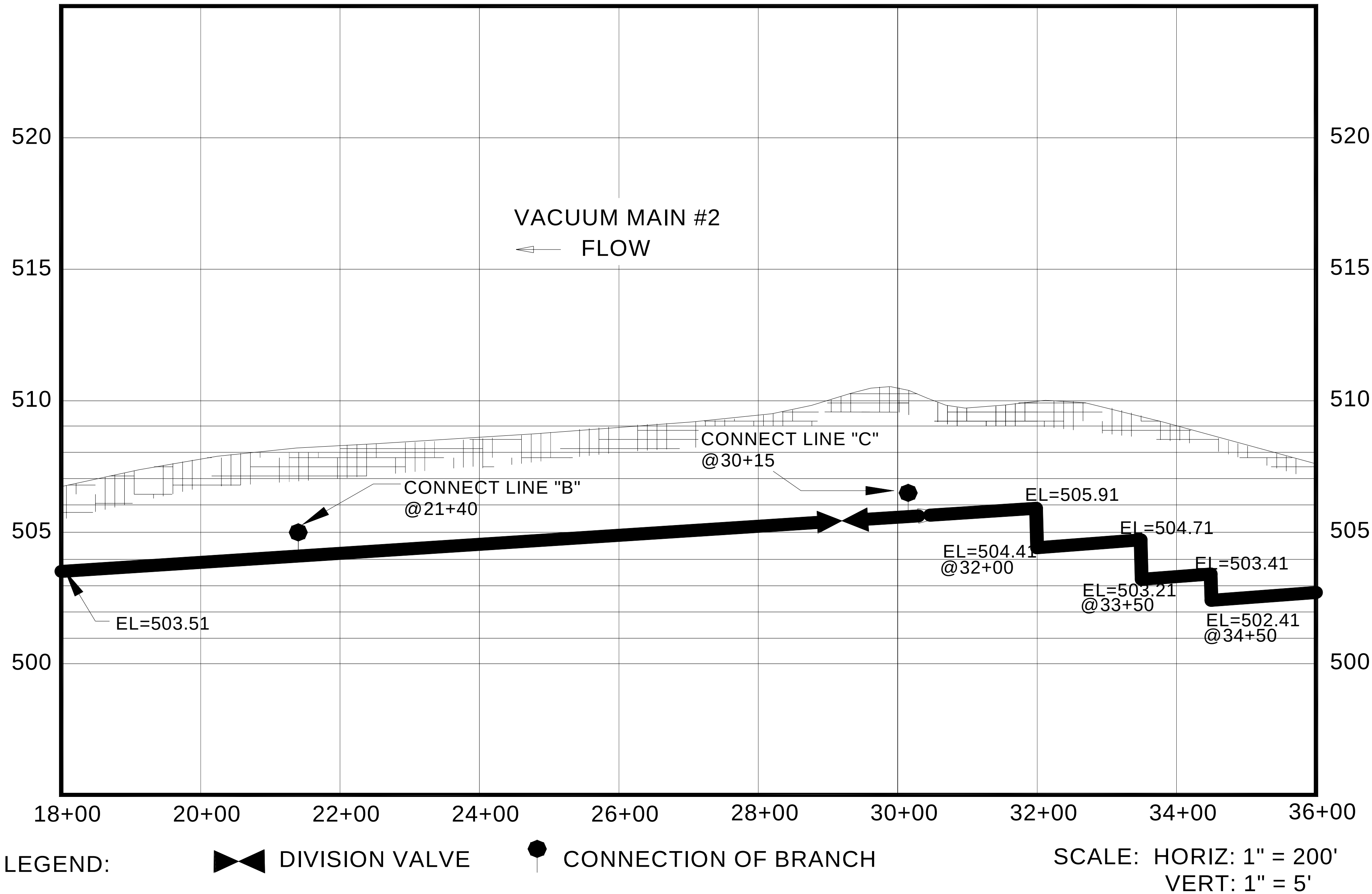
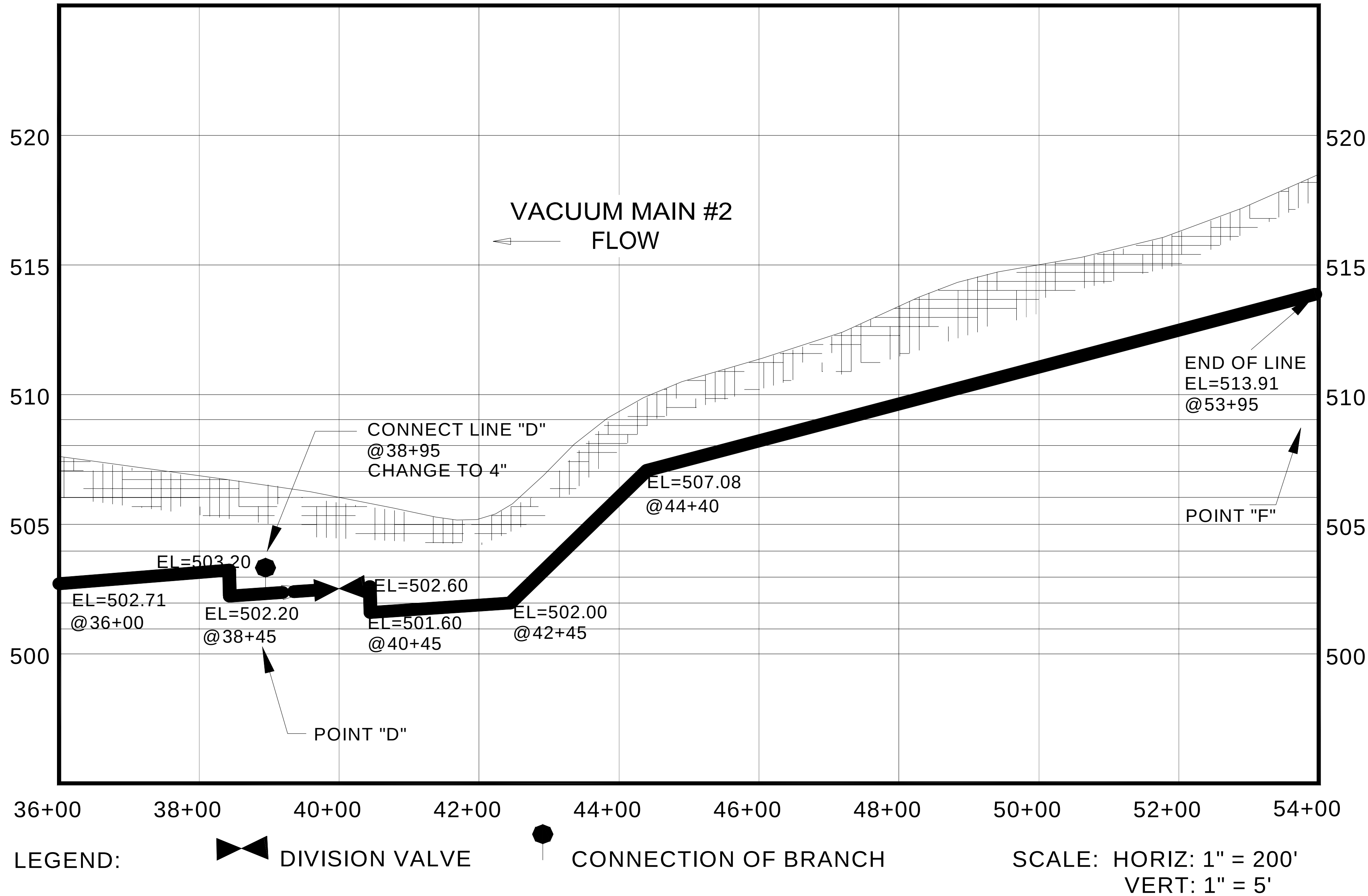


Figure F6-5 Sample Profile



Design Example Procedure

- To provide adequate space for liquid level controls within the collection tank
  - Estimate minimum 5.5 ft elevation between incoming vacuum sewers and building floor
  - This places building floor at elevation 496.50 for this example
- See pages Chapter 4 of 2005 Design Manual for calculation of line losses in main #2
  - Friction losses for slopes greater than 0.2% are ignored
  - Calculated static losses due to profile change equal lift height minus the pipe I.D.

