BASIS OF DESIGN

FOR

GROUNDWATER REMEDIATION SYSTEM
AT
FLINT HILLS RESOURCES, LP
NORTH TERMINAL
WILMINGTON, NORTH CAROLINA

CATLIN PROJECT NO. 201-125

MAY 16, 2003

PREPARED FOR:

REISS REMEDIATION, INC.
4111 EAST 37TH STREET NORTH
WICHITA, KANSAS 67201-2256

Prepared by:

CATLIN Engineers and Scientists
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Wilmington, North Carolina 28405
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1.0 DESIGN BASIS

The Basis of Design for this project focuses on the treatment of contaminated surficial groundwater at the Flint Hills Resources, LP (FHR) North Terminal in Wilmington, North Carolina. This design is being prepared in general accordance with the Corrective Action Plan Addendum (CAPA) report dated August 9, 2002 for use as part of the Non-Discharge Permit Application for the State of North Carolina Department of Environment and Natural Resources, Division of Water Quality. The Basis of Design and the Construction Plans are considered Attachments O and E, respectively, of the Non-Discharge Permit application.

This Basis of Design is limited to the proposed groundwater remediation systems discussed within. Two separate groundwater pump and treat systems have been proposed for the North Terminal. One system is proposed for the PX Facility (identified on Sheet 3) and the other is proposed for the Gasoline/#2 Fuel Oil Facility (identified on Sheet 4 and herein referred to as the Loading Rack Area). The sections within the Basis of Design have been subdivided by PX Facility and Loading Rack Area.

FHR North Terminal is located at 3325 River Road in Wilmington, North Carolina as illustrated on Sheet 1 of the Construction Plans. As discussed in the CAPA, the North Terminal is subdivided into two facilities. These facilities are identified as the PX Facility and the Gasoline/Fuel Oil Facility on Sheet 2 of the Construction Plans.

The proposed remediation system enhancements outlined in the CAPA included the installation of additional air sparge wells. The air sparge wells are operated independent of the groundwater pump/treat system and are not included as part of this Basis of Design.

The goals of this proposed groundwater remediation system is to collect and reduce recovered surficial groundwater concentrations to below the current NCAC T15A:02L Groundwater Quality Standards (2L GWQS) prior to discharge. The groundwater removed from the proposed recovery wells will be pumped into one of the proposed groundwater remediation systems. This basis of design is limited to only the design of the recovery wells, the associated groundwater remediation system components, and the infiltration gallery discussed within this document.

It is important to note that the site history has been discussed within the CAPA and was also considered in the design of this groundwater remediation system.

1.1 PX FACILITY

1.1.1 Groundwater Remediation System Components

The major design components of each system include the following:

- Recovery Wells
- Remediation Equipment Trailer
- Oil/Water Separator
- Air Stripper
- Effluent tank
- Infiltration Gallery

A description of each component and the associated manufacturer information is provided in the attached sections.

1.1.2 System Layout

Surficial groundwater will be pumped from recovery wells KRW-5, KRW-7 and KRW-8. See Sheet 3 of the Construction Plans for location of these recovery wells. Recovery well KRW-5 was installed on November 3, 1997, prior to submittal of the CAPA. This recovery well currently discharges to the Facility Wastewater Treatment Plant (FWTP); however, this well is proposed to be rerouted into the proposed groundwater remediation system. Recovery well KRW-7 was installed on November 13, 2002, after submittal of the CAPA. The location of KRW-7 was based on the suggested location provided in the Final Report Evaluation of Enhancements to the Existing Groundwater Recovery System by Breen GeoScience Management, Inc. (BREEN). Recovery well KRW-8 was installed on November 14, 2002, after submittal of the CAPA. The location of KRW-8 was based on the recommendation provided in the CAPA.

As previously noted, surficial groundwater will be pumped from recovery wells KRW-5, KRW-7 and KRW-8 via the use of electrical submersible pumps. The groundwater will discharge to the groundwater remediation system, which will consist of an oil/water separator, an air stripper, and an effluent tank. The treated groundwater will then be discharged to an infiltration gallery. The proposed location of the groundwater remediation system and infiltration gallery is provided on Sheet 5 of the Construction Plans. A schematic illustration of the groundwater flow from the recovery wells to the infiltration gallery is provided on Sheet 7 of the Construction

Plans.

1.1.3 Explanation of System Flow Rates

As previously discussed in Attachment I of the Non-Discharge Permit Application, the maximum flow rate may be 60 gpm at low groundwater conditions and 80 gpm at high groundwater conditions. The system components discussed above have been conservatively designed on the maximum flow rate of 80 gpm. The maximum flow rate will be determined by low and high groundwater conditions as measured in monitoring wells adjacent to the infiltration gallery. Low and high groundwater conditions will be established by a system performance test that has been suggested by BREEN to stimulate capture of fluid discharged to the infiltration gallery. In summary, this basis of design has been completed with the assumption that the maximum flow rate through the remediation system will be 80 gpm and that the quantity of recovery wells may be increased based on a system performance test.

1.2 LOADING RACK AREA

1.2.1 Groundwater Remediation System Components

The major design components of each system include the following:

- Recovery Wells
- Remediation Equipment Trailer
- Oil/Water Separator
- Air Stripper
- Effluent tank
- Infiltration Gallery

A description of each component and the associated manufacturer information is provided in the attached sections.

1.2.2 System Layout

Surficial groundwater will be pumped from recovery wells LRRW-1, LRRW-2, LRRW-3 and LRRW-4. These recovery wells were installed on December 23 and 30, 2002, after submittal of the CAPA at the locations illustrated on Sheet 4 of the Construction Plans. The location of the recovery wells was based on preliminary groundwater modeling completed by BREEN. These locations were verified in the Results Initial Aquifer Testing, 2" Monitoring Wells, Truck Loading Rack by BREEN.

As previously noted, surficial groundwater will be pumped from recovery wells LRRW-1, LRRW-2, LRRW-3 and LRRW-4 via the use of electrical

submersible pumps. The groundwater recovery pumps will discharge to the groundwater remediation system, which will consist of an oil/water separator, an air stripper, and an effluent tank. The treated groundwater will then be discharged to an infiltration gallery. The proposed location of the groundwater remediation system and infiltration gallery is provided on Sheet 6 of the Construction Plans. A schematic illustration of the groundwater flow from the recovery wells to the infiltration gallery is provided on Sheet 8 of the Construction Plans.

1.2.3 Explanation of System Flow Rates

As previously discussed in Attachment I of the Non-Discharge Permit Application, the BREEN Technical Memorandum recommended four recovery wells be proposed for the groundwater remediation system at the Loading Road Area. Recommendations in the Technical Memorandum state that the total pumping rate of the four recovery wells would be 23 gpm. CATLIN has assumed this flow rate would be the operational flow rate. However, in order to allow for the addition of recovery wells or pumping rates in the future, CATLIN has designed the groundwater remediation system for a maximum flow rate of 40 gpm.

1.3 REFERENCES

Breen GeoScience Management, Inc. November 5, 2001, Evaluation of Enhancements to the Existing Groundwater Recovery System Koch North Terminal Tank 301 Para-Xylene, Wilmington, NC.

Breen GeoScience Management, Inc. January 20, 2003, Revised Technical Memorandum, Subject: Addendum to November 2001, Groundwater Modeling Report entitled "Final Report, Evaluation of Enhancements to the Existing Groundwater Recovery System, Koch North Terminal Tank 301 Para-Xylene."

Breen GeoScience Management, Inc. March 13, 2003, Technical Memorandum No. 3, Subject: Results Initial Aquifer Testing, 2" Monitoring Wells, Truck Loading Rack.

Carlyle Gray & Associates, May 21, 1984, Final Report of Para-Xylene Spill Sun Refining and Marketing Terminal, Wilmington, NC.

CATLIN Engineers and Scientists, August 9, 2002, Corrective Action Plan Addendum.

Code of Federal Regulations 29, Part 1910, Revised as of July 1, 1990. Office of the Federal Register National Archives and Records Administration.

Fugro Geosciences, Inc., March 21, 2002, Report Number: 0304-1268, Report Rapid Optical Screening Tool (ROST) Testing and Related Services Koch Refinery, Wilmington, NC.

IT Corporation of North Carolina, Inc., July 3, 2001, "Semi-Annual Remediation System Monitoring Report", Prepared for Sun Refining and Marketing Company, Philadelphia, Pennsylvania.

IT Corporation of North Carolina, Inc., December 19, 2001, "Semi-Annual Remediation System Monitoring Report & September 2001 Soil and Groundwater Sample Study Results", Prepared for Sun Refining and Marketing Company, Philadelphia, Pennsylvania.

North Carolina Administrative Code, Title 15, Department of Environment, Health and Natural Resources, Division of Environmental Management, Subchapter 2L, Classifications and Water Quality Standards Applicable to the Groundwaters of North Carolina, November 1993.

Richard Catlin & Associates, June 6, 1996, "Report of Additional Groundwater Assessment Findings Northeast Extent of Para-Xylene Plume for Sun Refining and Marketing Company, Wilmington NC."

Richard Catlin & Associates, April 16, 1996, "Corrective Action Plan for Koch North Terminal Tank 301, 3325 River Road, Wilmington, North Carolina," Prepared for Koch Refining Company, L.P.

Richard Catlin & Associates, August 7, 2000; "Comprehensive Site Assessment for Koch North Terminal Tank 301, 3325 River Road, Wilmington, North Carolina," Prepared for Koch Refining Company, L.P.

2.0 RECOVERY WELLS

The design of the recovery wells consisted of the following items: the recovery well, the recovery well pump, and the recovery well pump protector devices. The following sections discuss the design of these items.

2.1 PX FACILITY

2.1.1 Design of Recovery Well

As previously discussed, the proposed groundwater remediation system will treat groundwater from recovery wells KMW-5, KMW-7 and KMW-8. The location of these wells is illustrated on Sheet 3 of the Construction Plans.

The recovery wells were generally installed to a depth in which a confining clay layer was encountered. The recovery wells were constructed of a 4-inch stainless steel casing and screen. The attached boring logs and well construction records illustrate the soil types encountered, the depth of the recovery wells, the length of casing and the length of screen for the recovery wells associated with the proposed groundwater remediation system.

2.1.2 Design of Recovery Well Pumps (KRW-5, KRW-7 and KRW-8, only)

2.1.2.1 Assumptions

- The distance from KRW-8 to the groundwater remediation system is slightly farther than KRW-7 and KRW-5. Therefore, the location of KRW-8 was used as the worst case headloss scenario for the design of the recovery well pumps.
- Drawdown in the recovery well will be approximately 15 feet.
- The distance from the recovery well to the groundwater remediation system is 270 feet.
- The discharge line will be 1 1/4 inch Green XLPE Hose manufactured by Goodyear or approved equivalent.
- The maximum pumping rate to achieve drawdown will be 20 gpm.
- KRW-5 pump size will be upgraded to accommodate the total head loss discussed below.

2.1.2.2 Selection

The attached recovery well pump design calculations and manufacturer information were used to select the recovery well pumps for KRW-5, KRW-7, and KRW-8. Based on the design calculations the minimum pump size must maintain a maximum flow

rate of 20 gpm with an approximate total head loss of 60 feet. The plan is to utilize the 16E7 (3/4 HP) Grundfos Redi Flo Environmental Submersible Pump with a Franklin Electric 4" Pollution Recovery Submersible Motor or approved equivalent for the recovery pumps at KRW-5, KRW-7 and KRW-8.

2.1.3 Design of Recovery Well Pump Protectors

2.1.3.1 Assumptions

- A pump protector is needed to prevent pump overload and underload.
- Each recovery well will require a separate pump protector device.

2.1.3.2 Selection

The attached recovery well pump protector design calculations and manufacturer information were used to select the recovery well pump protectors. Based on the selected recovery well pump, the plan is to utilize a Coyote Pump Protector, Model 3PH230V-ENC by Coyote Manufacturing, Inc. or approved equivalent for the recovery pump protectors at KRW-5, KRW-7, and KRW-8.

2.2 LOADING RACK AREA

2.2.1 Design of Recovery Well

As previously discussed, the proposed groundwater remediation system will treat groundwater from recovery wells LRRW-1, LRRW-2, LRRW-3, and LRRW-4. The location of these wells is illustrated on Sheet 4 of the Construction Plans.

The recovery wells were generally installed to a depth in which a confining clay layer was encountered. The recovery wells were constructed of a 4-inch stainless steel casing and screen. The attached boring logs and well construction records illustrate the soil types encountered, the depth of the recovery wells, the length of casing and the length of screen for the recovery wells associated with the proposed groundwater remediation system.

2.2.2 Design of Recovery Well Pumps

2.2.2.1 Assumptions

- The distance from LRRW-1 to the groundwater remediation system is slightly farther than LRRW-2, LRRW-3 and LRRW-4.

Therefore, the location of LRRW-1 was used as the worst case headloss scenario for the design of the recovery well pumps for LRRW-2, LRRW-3 and LRRW-4.

- Drawdown in the recovery well will be approximately 10 feet.
- The distance from the recovery well to the groundwater remediation system is 265 feet.
- The discharge line will be 1 1/4 inch Green XLPE Hose manufactured by Goodyear or approved equivalent.
- The maximum pumping rate will be 10 gpm.

2.2.2.2 Selected Recovery Well Pumps

- The attached recovery well pump design calculations and manufacturer information were used to select the recovery well pumps for LRRW-1, LRRW-2, LRRW-3 and LRRW-4. Based on the design calculations, the minimum pump size must maintain a maximum flow rate of 10 gpm with an approximate total head loss of 30 feet. The plan is to utilize the 10E5 (1/2 HP) Grundfos Redi Flo Environmental Submersible Pump with a Franklin Electric 4" Pollution Recovery Submersible Motor or approved equivalent for the recovery pumps at LRRW-1, LRRW-2, LRRW-3, and LRRW-4.

2.2.3 Design of Recovery Well Pump Protectors

2.1.3.3 Assumptions

- A pump protector is needed to prevent pump overload and underload.
- Each recovery well will require a separate pump protector device.

2.1.3.4 Selection

The attached recovery well pump protector design calculations and manufacturer information were used to select the recovery well pump protectors. Based on the selected recovery well pump, the plan is to utilize a Coyote Pump Protector, Model 3PH230V-ENC by Coyote Manufacturing, Inc. or approved equivalent for the recovery pump protectors at LRRW-1, LRRW-2, LRRW-3 and LRRW-4.

BORING LOGS AND WELL CONSTRUCTION RECORDS
FOR
APPLICABLE PX FACILITY RECOVERY WELLS

MAIL SERVICE CENTER –
RALEIGH, N.C. 27699-1636 – PHONE (919) 733-3221

WELL CONSTRUCTION RECORD

KRW-5

WELL CONTRACTOR: Bobbie Fowler
WELL CONTRACTOR CERTIFICATION #: 1142
STATE WELL CONSTRUCTION PERMIT #: N/A

1. WELL USE (Check Applicable Box): Residential Municipal Industrial Agricultural Monitoring
Recovery Heat Pump Water Injection Other If Other, list use: _____

2. WELL LOCATION: (Show sketch of the location below)
Nearest Town: Wilmington County: New Hanover

3325 River Road, KOCH NORTH TERMINAL
(Road Name and Numbers, Community, or Subdivision and Lot No.)

3. OWNER KOCH PETROLEUM GROUP, LP

ADDRESS 3334 River Road
(Street or Route No.)
Wilmington, North Carolina 28403
City or Town State Zip Code

4. DATE DRILLED 10/23/97
5. TOTAL DEPTH 20.0'
6. CUTTINGS COLLECTED X YES ____ NO
7. DOES WELL REPLACE EXISTING WELL? ____ YES X NO
8. STATIC WATER LEVEL Below Top of Casing 5.0 Ft.
(use "+" if Above Top of Casing)
9. TOP OF CASING IS 1.0 Ft. Above Land Surface*
*Top of casing terminated at/or below land surface requires a variance in accordance with 15A NCAC 2C.0118
10. YIELD (gpm): N/A METHOD OF TEST N/A
11. WATER ZONES (depth) Surficial Aquifer 5 – 50'
12. CHLORINATION: Type N/A Amount N/A
13. CASING:

	Depth			Diameter	Wall Thickness or Weight/Ft.	Material
From	0	To	.5 Ft.	6"	SCH 40	Stain. Stl.
From		To	Ft.			
From		To	Ft.			

14. GROUT:

	Depth			Material	Method
From	0	To	1 Ft.	Cement	Tremie
From		To	Ft.		

15. SCREEN:

	Depth			Diameter		Slot Size		Material
From	5.0	To	20.0 Ft.	6	in.	.010	in	Stain. Stl.
From		To	Ft.					
From		To	Ft.					

16. SAND/GRAVEL PACK:

	Depth			Size	Material
From	3.0	To	20.0 Ft.	Torpedo	SAND
From		To	Ft.		

17. REMARKS: _____

DRILLING LOG From	To	DEPTH Formation Description
0	20	TAN/BROWN FINE –COARSE SAND POORLY SORTED (SP)

If additional space is needed, use back of form

LOCATION SKETCH
(Show direction and distance from at least two State Roads, or other map reference points)

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTIONN STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF PERSON CONSTRUCTING THE WELL — DATE 10/2/00

FOR OFFICE USE ONLY
Quad No: _____
Serial No: _____

Submit original to Division of Water Quality, Groundwater Section within 30 days

GW-1 REV.12/99

WELL LOG

CATLIN ENGINEERS and SCIENTISTS
Wilmington, North Carolina

SHEET 1 OF 1

PROJECT NO.: 195-033	**STATE:** NC	**COUNTY:** New Hanover	**LOCATION:** Wilmington
PROJECT NAME: Koch North Terminal		**LOGGED BY:** Charles Ray	**WELL ID:** KRW-7
		DRILLER: Bobbie Fowler	
NORTHING:	**EASTING:**	**SYSTEM:**	
BORING LOCATION: Kock North Terminal			**T.O.C. ELEV.:**
DRILL MACHINE: Diedrich D-50	**METHOD:** HSA	**0 HOUR DTW:**	**BORING DEPTH:** 30.0
START DATE: 11/13/02	**FINISH DATE:** 11/13/02	**24 HOUR DTW:**	**WELL DEPTH:** 29.0

DEPTH	BLOW COUNT 6in	6in	6in	6in	OVA (ppm)	LAB.	USCS	LOG	DEPTH	SOIL AND ROCK DESCRIPTION	WELL DETAIL
									0.0	LAND SURFACE	0.0
13.5	7	8	10	14			SP		13.5	Med. SAND with few shell fragments.	0.0
17.5	9	12	14	16			SP		17.5	White, clean, med. SAND with trace clay.	6" Slot .010 SS SS
21.5	10	13	18	12			SP		24.0		24.0
25.5	5	7	10	12			CL		29.5	Light Olive color, SANDY CLAY, med. to cse. grained sand in matrix with med. plasticity.	29.0
29.5										Boring Terminated at Depth 30.0 ft	30.0

CATLIN BORING LOG 195-033.GPJ CATLIN.GDT 01/07/03

HP = Hydraulic Push NM = Not Measured

#2 Medium Sand

WELL CONSTRUCTION RECORD

KRW-7

North Carolina - Department of Environment and Natural Resources - Division of Water Quality - Groundwater Section

WELL CONTRACTOR (INDIVIDUAL) NAME (print) Bobbie Fowler, CWD CERTIFICATION # 2869

WELL CONTRACTOR COMPANY NAME CATLIN Engineers and Scientists PHONE # (910) 452-5861

STATE WELL CONSTRUCTION PERMIT# (if applicable) WR# 0800588 ASSOCIATED WQ PERMIT# (if applicable) NA

1. WELL USE (Check Applicable Box): Residential ☐ Municipal/Public ☐ Industrial ☐ Agricultural ☐
Monitoring ☐ Recovery ☒ Heat Pump Water Injection ☐ Other ☐ If Other, List Use _____

2. WELL LOCATION:
Nearest Town: Wilmington County New Hanover
3325 River Road, NC, 28406
(Street Name, Numbers, Community, Subdivision, Lot No., Zip Code)

Topographic/Land setting
☐Ridge ☐Slope ☐Valley ☒Flat
(check appropriate box)
Latitude/longitude of well location
_____
(degrees/minutes/seconds)
Latitude/longitude source: ☐GPS ☐Topographic map
(check box)

3. OWNER: Flint Hill Resources, LP
Address 3325 River Road
(Street or Route No.)
Wilmington NC 28406
City or Town State Zip Code
(910)- 799-0180
Area code- Phone number

4. DATE DRILLED 11/13/02
5. TOTAL DEPTH: 29.5
6. DOES WELL REPLACE EXISTING WELL? YES ☐ NO ☒
7. STATIC WATER LEVEL Below Top of Casing: 8 FT.
(Use "+" if Above Top of Casing)
8. TOP OF CASING IS 1 FT. Above Land Surface*
*Top of casing terminated at/or below land surface requires a variance in accordance with 15A NCAC 2C .0118.
9. YIELD (gpm): N/A METHOD OF TEST N/A
10. WATER ZONES (depth): Surficial
11. DISINFECTION: Type N/A Amount N/A
12. CASING:

	Depth		Diameter	Wall Thickness or Weight/Ft.	Material
From 24	To 29	Ft. 6"	Sch 40	SS
From	To	Ft.		
From	To	Ft.		