Design Example Procedure

- Select suitable standard size pumps and tanks
  - Consult manufacturers literature
  - Recalculate vacuum stations calculations using selected equipment sizes
  - Size vacuum and sewage pumps
    - Allow for additional house connections without overloading
  - For large vacuum stations three (3) vacuum pumps may be used to prevent use of extremely large pumps
  - Typically 25hp sliding vane pumps are largest model used by AIRVAC – standard models are:
    - 170 CFM @ 10HP
    - 305 CFM @ 15HP
    - 455 CFM @ 25 HP

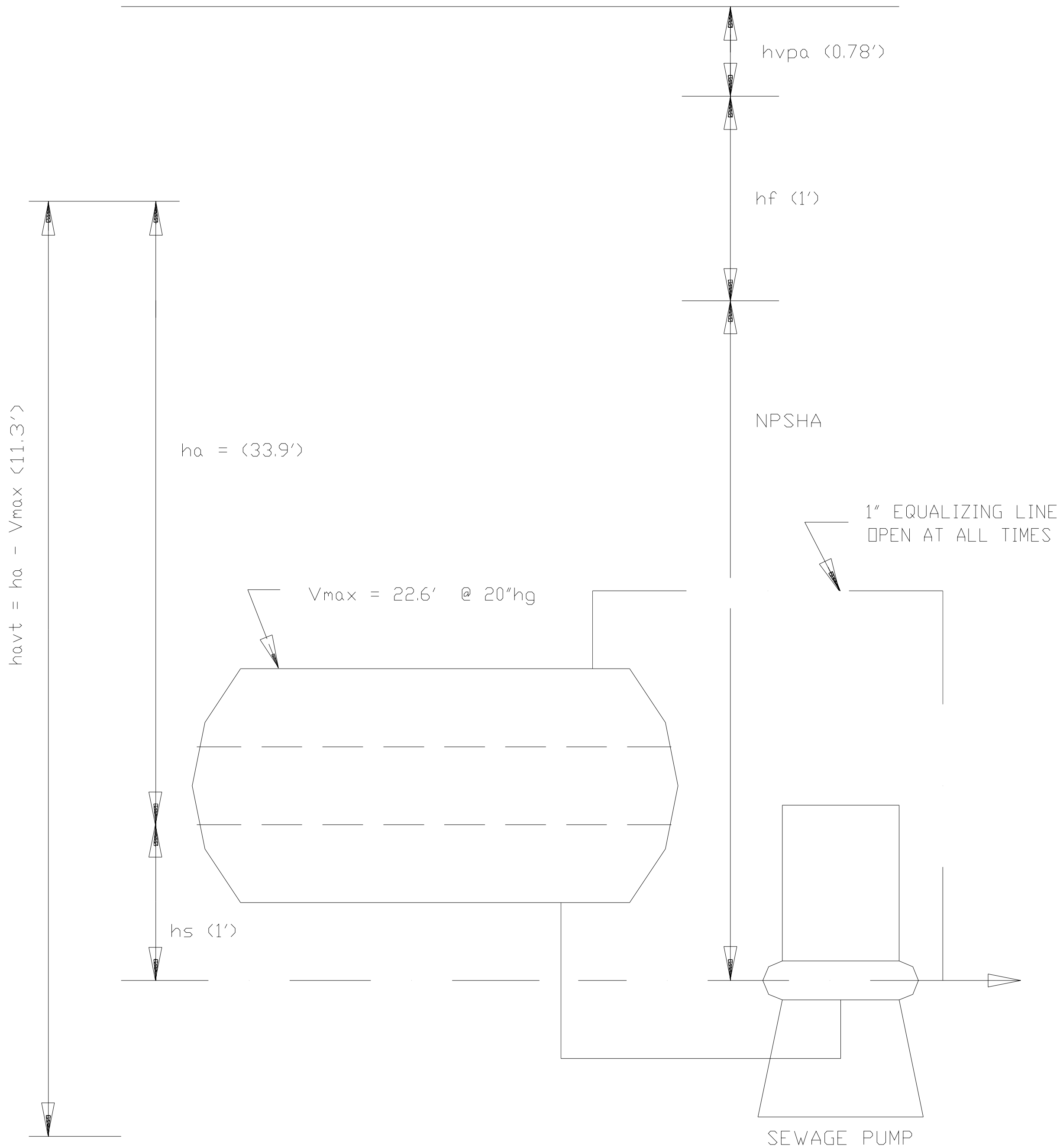


Figure F5-2 Calculation of NPSHA in AIRVAC System with Typical Values

Nomenclature

NPSHA = Net positive suction head available (feet of water)

NPSHA = havt + hs – hf – hvpa

Ha = Head available due to atmospheric pressure (see below)

Height above sea level	ha
0 ft	33.9 ft
500 ft	33.3 ft
1000 ft	32.7 ft
1500 ft	32.1 ft

Havt = Head available due to atmospheric pressure at liquid level less vacuum in collection tank (feet of water)

Nomenclature

Havt = ha – Vmax (for maximum collection tank vacuum of 20" Hg at sea level havt = 33.9 ft – 22.6 ft = 11.3 ft

Vmax = Maximum collection tank vacuum in feet of head

20" mercury = 22.6 ft

16" mercury = 18.1 ft

Hs = Depth of sewage above pump centerline – typically 1' minimum

Hvpa = Absolute vapor pressure of sewage at its pumping temperature (@ 68 degrees, hvpa = 0.78')

Hf = Friction loss in suction pipes (approximately 2 feet for vertical pumps, 1 foot for horizontal pumps)

NPSHR = NPSH required by pump selected

NPSHA must be greater than NPSHR

TDH Diagram

Total Dynamic Head on Discharge Pump (TDH) = Head Due to Vacuum + Static Head + Friction Loss

(at 16" Hg vacuum head due to vacuum = 18.1')