13. GROUT:

	Depth		Material	Method
From 0	To 1	Ft. Portland	Tremmie
From	To	Ft. Bentonite	Pour

14. SCREEN:

	Depth		Diameter	Slot Size	Material
From 1	To 24	Ft. 6	in. 0.010	in. SS
From	To	Ft.	in.	in.

15. SAND/GRAVEL PACK:

	Depth		Size	Material
From 1	To 30	Ft. Coarse	Torpedo
From	To	Ft.	

DEPTH From	To	DRILLING LOG Formation Description
0	23	FINE TO MED. SAND, FEW FINES AND CLAYS
23	25.5	SANDY CLAY
25.5	29.50	MED. TO COARSE GRAINED SANDY CLAY, MEDIUM PLASTICITY

LOCATION SKETCH
Show direction and distance in miles from at least two State Roads or County Roads. Include the road numbers and common road names.

SEE FIGURE

16. REMARKS: Casing was used where the well intersected a clay layer at 25 to +29.5 feet below grade.

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER

Bobbie Fowler 12-9-02

SIGNATURE OF PERSON CONSTRUCTING THE WELL DATE

Submit the original to the Division of Water Quality, Groundwater Section, 1636 Mail Service Center - Raleigh, NC 27699-1636 Phone No. (919) 733-3221, within 30 days.

GW-1 REV. 07/2001

WELL LOG

CATLIN ENGINEERS and SCIENTISTS
Wilmington, North Carolina

PROJECT NO.: 195-033	**STATE:** NC	**COUNTY:** New Hanover	**LOCATION:** Wilmington
PROJECT NAME: Koch North Terminal		**LOGGED BY:** Charles Ray	**WELL ID:** KRW-8
		DRILLER: Bobbie Fowler	
NORTHING:	**EASTING:**	**SYSTEM:**	
BORING LOCATION: Kock North			**T.O.C. ELEV.:**
DRILL MACHINE: Diedrich D-50	**METHOD:** HSA	**0 HOUR DTW:**	**BORING DEPTH:** 30.0
START DATE: 11/14/02	**FINISH DATE:** 11/14/02	**24 HOUR DTW:**	**WELL DEPTH:** 28.0

DEPTH	BLOW COUNT 6in	6in	6in	6in	OVA (ppm)	LAB.	USCS	LOG	SOIL AND ROCK DESCRIPTION	WELL DETAIL
									0.0 LAND SURFACE	0.0
0.0	G	R	A	B			SP		Olive, med. grained SAND with few fines. Odor present.	0.0
13.0	21	21	34	44					17.0	
17.0	24	26	35	32			SP		S.A.A, med. to cse. grained. High odor. 20.0	
21.0	10	7	9	11			SP		Tan, S.A.A. Slight odor. 25.0	23.0
25.0	8	18	36	32			CL		Mottled, fine to med. grained, SANDY CLAY with high plasticity. No odor. 27.0	25.0
							SC		Green, fine to med. grained, CLAYEY SAND. Glaconite sand. No odor.	28.0
29.0	G	R	A	B					30.0	30.0

6" Slot .010 SS SS

CATLIN BORING LOG 195-033.GPJ CATLIN.GDT 12/13/02

HP = Hydraulic Push NM = Not Measured

#2 Medium Sand Bentonite Pellets

WELL LOG

CATLIN ENGINEERS and SCIENTISTS
Wilmington, North Carolina

PROJECT NO.: 195-033	**STATE:** NC	**COUNTY:** New Hanover	**LOCATION:** Wilmington
PROJECT NAME: Koch North Terminal		**LOGGED BY:** Charles Ray	**WELL ID:** KRW-8
		DRILLER: Bobbie Fowler	
NORTHING:	**EASTING:**	**SYSTEM:**	
BORING LOCATION: Kock North			**T.O.C. ELEV.:**
DRILL MACHINE: Diedrich D-50	**METHOD:** HSA	**0 HOUR DTW:**	**BORING DEPTH:** 30.0
START DATE: 11/14/02	**FINISH DATE:** 11/14/02	**24 HOUR DTW:**	**WELL DEPTH:** 28.0

DEPTH	BLOW COUNT 6in	6in	6in	6in	OVA (ppm)	LAB.	USCS	LOG	DEPTH	SOIL AND ROCK DESCRIPTION	WELL DETAIL
30.0										Boring Terminated at Depth 30.0 ft	

HP = Hydraulic Push NM = Not Measured

#2 Medium Sand Bentonite Pellets

CATLIN BORING LOG 195-033.GPJ CATLIN.GDT 12/13/02

WELL CONSTRUCTION RECORD

KRW-8

North Carolina - Department of Environment and Natural Resources - Division of Water Quality - Groundwater Section

WELL CONTRACTOR (INDIVIDUAL) NAME (print) Bobbie Fowler, CWD CERTIFICATION # 2869

WELL CONTRACTOR COMPANY NAME CATLIN Engineers and Scientists PHONE # (910) 452-5861

STATE WELL CONSTRUCTION PERMIT# (if applicable) WR# 0800588 ASSOCIATED WQ PERMIT# (if applicable) NA

1. WELL USE (Check Applicable Box): Residential ☐ Municipal/Public ☐ Industrial ☐ Agricultural ☐ Monitoring ☐ Recovery ☒ Heat Pump Water Injection ☐ Other ☐ If Other, List Use_____

2. WELL LOCATION:
Nearest Town: Wilmington County New Hanover
3325 River Road, NC, 28406
(Street Name, Numbers, Community, Subdivision, Lot No., Zip Code)

Topographic/Land setting
☐Ridge ☐Slope ☐Valley ☒Flat
(check appropriate box)
Latitude/longitude of well location
_____
(degrees/minutes/seconds)
Latitude/longitude source: ☐GPS ☐Topographic map
(check box)

3. OWNER: Flint Hill Resources, LP
Address 3325 River Road
(Street or Route No.)
Wilmington NC 28406
City or Town State Zip Code
(910)- 799-0180
Area code- Phone number

4. DATE DRILLED 11/14/02
5. TOTAL DEPTH: 30
6. DOES WELL REPLACE EXISTING WELL? YES ☐ NO ☒
7. STATIC WATER LEVEL Below Top of Casing: 5 FT.
(Use "+" if Above Top of Casing)
8. TOP OF CASING IS 1 FT. Above Land Surface*
***Top of casing terminated at/or below land surface requires a variance in accordance with 15A NCAC 2C .0118.**
9. YIELD (gpm): N/A METHOD OF TEST N/A
10. WATER ZONES (depth): Surficial

DEPTH From	DEPTH To	DRILLING LOG Formation Description
0	25	FINE TO MEDIUM GRAINED SAND
25	27	FINE TO MEDIUM GRAINED SANDY CLAY high PLASTICITY
27	30	GREEN FINE TO MED. GRAINED CLAYEY SAND

11. DISINFECTION: Type N/A Amount N/A
12. CASING:

	Depth From	To	Ft.	Diameter	Wall Thickness or Weight/Ft.	Material
	23	28		6"	Sch 40	SS

13. GROUT:

	Depth From	To	Ft.	Material	Method
	0	1		Portland	Tremmie
	25	30		Bentonite	Pour

14. SCREEN:

	Depth From	To	Ft.	Diameter	Slot Size	Material
	1	23		6 in.	0.010 in.	SS
				in.	in.	

15. SAND/GRAVEL PACK:

	Depth From	To	Ft.	Size	Material
	1	25		Coarse	Torpedo

LOCATION SKETCH
Show direction and distance in miles from at least two State Roads or County Roads. Include the road numbers and common road names.

SEE FIGURE

16. REMARKS: Casing was used where the well intersected a clay layer at 25-27 feet below grade.

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER

[signature] 12-9-02

SIGNATURE OF PERSON CONSTRUCTING THE WELL DATE

Submit the original to the Division of Water Quality, Groundwater Section, 1636 Mail Service Center - Raleigh, NC 27699-1636 Phone No. (919) 733-3221, within 30 days.

GW-1 REV. 07/2001

BORING LOGS AND WELL CONSTRUCTION RECORDS
FOR
APPLICABLE LOADING RACK AREA RECOVERY WELLS

WELL CONSTRUCTION RECORD

North Carolina - Department of Environment and Natural Resources - Division of Water Quality - Groundwater Section

WELL CONTRACTOR (INDIVIDUAL) NAME (print) Bobbie Fowler — CERTIFICATION # 2869

WELL CONTRACTOR COMPANY NAME CATLIN Engineers & Scientists — PHONE # (910) 452-5861

STATE WELL CONSTRUCTION PERMIT # (if applicable) 2869 — ASSOCIATED WQ PERMIT # (if applicable) N/A

LRRW-1

1. WELL USE (Check Applicable Box): Residential ☐ Municipal/Public ☐ Industrial ☐ Agricultural ☐
   Monitoring ☐ Recovery ☒ Heat Pump Water Injection ☐ Other ☐ If Other, List Use _____
2. WELL LOCATION: (Show sketch of the location below)
   Nearest Town: Wilmington County: New Hanover
   _____
   (Road Name and Numbers, Community, Subdivision, Lot No., Zip Code)

   Topographic/Land Setting
   ☐ Ridge ☐ Slope ☐ Valley ☒ Flat
   (check appropriate box)

   Northing/Easting of well location
   _____ / _____
3. OWNER: Flint Hills Resources, LP
   Address: 3334 River Road
   (Street or Route No.)
   Wilmington (City or Town) NC (State) 28412 (Zip Code)
   (910) 799-0180
   Area code - Phone number

   Latitude/longitude source: ☐ GPS ☐ Topo. map
   (check box)
4. DATE DRILLED: 12/23/2002
5. TOTAL DEPTH: 20
6. DOES WELL REPLACE EXISTING WELL? YES ☐ NO ☒
7. STATIC WATER LEVEL Below Top of Casing 2.0 FT.
   (Use "+" if Above Top of Casing)
8. TOP OF CASING IS 0 FT. Above Land Surface*
   * Top of casing terminated at/or below land surface requires a variance in accordance with 15A NCAC 2C.0118
9. YIELD (gpm): N/A METHOD OF TEST N/A
10. WATER ZONES (depth): Surficial Aquifer
12. DISINFECTION: Type N/A Amount N/A

DEPTH From	To	DRILLING LOG Formation Description
		SEE ATTACHED

13. CASING:

Depth From	To	Diameter	Wall Thickness or Weight/Ft.	Material
____	____ ft.	_____ in.	_____	_____
____	____ ft.	_____ in.	_____	_____
____	____ ft.	_____ in.	_____	_____

14. GROUT:

Depth From	To	Material	Method
____	____ ft.	_____	_____
____	____ ft.	_____	_____

15. SCREEN:

Depth From	To	Diameter	Slot Size	Material
0	20 ft.	4 in.	Slot .010 in.	SS
____	____ ft.	_____ in.	_____ in.	_____

16. SAND/GRAVEL PACK:

Depth From	To	Size	Material
0	21 ft.	#2 Medium	Torpedo Sand
____	____ ft.	_____	_____

LOCATION SKETCH

Show direction and distance in miles from at least two State Roads or County Roads. Include road numbers and common road names.

SEE ATTACHED

17. REMARKS: _____

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Bobbie Fowler — 1-3-03

SIGNATURE OF PERSON CONSTRUCTING THE WELL — DATE

Submit original to Division of Water Quality, Groundwater Section, 1636 Mail Service Center - Raleigh, NC 27699-1636 Phone No. (919) 733-3221, within 30 days.

Modified from: GW-1 REV.07/2001

NC WELL CONSTRUCTION RECORD 201-125.GPJ CATLIN.GDT 01/03/03

WELL LOG

CATLIN ENGINEERS and SCIENTISTS
Wilmington, North Carolina

SHEET 1 OF 1

PROJECT NO.: 201-125	STATE: NC	COUNTY: New Hanover	LOCATION: Wilmington	
PROJECT NAME: FHR North Terminal		LOGGED BY: STEVE TYLER		WELL ID: LRRW-1
		DRILLER: Bobbie Fowler		
NORTHING:	EASTING:	SYSTEM:		T.O.C. ELEV.:
BORING LOCATION:				
DRILL MACHINE: CME 45B ATV	METHOD: MR	0 HOUR DTW: 2.0		BORING DEPTH: 21.0
START DATE: 12/23/02	FINISH DATE: 12/23/02	24 HOUR DTW: 2.0		WELL DEPTH: 20.0

DEPTH	BLOW COUNT 6in	6in	6in	6in	OVA (ppm)	LAB.	USCS	LOG	SOIL AND ROCK DESCRIPTION DEPTH		WELL DETAIL
									0.0	LAND SURFACE	0.0
							SP			Tan, poorly graded, fine to med. grained SAND with few fines. Slight HCO from 3.0' to 7.0' bls.	4" Slot .010 SS
									21.0	Boring Terminated at Depth 21.0 ft	20.0 21.0

HP = Hydraulic Push NM = Not Measured

#2 Medium Sand

CATLIN BORING LOG 201-125.GPJ CATLIN.GDT 01/03/03

WELL CONSTRUCTION RECORD

North Carolina - Department of Environment and Natural Resources - Division of Water Quality - Groundwater Section

WELL CONTRACTOR (INDIVIDUAL) NAME (print) Bobbie Fowler CERTIFICATION # 2869

WELL CONTRACTOR COMPANY NAME CATLIN Engineers & Scientists PHONE # (910) 452-5861

STATE WELL CONSTRUCTION PERMIT # (if applicable) 2869 ASSOCIATED WQ PERMIT # (if applicable) N/A

LRRW-2

1. WELL USE (Check Applicable Box): Residential ☐ Municipal/Public ☐ Industrial ☐ Agricultural ☐
   Monitoring ☐ Recovery ☒ Heat Pump Water Injection ☐ Other ☐ If Other, List Use _____
2. WELL LOCATION: (Show sketch of the location below)
   Nearest Town: Wilmington County: New Hanover
   _____
   (Road Name and Numbers, Community, Subdivision, Lot No., Zip Code)

   Topographic/Land Setting
   ☐Ridge ☐Slope ☐Valley ☒Flat
   (check appropriate box)
   Northing/Easting of well location
   _____ / _____
3. OWNER: Flint Hills Resources, LP
   Address: 3334 River Road
   (Street or Route No.)
   Wilmington (City or Town) NC (State) 28412 (Zip Code)
   (910) 799-0180
   Area code - Phone number

   Latitude/longitude source: ☐GPS ☐Topo. map
   (check box)
4. DATE DRILLED: 12/23/2002
5. TOTAL DEPTH: 20
6. DOES WELL REPLACE EXISTING WELL? YES ☐ NO ☒
7. STATIC WATER LEVEL Below Top of Casing 2.0 FT.
   (Use "+" if Above Top of Casing)
8. TOP OF CASING IS 0 FT. Above Land Surface*
   * Top of casing terminated at/or below land surface requires a variance in accordance with 15A NCAC 2C.0118
9. YIELD (gpm): N/A METHOD OF TEST N/A
10. WATER ZONES (depth): Surficial Aquifer
    _____
12. DISINFECTION: Type N/A Amount N/A
13. CASING:

Depth From	To	Diameter	Wall Thickness or Weight/Ft.	Material
	ft.	in.		
	ft.	in.		
	ft.	in.		

14. GROUT:

Depth From	To	Material	Method
	ft.		
	ft.		

15. SCREEN:

Depth From	To	Diameter	Slot Size	Material
0	20 ft.	4 in.	Slot .010 in.	SS
	ft.	in.	in.	

16. SAND/GRAVEL PACK:

Depth From	To	Size	Material
0	21 ft.	#2 Medium	Torpedo Sand
	ft.		

17. REMARKS: _____

DEPTH From	To	DRILLING LOG Formation Description
		SEE ATTACHED

LOCATION SKETCH

Show direction and distance in miles from at least two State Roads or County Roads. Include road numbers and common road names.

SEE ATTACHED

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Bobbie Fowler 1-3-03

SIGNATURE OF PERSON CONSTRUCTING THE WELL DATE

Submit original to Division of Water Quality, Groundwater Section, 1636 Mail Service Center - Raleigh, NC 27699-1636 Phone No. (919) 733-3221, within 30 days.

Modified from: GW-1 REV.07/2001

JC WELL CONSTRUCTION RECORD 201-125.GPJ CATLIN.GDT 01/03/03

WELL LOG

CATLIN ENGINEERS and SCIENTISTS
Wilmington, North Carolina

SHEET 1 OF 1

PROJECT NO.: 201-125	STATE: NC	COUNTY: New Hanover	LOCATION: Wilmington
PROJECT NAME: FHR North Terminal		LOGGED BY: STEVE TYLER	WELL ID: LRRW-2
		DRILLER: Bobbie Fowler	
NORTHING:	EASTING:	SYSTEM:	T.O.C. ELEV.:
BORING LOCATION:			
DRILL MACHINE: CME 45B ATV	METHOD: MR	0 HOUR DTW: 2.0	BORING DEPTH: 21.0
START DATE: 12/23/02	FINISH DATE: 12/23/02	24 HOUR DTW: 2.0	WELL DEPTH: 20.0

DEPTH	BLOW COUNT 6in	6in	6in	6in	OVA (ppm)	LAB.	USCS	LOG	SOIL AND ROCK DESCRIPTION	WELL DETAIL
									0.0 LAND SURFACE	0.0
							SP		Tan, poorly graded, fine to med. SAND with few fines. Slight HCO from 2.5' to 8.5' bls.	4" Slot .010 SS
									20.0	20.0
							SC		21.0 Light green, fine to med., CLAYEY SAND with moderate plasticity.	21.0
									Boring Terminated at Depth 21.0 ft	

HP = Hydraulic Push NM = Not Measured

#2 Medium Sand

CATLIN BORING LOG 201-125.GPJ CATLIN.GDT 01/03/03

WELL CONSTRUCTION RECORD

North Carolina - Department of Environment and Natural Resources - Division of Water Quality - Groundwater Section

WELL CONTRACTOR (INDIVIDUAL) NAME (print) Bobbie Fowler — CERTIFICATION # 2869

WELL CONTRACTOR COMPANY NAME CATLIN Engineers & Scientists — PHONE # (910) 452-5861

STATE WELL CONSTRUCTION PERMIT # (if applicable) 2869 — ASSOCIATED WQ PERMIT # (if applicable) N/A

LRRW-3

1. WELL USE (Check Applicable Box): Residential ☐ Municipal/Public ☐ Industrial ☐ Agricultural ☐
   Monitoring ☐ Recovery ☒ Heat Pump Water Injection ☐ Other ☐ If Other, List Use _____
2. WELL LOCATION: (Show sketch of the location below)
   Nearest Town: Wilmington County: New Hanover
   _____
   (Road Name and Numbers, Community, Subdivision, Lot No., Zip Code)