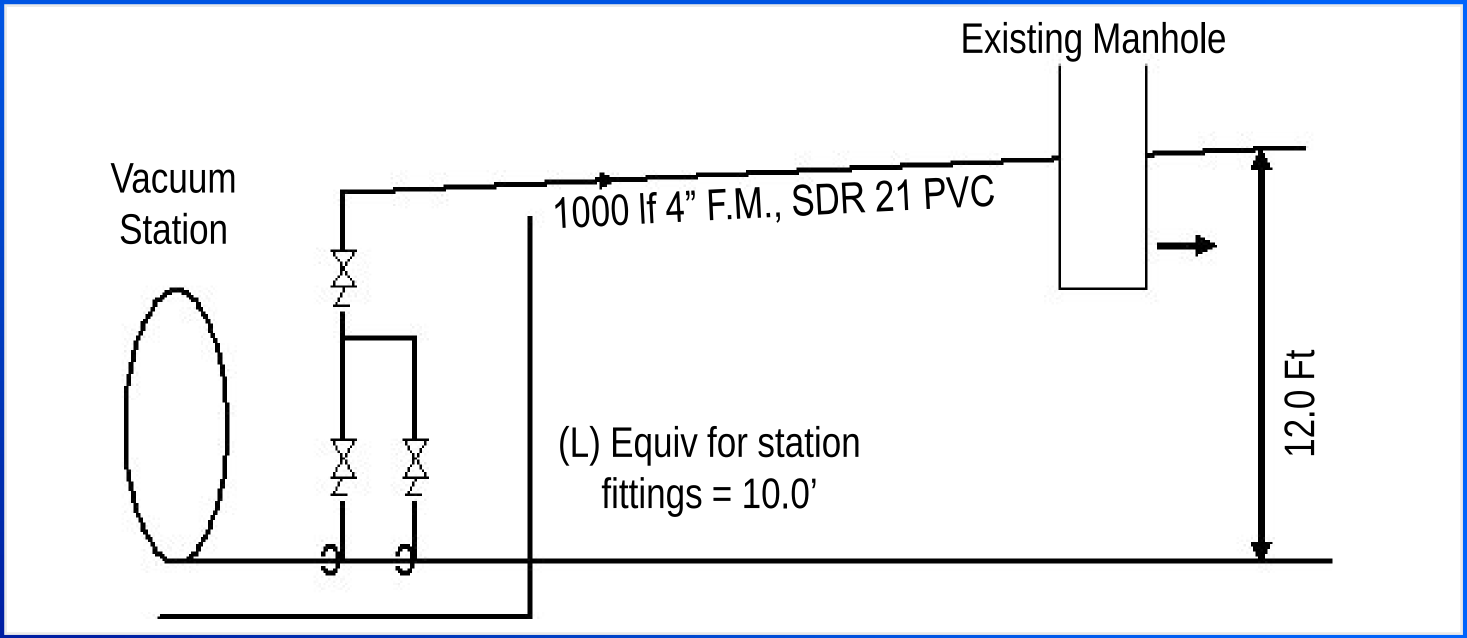
= 18.1' + 12' + 14.75' TDH = 44.85'

(at 20" Hg vacuum head due to vacuum = 22.6')

= 22.6' + 12' + 14.75' TDH -= 49.4'

NPSH Calculation NPSHA = Havt* + hs - hf - hvpa + heq

*(havt = ha + Vmax) = 33.9 + (-) 22.6 = 11.3 = 11.3 + 1.0 - 0.50 - 0.78 + 0 NPSHA = 11.02'

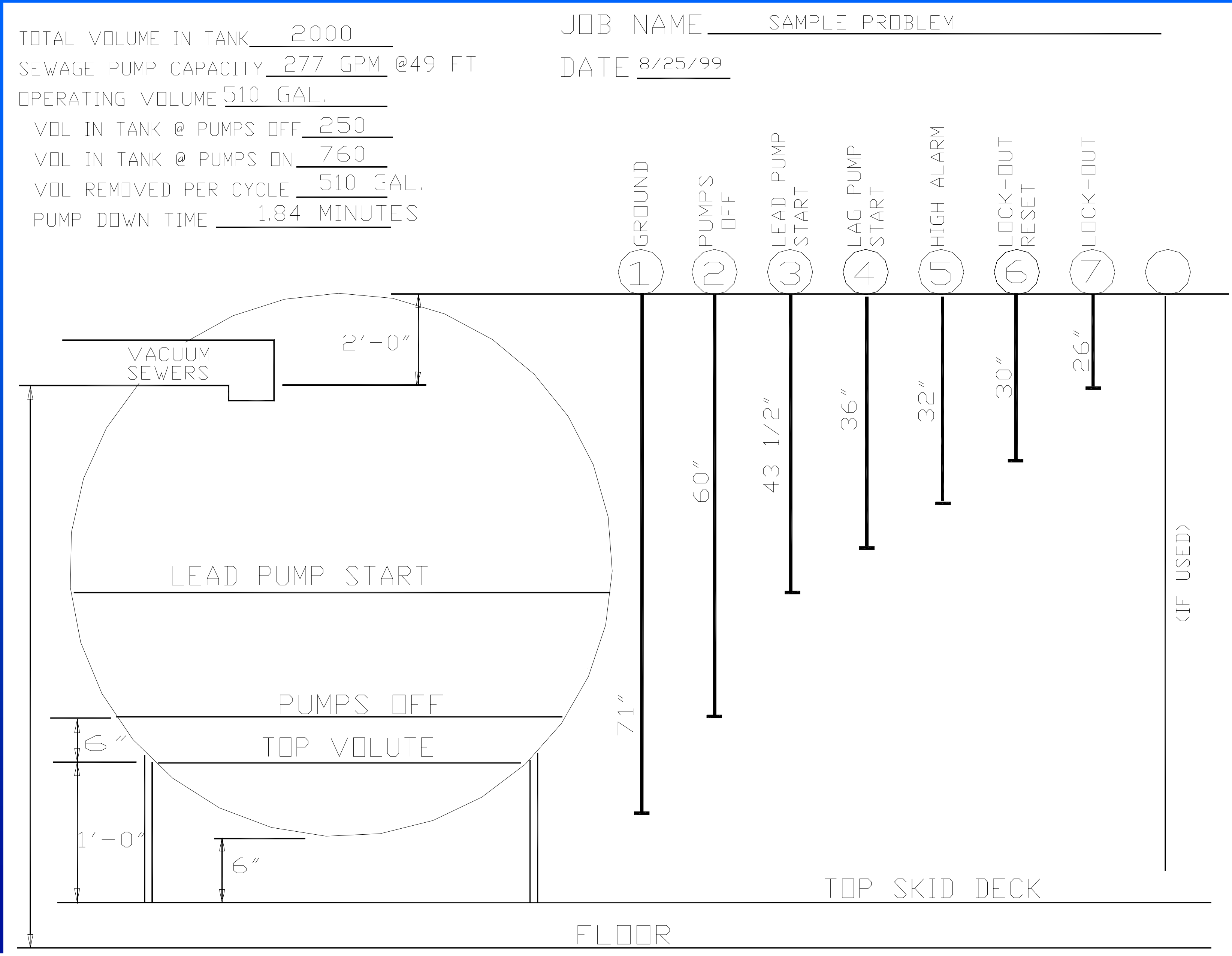


VEL = 4.24 FPS

H_L / 100' = 1.46 FT.

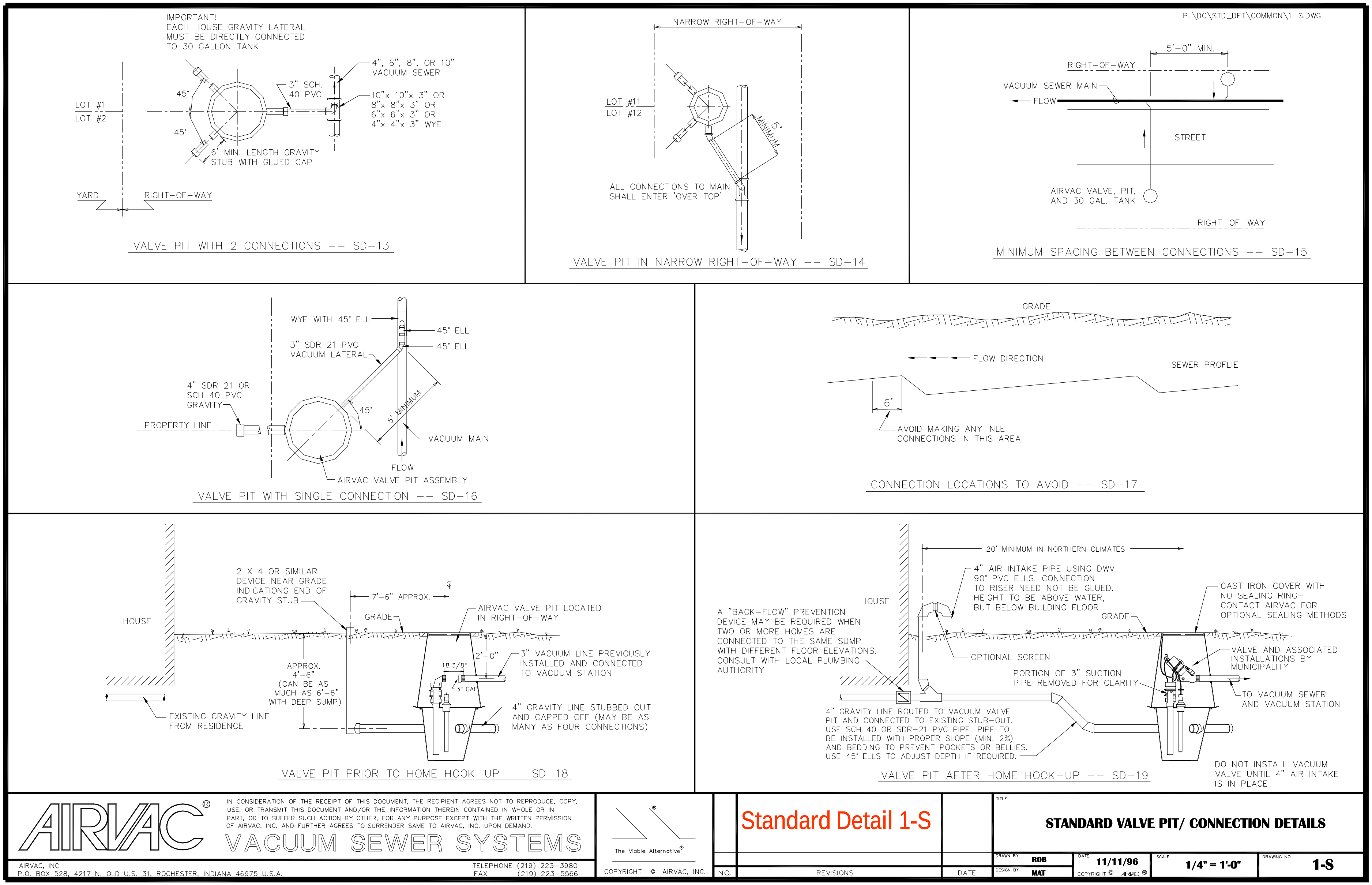
$H_L = \left[\frac{1010}{100}\right] (1.46) = 14.75$

Tank Volume

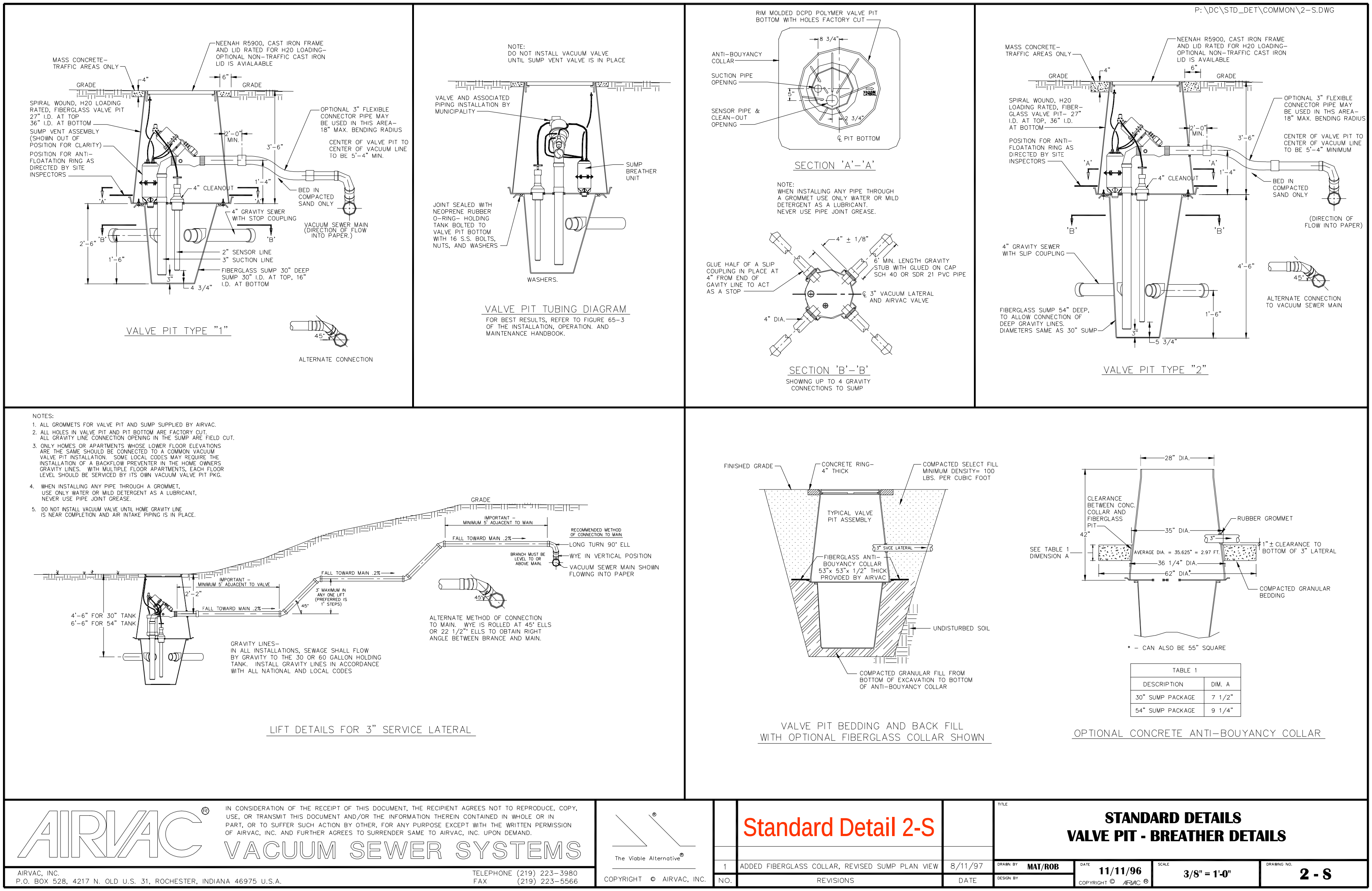


TOTAL VOLUME IN TANK 2000
SEWAGE PUMP CAPACITY 277 GPM @49 FT
OPERATING VOLUME 510 GAL.
VOL IN TANK @ PUMPS OFF 250
VOL IN TANK @ PUMPS ON 760
VOL REMOVED PER CYCLE 510 GAL.
PUMP DOWN TIME 1.84 MINUTES
JOB NAME SAMPLE PROBLEM
DATE 8/25/99
GROUND
PUMPS OFF
LEAD PUMP START
LAG PUMP START
HIGH ALARM
LOCK-OUT RESET
LOCK-OUT
1
2
3
4
5
6
7
VACUUM SEWERS
2'-0"
71"
60"
43 1/2"
36"
32"
30"
26"
(IF USED)
LEAD PUMP START
PUMPS OFF
6"
TOP VOLUTE
1'-0"
6"
TOP SKID DECK
FLOOR