   Topographic/Land Setting
   ☐ Ridge ☐ Slope ☐ Valley ☒ Flat
   (check appropriate box)
   Northing/Easting of well location
   _____ / _____
3. OWNER: Flint Hills Resources, LP
   Address: 3334 River Road
   (Street or Route No.)
   Wilmington (City or Town) NC (State) 28412 (Zip Code)
   (910) 799-0180
   Area code - Phone number

   Latitude/longitude source: ☐ GPS ☐ Topo. map
   (check box)
4. DATE DRILLED: 12/30/2002
5. TOTAL DEPTH: 20
6. DOES WELL REPLACE EXISTING WELL? YES ☐ NO ☒
7. STATIC WATER LEVEL Below Top of Casing 2.0 FT.
   (Use "+" if Above Top of Casing)
8. TOP OF CASING IS 0 FT. Above Land Surface*
   * Top of casing terminated at/or below land surface requires a variance in accordance with 15A NCAC 2C.0118
9. YIELD (gpm): N/A METHOD OF TEST N/A
10. WATER ZONES (depth): Surficial Aquifer
    _____
12. DISINFECTION: Type N/A Amount N/A
13. CASING:

Depth From	To	ft.	Diameter	in.	Wall Thickness or Weight/Ft.	Material

14. GROUT:

Depth From	To	ft.	Material	Method

15. SCREEN:

Depth From	To	ft.	Diameter	in.	Slot Size	in.	Material
0	20		4		Slot .010		SS

16. SAND/GRAVEL PACK:

Depth From	To	ft.	Size	Material
0	21		#2 Medium	Torpedo Sand

SEE ATTACHED

LOCATION SKETCH

Show direction and distance in miles from at least two State Roads or County Roads. Include road numbers and common road names.

SEE ATTACHED

17. REMARKS: _____

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Bobbie Fowler — 1-3-03

SIGNATURE OF PERSON CONSTRUCTING THE WELL — DATE

Submit original to Division of Water Quality, Groundwater Section, 1636 Mail Service Center - Raleigh, NC 27699-1636 Phone No. (919) 733-3221, within 30 days.

Modified from: GW-1 REV.07/2001

C WELL CONSTRUCTION RECORD 201-125.GPJ CATLIN.GDT 01/03/03

WELL LOG

CATLIN ENGINEERS and SCIENTISTS
Wilmington, North Carolina

SHEET 1 OF 1

PROJECT NO.: 201-125	STATE: NC	COUNTY: New Hanover	LOCATION: Wilmington
PROJECT NAME: FHR North Terminal		LOGGED BY: STEVE TYLER	WELL ID: LRRW-3
		DRILLER: Bobbie Fowler	
NORTHING:	EASTING:	SYSTEM:	T.O.C. ELEV.:
BORING LOCATION:			BORING DEPTH: 21.0
DRILL MACHINE: CME 45B ATV	METHOD: MR	0 HOUR DTW: 2.0	WELL DEPTH: 20.0
START DATE: 12/30/02	FINISH DATE: 12/30/02	24 HOUR DTW: 2.0	

DEPTH	BLOW COUNT 6in	6in	6in	6in	OVA (ppm)	LAB.	USCS	LOG	DEPTH	SOIL AND ROCK DESCRIPTION	WELL DETAIL
									0.0	LAND SURFACE	0.0
							SP			Tan, poorly graded, fine to med. SAND with few fines. Moderate to slight HCO from 2.5' to 10.0' bls.	4" Slot .010 SS
									20.0		20.0
							SC		21.0	Light green, fine to med., CLAYEY SAND with moderate plasticity.	21.0
										Boring Terminated at Depth 21.0 ft	

CATLIN BORING LOG 201-125.GPJ CATLIN.GDT 01/03/03

HP = Hydraulic Push NM = Not Measured

#2 Medium Sand

WELL CONSTRUCTION RECORD

North Carolina - Department of Environment and Natural Resources - Division of Water Quality - Groundwater Section

WELL CONTRACTOR (INDIVIDUAL) NAME (print) Bobbie Fowler — CERTIFICATION # 2869

WELL CONTRACTOR COMPANY NAME CATLIN Engineers & Scientists — PHONE # (910) 452-5861

STATE WELL CONSTRUCTION PERMIT # (if applicable) 2869 — ASSOCIATED WQ PERMIT # (if applicable) N/A

LRRW-4

1. WELL USE (Check Applicable Box): Residential ☐ Municipal/Public ☐ Industrial ☐ Agricultural ☐
   Monitoring ☐ Recovery ☒ Heat Pump Water Injection ☐ Other ☐ If Other, List Use _____
2. WELL LOCATION: (Show sketch of the location below)
   Nearest Town: Wilmington County: New Hanover
   _____
   (Road Name and Numbers, Community, Subdivision, Lot No., Zip Code)

Topographic/Land Setting
☐ Ridge ☐ Slope ☐ Valley ☒ Flat
(check appropriate box)

Northing/Easting of well location
_____ / _____

3. OWNER: Flint Hills Resources, LP
   Address: 3334 River Road
   (Street or Route No.)
   Wilmington (City or Town) NC (State) 28412 (Zip Code)
   (910) 799-0180
   Area code - Phone number

Latitude/longitude source: ☐ GPS ☐ Topo. map
(check box)

DEPTH From	To	DRILLING LOG Formation Description
		SEE ATTACHED

4. DATE DRILLED: 12/23/2002
5. TOTAL DEPTH: 20
6. DOES WELL REPLACE EXISTING WELL? YES ☐ NO ☒
7. STATIC WATER LEVEL Below Top of Casing 2.0 FT.
   (Use "+" if Above Top of Casing)
8. TOP OF CASING IS 0 FT. Above Land Surface*
   * Top of casing terminated at/or below land surface requires a variance in accordance with 15A NCAC 2C.0118
9. YIELD (gpm): N/A METHOD OF TEST N/A
10. WATER ZONES (depth): Surficial Aquifer
    _____
12. DISINFECTION: Type N/A Amount N/A
13. CASING:

Depth From	To	Diameter	Wall Thickness or Weight/Ft.	Material
	ft.	in.		
	ft.	in.		
	ft.	in.		

14. GROUT:

Depth From	To	Material	Method
	ft.		
	ft.		

15. SCREEN:

Depth From	To	Diameter	Slot Size	Material
0	20 ft.	4 in.	Slot .010 in.	SS
	ft.	in.	in.	

16. SAND/GRAVEL PACK:

Depth From	To	Size	Material
0	21 ft.	#2 Medium	Torpedo Sand
	ft.		

LOCATION SKETCH
Show direction and distance in miles from at least two State Roads or County Roads. Include road numbers and common road names.

SEE ATTACHED

17. REMARKS: _____

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

[signature] 1-3-03

SIGNATURE OF PERSON CONSTRUCTING THE WELL — DATE

Submit original to Division of Water Quality, Groundwater Section, 1636 Mail Service Center - Raleigh, NC 27699-1636 Phone No. (919) 733-3221, within 30 days.

Modified from: GW-1 REV.07/2001

C WELL CONSTRUCTION RECORD 201-125.GPJ CATLIN.GDT 01/03/03

WELL LOG

CATLIN ENGINEERS and SCIENTISTS
Wilmington, North Carolina

SHEET 1 OF 1

PROJECT NO.: 201-125	STATE: NC	COUNTY: New Hanover		LOCATION: Wilmington	
PROJECT NAME: FHR North Terminal		LOGGED BY: STEVE TYLER		WELL ID: LRRW-4	
		DRILLER: Bobbie Fowler			
NORTHING:	EASTING:	SYSTEM:		T.O.C. ELEV.:	
BORING LOCATION:					
DRILL MACHINE: CME 45B ATV	METHOD: MR		0 HOUR DTW: 2.0	BORING DEPTH: 21.0	
START DATE: 12/23/02	FINISH DATE: 12/23/02		24 HOUR DTW: 2.0	WELL DEPTH: 20.0	

DEPTH	BLOW COUNT 6in	6in	6in	6in	OVA (ppm)	LAB.	USCS	LOG	SOIL AND ROCK DESCRIPTION	WELL DETAIL
									DEPTH	
									0.0 LAND SURFACE	0.0
							SP		Tan, poorly graded, fine to med. SAND with few fines. Slight HCO from 1.5' to 4.5' and 8.0' to 12.0' bls. Moderate HCO from 4.5' to 8.0' bls.	4" Slot .010 SS
									20.0	20.0
							SC		21.0 Light green, fine to med., CLAYEY SAND with moderate plasticity.	21.0
									Boring Terminated at Depth 21.0 ft	

CATLIN BORING LOG 201-125.GPJ CATLIN.GDT 01/03/03

HP = Hydraulic Push NM = Not Measured

#2 Medium Sand

RECOVERY WELL PUMP DESIGN CALCULATIONS
AND MANUFACTURER INFORMATION
FOR
PX FACILITY

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 195-033

Drawn/Calculated by: Jeff Becken
Date: 11/14/02
Reviewed by: WJV

Design Recovery Well Pump

Calculate Head Loss

- Calculate from proposed recovery well KRW-8 which is assumed worst case due to distance from treatment system (270' - Approximate)

- Assumptions
  ~~- Top of water table~~
  - Drawdown in KRW-8 will be 15 ft
  - Water discharges into oil/water separator which sits 5 feet above ground surface
  - Concrete pad thickness (maximum) = 0.5 feet
  - Discharge line will be 1¼" Green XLPE Hose by Goodyear that will run from pump to pretreatment system. Head Loss for this hose is 4.15 psi per 100 LF per manufacturer information on attached pages

$$4.15 \text{ psi} \times 2.309 \frac{\text{ft of Head}}{\text{psi}} = 9.58 \text{ feet per 100 LF}$$

$$\text{ft of } H_2O$$

  - Flow through hose is 20 gallons per minute.
  - Minor losses are 20% of total hose length

Calculate ELEVATION HEAD LOSS

= Drawdown + elevation difference between pumping well and pretreatment system + height of oil/water separator (discharge point)

where
- Pumping well elevation = 35.23 feet → MW-12 TOC elevation
- pretreatment system elevation = 33.90 feet → MW-13 TOC elevation

$$= 15 \text{ ft} + (33.90 - 35.23) \text{ ft} + 5 \text{ ft}$$

$$= 18.67 \text{ ft}$$

Use 20 feet

Catalog #01-130
Supersedes Catalog #99-130

Head Loss In Hose

INDUSTRIAL HOSE PRODUCTS

Water Flow Pressure Loss (PSI Per 100 Feet Of Hose)