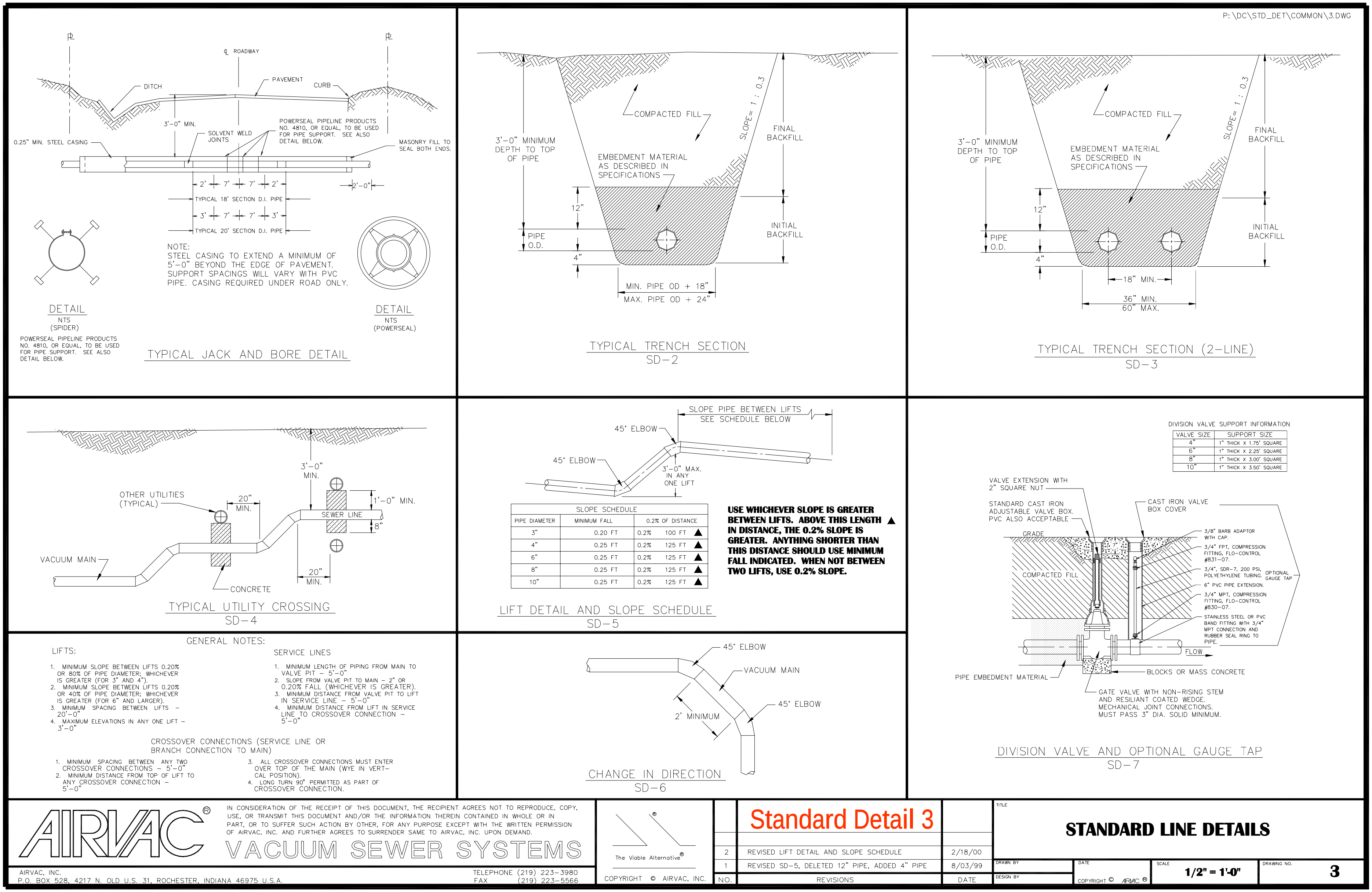
Standard Valve Pit / Connection Details



Standard Valve Pit – Breather Details

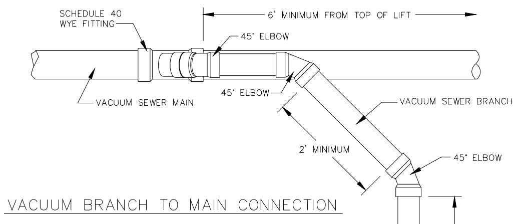


Standard Line Details

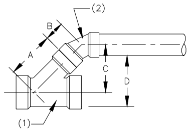


Standard Line Connection Details

P: \DC\STD_DET\COMMON\4.DWG



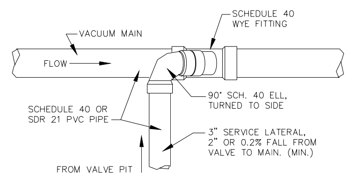
VACUUM BRANCH TO MAIN CONNECTION



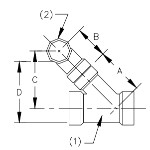
DIMENSIONS BASED ON SPEARS MANUFACTURING
(1) 45 DEG WYE, SOCKET x SOCKET x SOCKET
(2) 45 DEG ELL, SOCKET x SOCKET

WYE SIZE	A	B	C	D- INVERT
4 x 4 x 4	8 3/4"	3 5/16"	8.53"	0.71'
4 x 4 x 3	9 1/4"	3 1/16"	8.70"	0.73'
6 x 6 x 6	12 1/8"	5 9/16"	12.5"	1.04'
6 x 6 x 4	10"	3 5/16"	9.41"	0.78'
6 x 6 x 3	10 1/2"	3 1/16"	9.59"	0.80'
8 x 8 x 8	18 3/4"	6 13/16"	18.07"	1.52'
8 x 8 x 6	16 1/4"	5 9/16"	15.42"	1.30'
8 x 8 x 4	14 1/4"	3 5/16"	12.42"	1.05'
8 x 8 x 3	13"	3 1/16"	11.36"	0.99'
10 x 10 x 10	22 3/8"	8 19/32"	21.90"	1.89'
10 x 10 x 8	20 1/4"	6 13/16"	19.13"	1.61'
10 x 10 x 6	17 3/4"	5 9/16"	16.46"	1.42'
10 x 10 x 4	15 3/4"	3 5/16"	13.48"	1.18'
10 x 10 x 3	14 3/4"	3 1/16"	12.33"	1.08'

VACUUM BRANCH TO MAIN LINE CONNECTION
SD-8



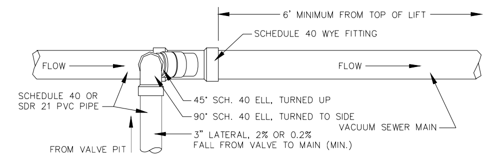
VALVE PIT TO MAIN CONNECTIONS



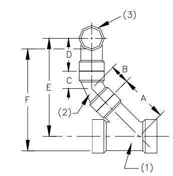
DIMENSIONS BASED ON SPEARS MANUFACTURING
(1) 45 DEG WYE, SOCKET x SOCKET x SOCKET
(2) 90 DEG ELL, SOCKET x SOCKET