Flow of water in U.S. gal. per min.	Flow of water in cu. feet per sec.	Actual Internal Diameter, Inches								
		½	⅝	¾	1	1¼	1½	2	2½	3
0.5	.001	0.4								
1.5	.003	3.02	1.01	0.42						
2.5	.005	7.75	2.58	1.08						
5	.011	27.8	9.27	3.86	0.95	0.32	0.13			
10	.022	99.5	33.2	13.8	3.38	1.14	0.47	0.12		
40	.088				44.7	15.1	6.20	1.52	0.51	0.21
45	.099				55.0	18.6	7.65	1.87	0.63	0.26
50	.110				67.5	22.8	9.35	2.28	0.78	0.32
60	.132				94.3	31.8	13.1	3.19	1.08	0.45
70	.154				126.0	42.5	17.5	4.25	1.44	0.60
175	.390						94.5	23.1	7.83	3.23
200	.446						122.0	29.6	10.1	4.15
225	.501							36.8	12.5	5.15
250	.557							44.6	15.2	6.28
275	.613							53.3	18.1	7.45
450	1.00								44.9	18.6
500	1.11								54.5	22.5
600	1.34								76.5	31.6
700	1.56								102.0	42.1
800	1.78								131.0	53.9
1400	3.12									
1500	3.34									
1600	3.56									
1800	4.01									
2000	4.45									

Note: *The pressure loss experienced by a liquid flowing through a hose depends on the rate of flow, the viscosity of the liquid, the hose I.D., the smoothness of the tube, and the hose length. This chart shows the relationship between rate of flow, I.D., and pressure loss for water at 68°F with a viscosity of one centipoise. The pressure is directly proportional to the length of the hose, therefore, the data shown can be easily extended by use of proportions, e.g., the pressure drop for 50 feet of hose length is half that for 100 feet.*

GOODYEAR

See Page 2 for complete product warranty and terms of sale information. In V-Cat, please reference the Conditions of Sale page in the General Information section. Information in this catalog supersedes all previously printed material. Information valid through December 31, 2002.

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 195-033

Drawn/Calculated by: Jeff Becker
Date:
Reviewed by: WJW

Design Recovery Well Pump (cont.)

Calculate Head Loss (cont.)

Velocity Head Loss

= (friction head loss per 100 LF) x Total length x minor losses

= (9.58 ft/100 LF) x (270 ft) x 1.2

= 31.0 ft

Use 35 feet

Total Head Loss

= Elevation Head Loss + Velocity Head Loss

= 20 feet + 35 feet

= 55 feet

Use 60 feet

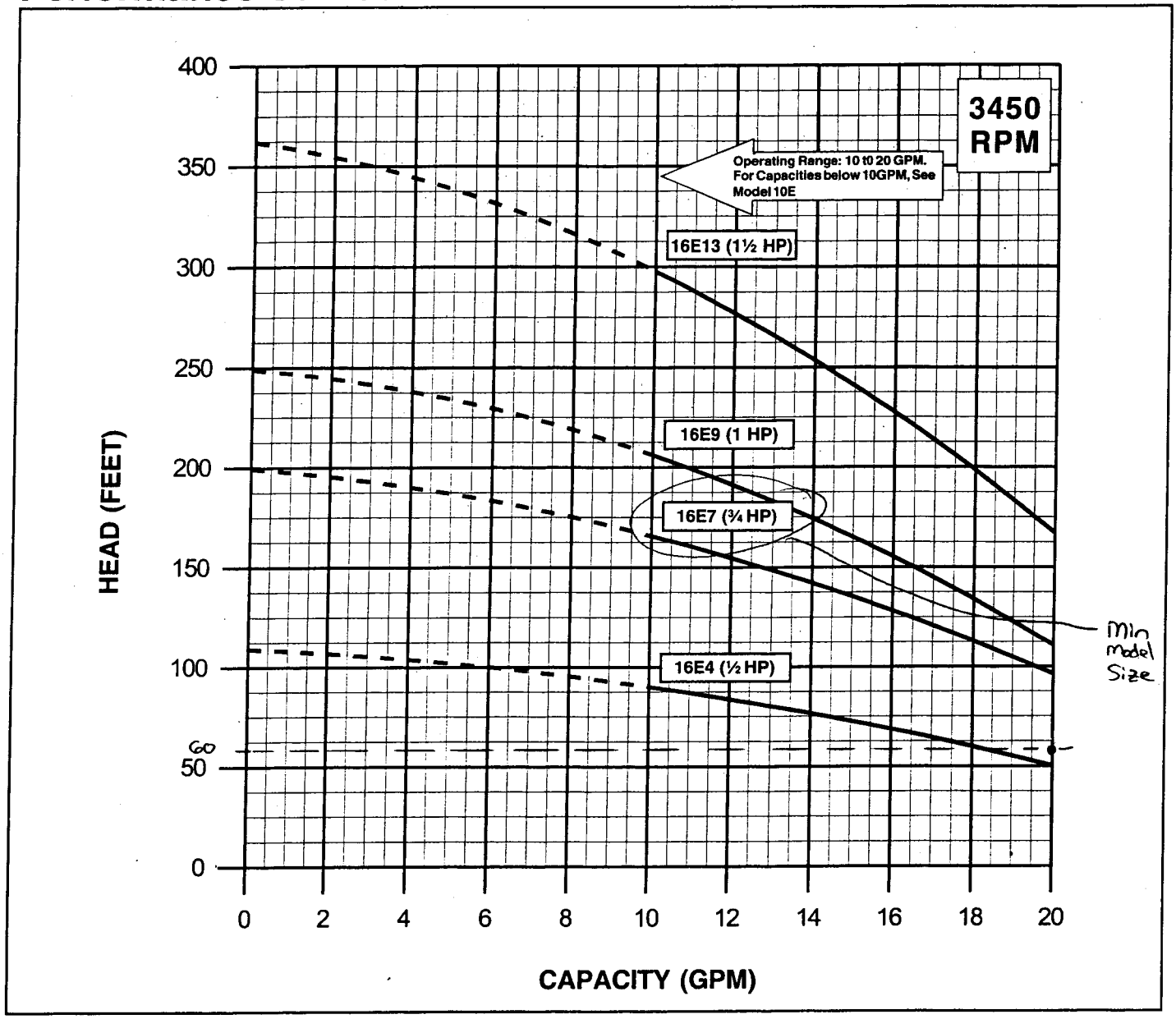
Select Pump

Based on attached pump curve, the minimum pump size for 20 gpm and 60 feet of head is the model 16E7 (3/4 HP).

Use: 16E7 (3/4HP) Grundfos Redi Flo Environmental Submersible Pump with a Franklin Electric 4" Pollution Recovery Submersible Motor or approved equivalent.

Performance Curves

16E



Materials of Construction

REDI-FLO4 PUMP END

Description	Material
Check Valve Housing, Check Valve, Diffuser Chamber, Impeller, Suction Interconnector, Inlet Screen, Pump Shaft, Straps, Cable Guard, Priming Inducer	304 SS
Check Valve Seat	304 SS & Teflon®
Impeller Seal Ring	Teflon®
Coupling	316/431 SS
Intermediate Bearings	Teflon®

GRUNDFOS ENVIRONMENTAL MOTOR

Description	Material
NEMA Top, Studs & Fasteners, Stator Housing, Fill Plug Screw	304 SS
Nuts	316 SS
Sand Slinger	FPM
Shaft Extension	431 SS
Diaphragm	FPM
Fill Plug Washer	Teflon®

GRUNDFOS ENVIRONMENTAL MOTOR LEADS

Description	Material
Connector Sleeve	304 SS
Connector Potting	Scotch Cast #4® Epoxy w/FPM Cap
Connector Plug	FPM
Lead Insulation	Teflon®
Conductor	Stranded Copper, 12 AWG

NOTES: Specifications are subject to change without notice.
Teflon® is a registered trademark of DuPont.
Scotch Cast #4® is a registered trademark of 3M Company.

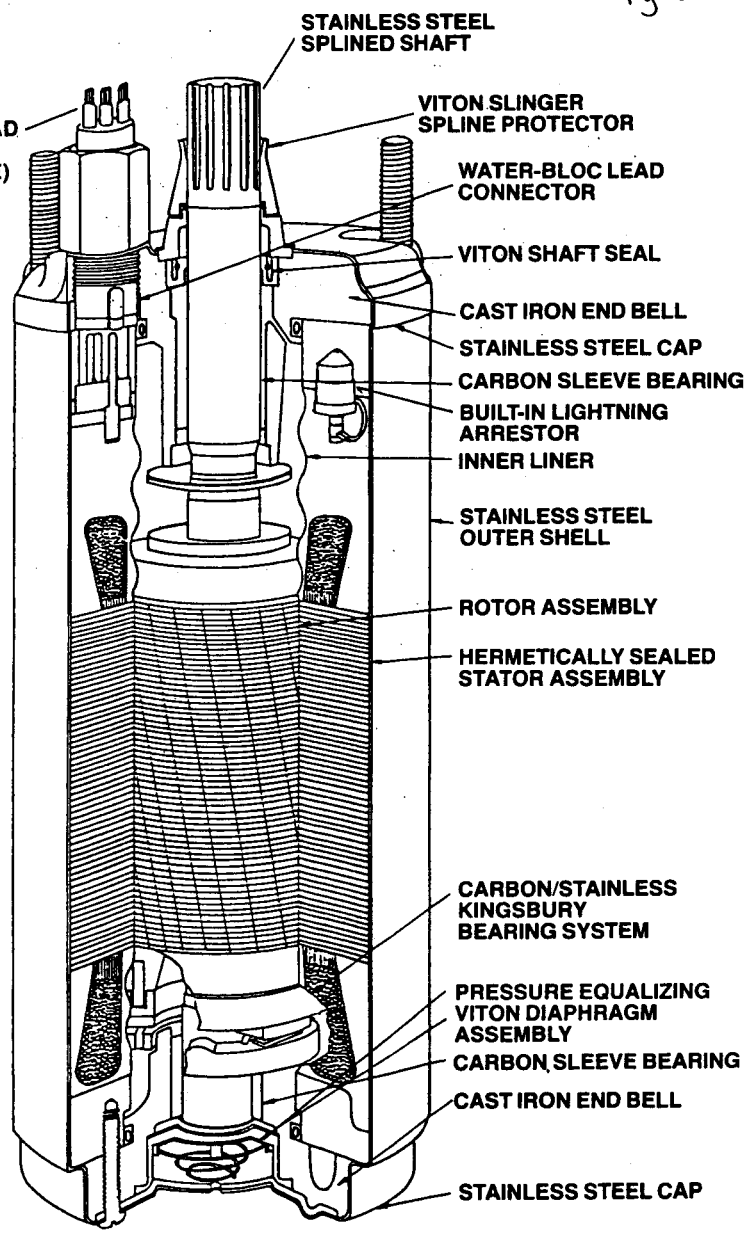
GRUNDFOS®

GRUNDFOS Pumps Corporation • 3131 N. Business Park Ave. Fresno, CA 93727
Customer Service Centers: Allentown, PA • Fresno, CA
Phone: (800)333-1366 • **Fax: (800)333-1363**
Canada: Oakville, Ontario • **Mexico:** Apodaca, N.L.

L-RF4-TL-016 | Rev. 4/01
PRINTED IN USA

Recommended motor by Grundfos for the 16E7 submersible pump.

FRANKLIN'S 4" POLLUTION RECOVERY SUBMERSIBLE MOTOR



CONSTRUCTION MATERIALS (4-INCH) SPECIAL PURPOSE

Castings	304 S.S. Over Iron
Shell	201 S.S.
Shaft Extension	303 S.S.
Fasteners	316 S.S.
Seal Cover	Acetal
Seal	Viton
Diaphragm	Viton
Diaphragm Plate	304 S.S.
Diaphragm Spring	302 S.S.
Diaphragm Cover	316 S.S.
Slinger	Viton
Lead Sleeve	Nickel Plated SAE 330 Brass
Lead Jam Nut	316 S.S.
Lead Potting	Epoxy
Lead Bushing	Viton
Lead Wire	Teflon
Coupling	416 S.S.

NOTE: Lead Sleeve, Jam Nut, Potting, Wire and Coupling are sold separate.

4-INCH WATER WELL SPECIAL PURPOSE MOTORS

H.P.	DOWNWARD THRUST (LBS.)	VOLTS	SERVICE FACTOR
3-WIRE 60 Hz SUPER STAINLESS, 1Ø, CAPACITOR START			
⅓*	300	115	1.75
	300	230	1.75
½*	300	115	1.60
	300	230	1.60
¾*	300	230	1.50
1*	400	230	1.40
1½*	400	230	1.30
2*	400	230	1.25
2-WIRE, SPLIT PHASE, 60 Hz, 3450 RPM			
⅓	300	115	1.75
	300	230	1.75
½	300	115	1.60
	300	230	1.60
¾	300	230	1.50
1	400	230	1.40
1½	400	230	1.30

WARNINGS: Serious or fatal electric shock may result from failure to connect all metal plumbing, and the motor, if outside a drilled well, to the power supply grounding terminal with wire no smaller than motor cable wires. Do not use motor in swimming areas.

*REQUIRES CONTROL BOX

Franklin Electric
Bluffton, Indiana 46714

RECOVERY WELL PUMP DESIGN CALCULATIONS
AND MANUFACTURER INFORMATION
FOR
LOADING RACK AREA

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: ~~218~~ E&L 125

Drawn/Calculated by: Jeff Becken
Date: 1/16/03
Reviewed by: Bill Walsh

Design Recovery Well Pump

Calculate Head Loss

- Calculate from the recovery well located farthest from the proposed remediation system location. Which is assumed to be worst case scenario. Farthest well is LRRW-1 which is approximately 265 feet from system proposed location.

- Assumptions
  - Drawdown in LRRW-1 will be 10 feet.
  - Water discharges from recovery well into oil/water separator which sits 5 feet above ground surface
  - Discharge line will be 1¼" Green XLPE Hose by Goodyear that will run from pump to remediation system. Head loss from this hose is 1.14 psi per 100 LF per manufacturer information on attached pages:

$$1.14 \text{ psi} \times 2.308 \frac{\text{ft of head}}{\text{psi}} = 2.63 \text{ ft of } H_2O \text{ per } 100 \text{ LF}$$ ✓

  - Maximum flow through the discharge line is estimated to be 10 gallons per minute.
  - minor losses are 20% of total hose length

CATLIN
ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN # : ~~210~~ 125

Drawn/Calculated by: Jeff Becken
Date: 1/16/03
Reviewed by: BILL WASH

Design Recovery Well Pump (Cont.)
Calculate Elevation Head Loss

= Drawdown + elevation difference between pumping well and pretreatment system + height of oil/water separator (discharge point) + depth of water from ground surface

Where:

- Pumping well elevation = Assumed to be similar to top of casing for KMW-6 which is 29.90 feet
- pretreatment system elevation = Assumed to be average of top of casing for KMW-7 (25.11') and KMW-11 (27.34') which is 26.23 feet
- depth of water averages @ 1.5 feet below ground surface

= 10 feet + (26.23 - 24.90) ft + 5 feet + 1.5 ft

= 17.83 feet

Use 20 feet

Catalog #01-130
Supersedes Catalog #99-130

INDUSTRIAL HOSE PRODUCTS

Water Flow Pressure Loss
(PSI Per 100 Feet Of Hose)

Flow of water in U.S. gal. per min.	Flow of water in cu. feet per sec.	Actual Internal Diameter, Inches								
		½	⅝	¾	1	1¼	1½	2	2½	3
0.5	.001	0.4								
1.5	.003	3.02	1.01	0.42						
2.5	.005	7.75	2.58	1.08						
5	.011	27.8	9.27	3.86	0.95	0.32	0.13			
10	.022	99.5	33.2	13.8	3.38	1.14	0.47	0.12		
15	.033		71.0	29.6	7.25	2.45	1.01	0.25	0.08	
20	.044		125.0	50.5	12.4	4.15	1.71	0.42	0.14	
25	.055			76.5	18.7	6.34	2.60	0.64	0.22	
30	.066			108.0	26.3	8.90	3.66	0.90	0.30	0.13
35	.077			142.0	34.8	11.8	4.83	1.18	0.40	0.17
40	.088				44.7	15.1	6.20	1.52	0.51	0.21
45	.099				55.0	18.6	7.65	1.87	0.63	0.26
50	.110				67.5	22.8	9.35	2.28	0.78	0.32
60	.132				94.3	31.8	13.1	3.19	1.08	0.45
70	.154				126.0	42.5	17.5	4.25	1.44	0.60
80	.176					54.6	22.4	5.46	1.86	0.77
90	.198					67.5	27.8	6.80	2.30	0.96
100	.221					81.3	33.5	8.19	2.79	1.15
125	.276					124.0	50.6	12.4	4.20	1.74
150	.334						72.4	17.6	5.97	2.46
175	.390						94.5	23.1	7.83	3.23
200	.446						122.0	29.6	10.1	4.15
225	.501							36.8	12.5	5.15
250	.557							44.6	15.2	6.28
275	.613							53.3	18.1	7.45
300	.668							62.5	21.2	8.75
325	.724							72.5	24.6	10.2
350	.780							83.2	28.2	11.6
375	.836							94.5	32.1	13.2
400	.891							107.0	36.2	14.9
450	1.00								44.9	18.6
500	1.11								54.5	22.5
600	1.34								76.5	31.6
700	1.56								102.0	42.1
800	1.78								131.0	53.9
900	2.00									66.8
1000	2.23									81.6
1100	2.45									97.9
1200	2.67									114.0
1300	2.90									132.0
1400	3.12									
1500	3.34									
1600	3.56									
1800	4.01									
2000	4.45									

Note: *The pressure loss experienced by a liquid flowing through a hose depends on the rate of flow, the viscosity of the liquid, the hose I.D., the smoothness of the tube, and the hose length. This chart shows the relationship between rate of flow, I.D., and pressure loss for water at 68°F with a viscosity of one centipoise. The pressure is directly proportional to the length of the hose, therefore, the data shown can be easily extended by use of proportions, e.g., the pressure drop for 50 feet of hose length is half that for 100 feet.*

GOODYEAR

See Page 2 for complete product warranty and terms of sale information. In V-Cat, please reference the Conditions of Sale page in the General Information section. Information in this catalog supersedes all previously printed material. Information valid through December 31, 2002.

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: ~~210~~ 201-125

Drawn/Calculated by: Jeff Backen
Date: 1/16/03
Reviewed by: BOB WALSH

Design Recovery Well Pump (cont.)

Calculate Head Loss (cont.)