WYE SIZE	A	B	C	D- INVERT
4 x 4 x 3	9 1/4"	3 25/32"	9.32"	0.78'
6 x 6 x 3	10 1/2"	3 25/32"	10.21"	0.85'
8 x 8 x 3	13"	3 25/32"	11.86"	1.00'
10 x 10 x 3	14 3/8"	3 25/32"	12.84"	1.10'

VACUUM SERVICE LATERAL TO MAIN OR BRANCH CONNECTION
SD-9



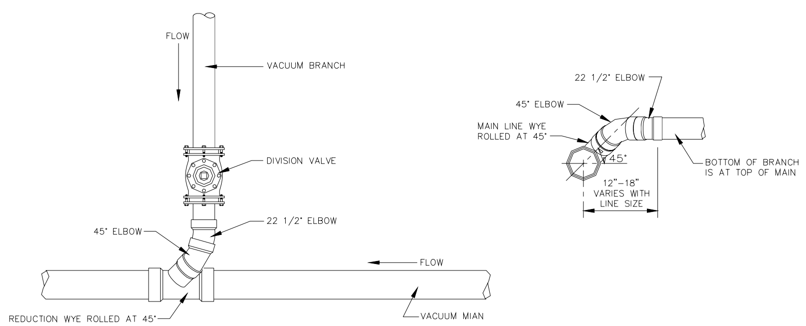
VALVE PIT TO MAIN CONNECTIONS



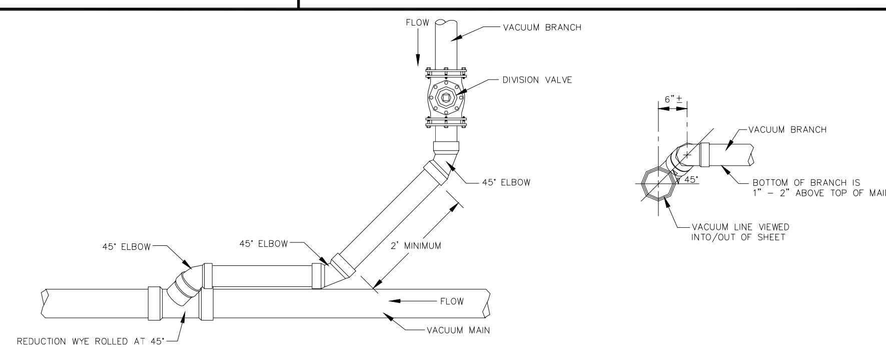
DIMENSIONS BASED ON SPEARS MANUFACTURING
(1) 45 DEG WYE, SOCKET x SOCKET x SOCKET
(2) 45 DEG ELL, SOCKET x SOCKET
(3) 90 DEG ELL, SOCKET x SOCKET

WYE SIZE	A	B	C	D	E	F- INVERT
4 x 4 x 3	9 1/4"	3 1/16"	3 1/16"	3 25/32"	15.55"	1.31'
6 x 6 x 3	10 1/2"	3 1/16"	3 1/16"	3 25/32"	16.43"	1.38'
8 x 8 x 3	13"	3 1/16"	3 1/16"	3 25/32"	18.20"	1.53'
10 x 10 x 3	14 3/8"	3 1/16"	3 1/16"	3 25/32"	19.17"	1.62'

VALVE SERVICE CONNECTIONS
SD-10



ALTERNATE VACUUM BRANCH TO MAIN LINE CONNECTION
SD-11



ALTERNATE VACUUM BRANCH TO MAIN LINE CONNECTION
SD-12

AIRVAC® VACUUM SEWER SYSTEMS

AIRVAC, INC.
P.O. BOX 528, 4217 N. OLD U.S. 31, ROCHESTER, INDIANA 46975 U.S.A.
TELEPHONE (219) 223-3980
FAX (219) 223-5566

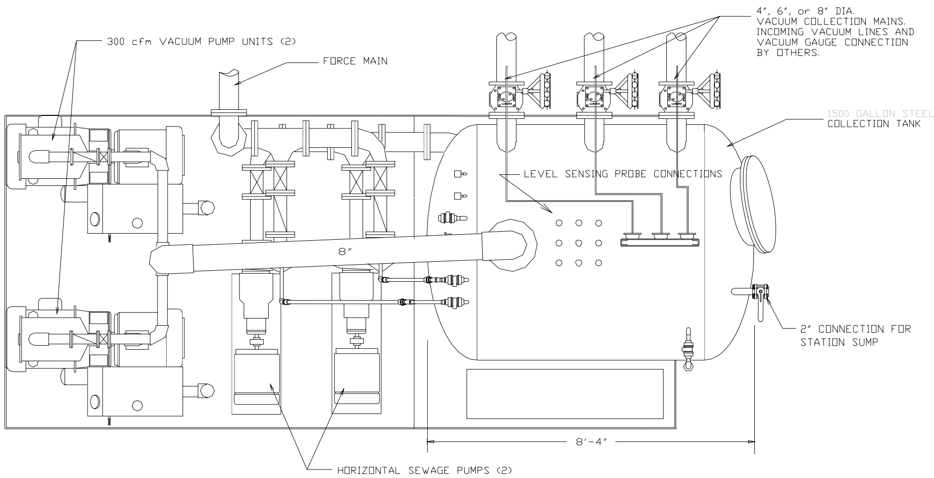
The Viable Alternative®

Standard Detail 4

NO.	REVISIONS	DATE
1	REVISED TABLES AND PIPING	7/12/98

TITLE: LINE CONNECTION DETAILS
AIRVAC STANDARD
DRAWN BY: ROB
DESIGN BY:
DATE: 1/25/99
COPYRIGHT © AIRVAC ®
SCALE: 1" = 1'-0"
DRAWING NO. 4

Standard Skid (2) 300 CFM Vacuum Pumps & 1500 Gal. Collection Tank



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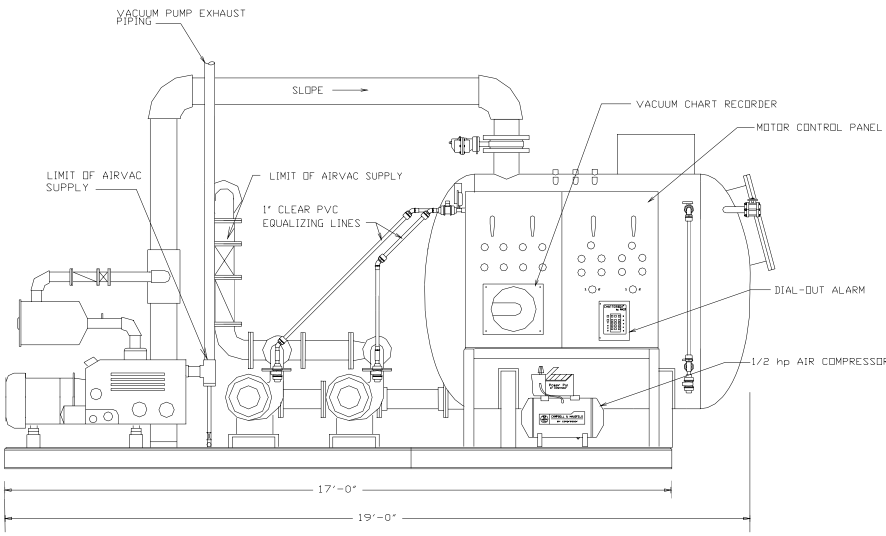
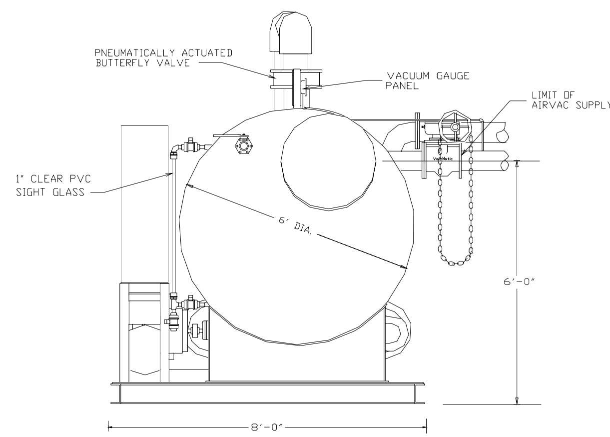
NOTE:

UNIT SHOWN IS A TYPICAL EXAMPLE. SIZE OF COLLECTION TANK AND SEWAGE PUMPS CAN BE VARIED TO SUIT DIFFERENT APPLICATIONS. PLEASE CONSULT AIRVAC.





AIRVAC® VACUUM SEWERAGE SYSTEM

P.O. BOX 528, ROCHESTER, INDIANA 46975 U.S.A.
A DIVISION OF B.M.C.I.

TELEPHONE (219) 223-3980
FAX (219) 223-5566

The Viable Alternative®

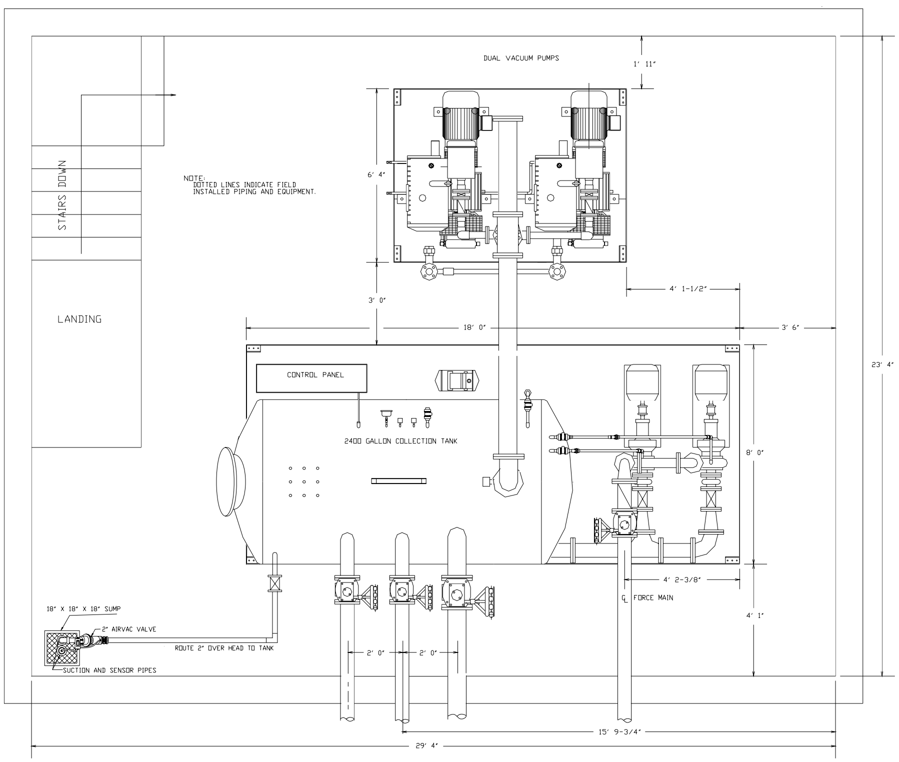
NO.	REVISIONS	DATE
	Standard Skid P20A	

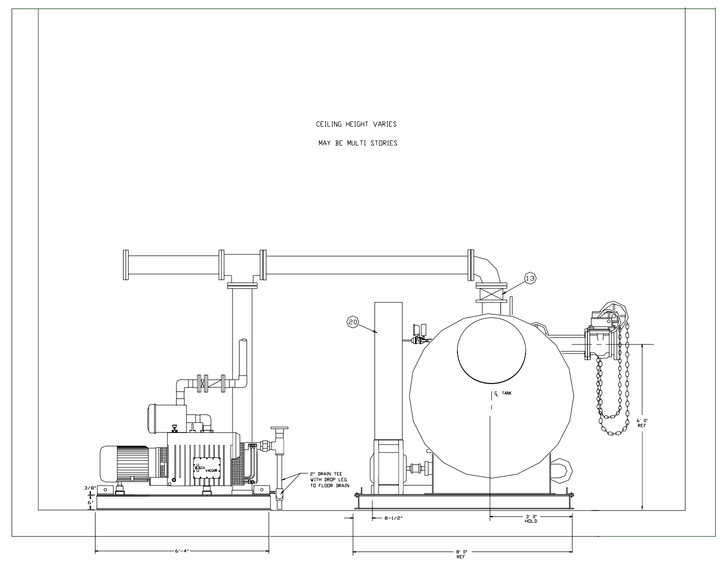
TITLE: STANDARD VACUUM COLLECTION SKID WITH TWO 300 CFM VACUUM PUMPS AND 1500 GALLON SEWAGE COLLECTION TANK

DRAWN BY	DATE	SCALE	DRAWING NO.
ROB	8-13-93	0" 6" 12"	P-20A

DESIGN BY

Two-Skid Package Station – (2) 430 CFM Vacuum Pumps 2400 Gal. Tank





AIRVAC® VACUUM SEWERAGE SYSTEM

P.O. BOX 528, ROCHESTER, INDIANA 46975 U.S.A.
A DIVISION OF B.M.C.I.

TELEPHONE (219) 223-3980
FAX (219) 223-5566

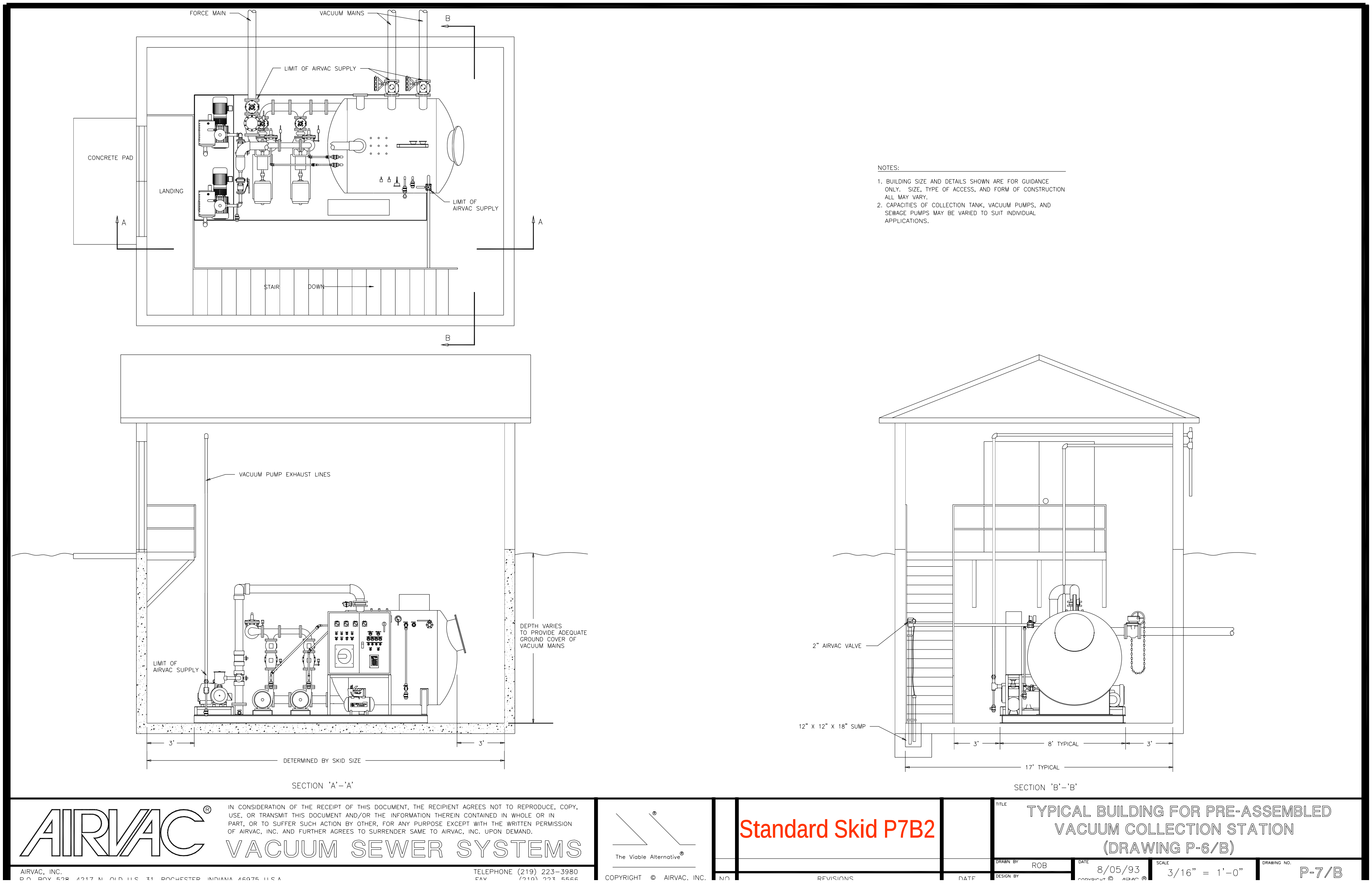
The Viable Alternative

Standard Skid P23

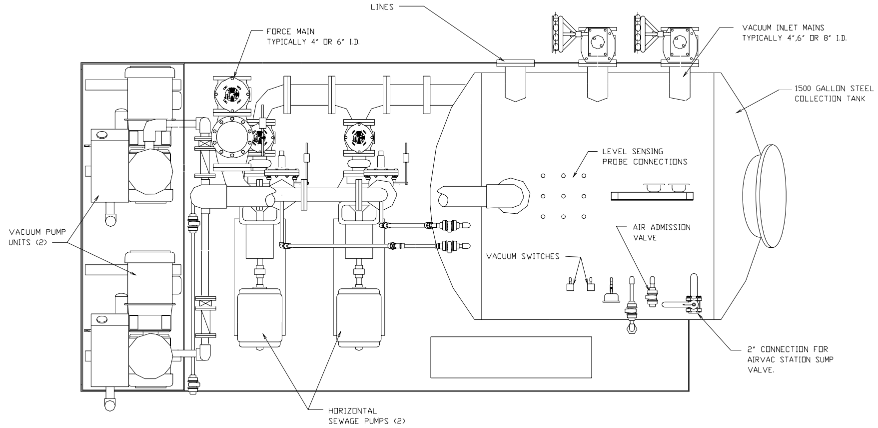
NO. | REVISIONS | DATE

TITLE	TWO-SKID PACKAGE STATION ARRANGEMENT 2400 GALLON TANK, (2) 430 CFM VACUUM PUMPS
CLIENT	TYPICAL STATION
DRAWN BY	ROB
DATE	9-28-94
SCALE	N.T.S.
DRAWING NO.	P-23
SHEET	OF

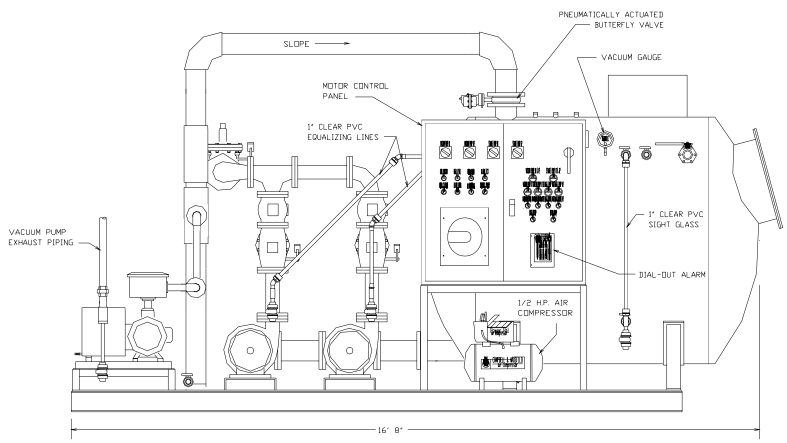
Typical Building for Pre-assembled Station

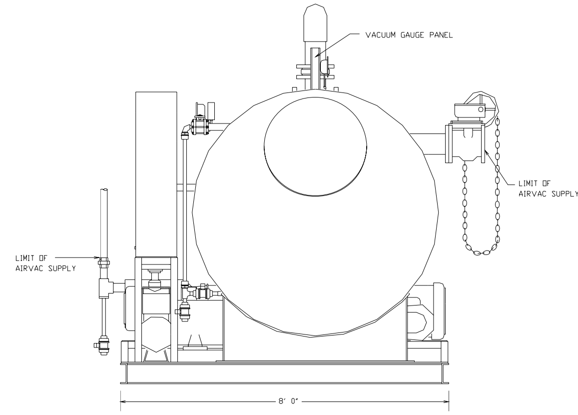


Typical Pre-assembled Skid for Vacuum Collection Station



NOTE:
UNIT SHOWN IS A TYPICAL EXAMPLE. SIZE OF COLLECTION TANK, SEWAGE PUMPS, AND VACUUM PUMPS CAN ALL BE VARIED TO SUIT DIFFERENT APPLICATIONS. PLEASE CONSULT AIRVAC.
APPROXIMATE NUMBER OF HOMES SERVED WOULD BE 300 FOR THIS STATION.





AIRVAC® VACUUM SEWERAGE SYSTEM

P.O. BOX 528, ROCHESTER, INDIANA 46975 U.S.A.
A DIVISION OF B.M.C.I.
TELEPHONE (219) 223-3980
FAX (219) 223-5566

The Viable Alternative®

Standard Skid P6B

NO.	REVISIONS	DATE

TITLE: TYPICAL PRE-ASSEMBLED SKID UNIT FOR VACUUM COLLECTION STATION

DRAWN BY	DATE	SCALE	DRAWING NO.
ROB	8-3-93	0" 12" 24"	P-6/B