Velocity Head Loss

= (friction head loss per 100LF) x Total Length x minor losses

= (2.63 ft/100LF) x 265 feet x 1.2

= 8.36 feet

Use 10 feet

Total Head Loss

= Elevation Head Loss + Velocity Head Loss

= 20 feet + 10 feet

= 30 feet

Use 30 feet

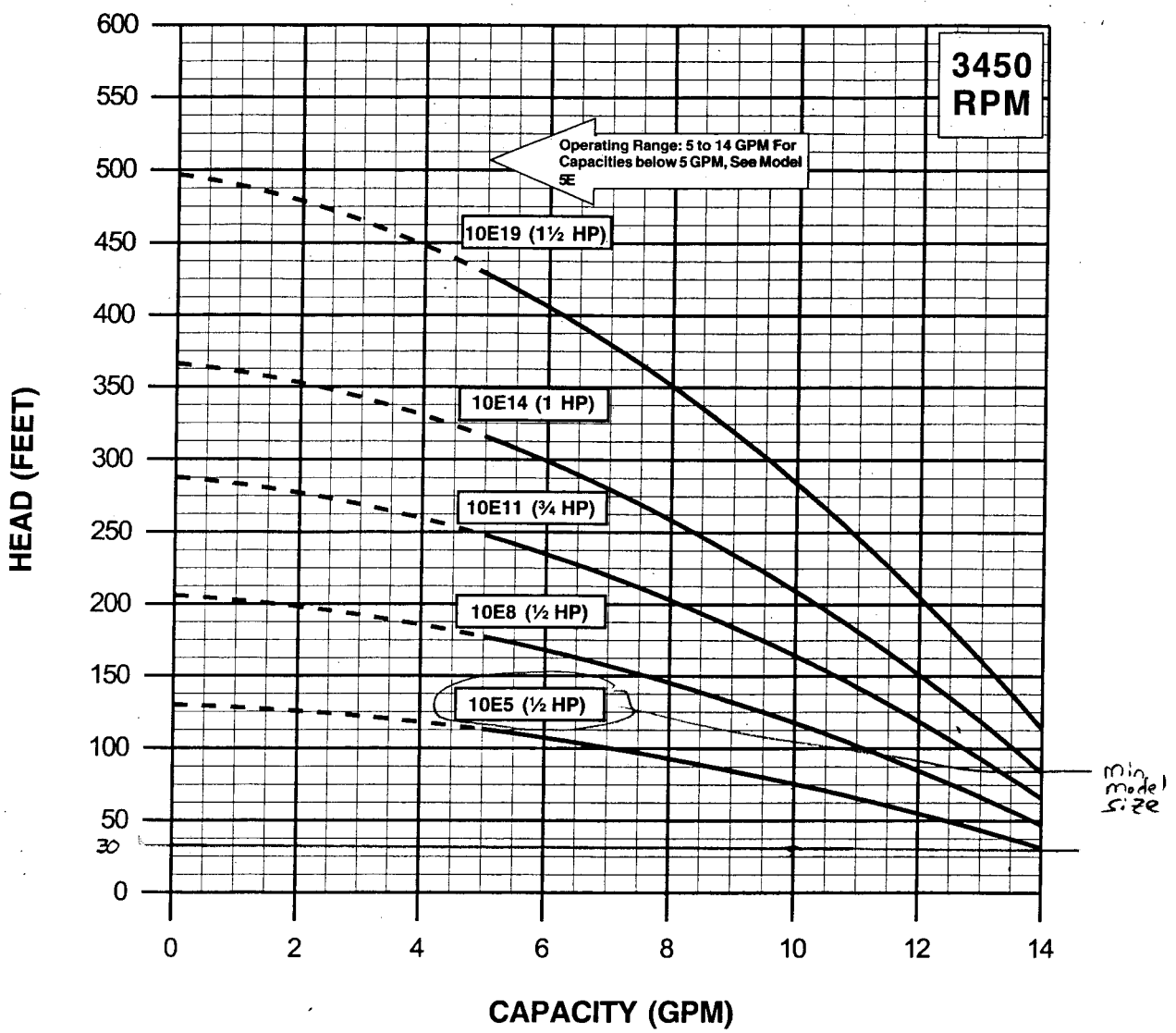
Select Pump

- Based on attached pump curve, the minimum pump size for 10 gpm and 30 feet of head is the model 10ES5 (½ HP).

Use: 10ES5 (1/2 HP) Grundfos Redi-Flo Environmental Submersible Pump with a Franklin Electric 4" Pollution Recovery Submersible Motor or approved equivalent. [2 wire, 230ϕ, 60Hz - 3phase]

Performance Curves

10E



Materials of Construction

REDI-FLO4 PUMP END

Description	Material
Check Valve Housing, Check Valve, Diffuser Chamber, Impeller, Suction Interconnector, Inlet Screen, Pump Shaft, Straps, Cable Guard, Priming Inducer	304 SS
Check Valve Seat	304 SS & Teflon®
Impeller Seal Ring	Teflon®
Coupling	316/431 SS
Intermediate Bearings	Teflon®

GRUNDFOS ENVIRONMENTAL MOTOR

Description	Material
NEMA Top, Studs & Fasteners, Stator Housing, Fill Plug Screw	304 SS
Nuts	316 SS
Sand Slinger	FPM
Shaft Extension	431 SS
Diaphragm	FPM
Fill Plug Washer	Teflon®

GRUNDFOS ENVIRONMENTAL MOTOR LEADS

Description	Material
Connector Sleeve	304 SS
Connector Potting	Scotch Cast #4® Epoxy w/FPM Cap
Connector Plug	FPM
Lead Insulation	Teflon®
Conductor	Stranded Copper, 12 AWG

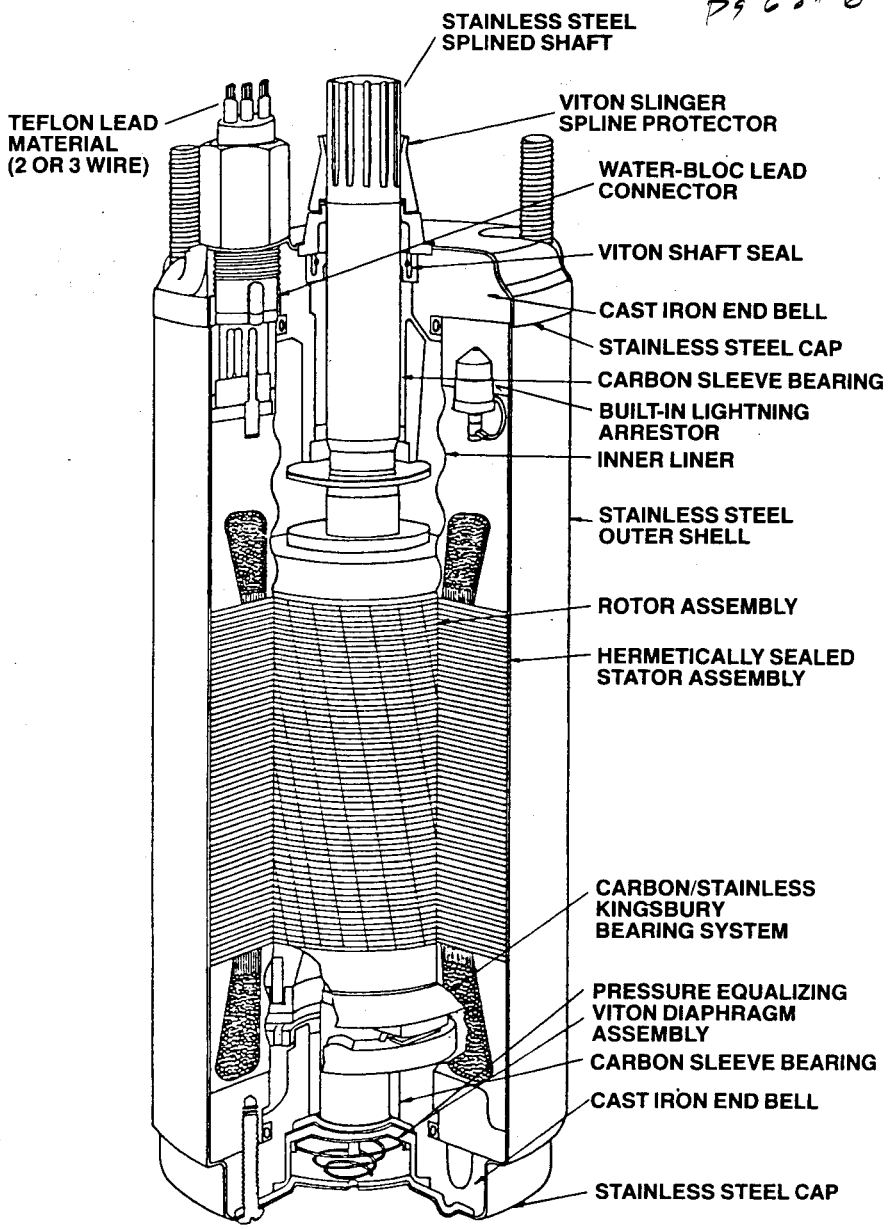
NOTES: Specifications are subject to change without notice.
Teflon® is a registered trademark of DuPont.
Scotch Cast #4® is a registered trademark of 3M Company.

GRUNDFOS®

GRUNDFOS Pumps Corporation • 3131 N. Business Park Ave. Fresno, CA 93727
Customer Service Centers: Allentown, PA • Fresno, CA
Phone: (800)333-1366 • Fax: (800)333-1363
Canada: Oakville, Ontario • **Mexico:** Apodaca, N.L.

L-RF4-TL-010 | Rev. 4/01
PRINTED IN USA

FRANKLIN'S 4" POLLUTION RECOVERY SUBMERSIBLE MOTOR



CONSTRUCTION MATERIALS (4-INCH) SPECIAL PURPOSE

Castings	304 S.S. Over Iron
Shell	201 S.S.
Shaft Extension	303 S.S.
Fasteners	316 S.S.
Seal Cover	Acetal
Seal	Viton
Diaphragm	Viton
Diaphragm Plate	304 S.S.
Diaphragm Spring	302 S.S.
Diaphragm Cover	316 S.S.
Slinger	Viton
Lead Sleeve	Nickel Plated SAE 330 Brass
Lead Jam Nut	316 S.S.
Lead Potting	Epoxy
Lead Bushing	Viton
Lead Wire	Teflon
Coupling	416 S.S.

NOTE: Lead Sleeve, Jam Nut, Potting, Wire and Coupling are sold separate.

4-INCH WATER WELL SPECIAL PURPOSE MOTORS

H.P.	DOWNWARD THRUST (LBS.)	VOLTS	SERVICE FACTOR
3-WIRE 60 Hz SUPER STAINLESS, 1Ø, CAPACITOR START			
⅓*	300	115	1.75
	300	230	1.75
½*	300	115	1.60
	300	230	1.60
¾*	300	230	1.50
1*	400	230	1.40
1½*	400	230	1.30
2*	400	230	1.25
2-WIRE, SPLIT PHASE, 60 Hz, 3450 RPM			
⅓	300	115	1.75
	300	230	1.75
½	300	115	1.60
	300	230	1.60
¾	300	230	1.50
1	400	230	1.40
1½	400	230	1.30

WARNINGS: Serious or fatal electric shock may result from failure to connect all metal plumbing, and the motor, if outside a drilled well, to the power supply grounding terminal with wire no smaller than motor cable wires. Do not use motor in swimming areas.

*REQUIRES CONTROL BOX

Franklin Electric
Bluffton, Indiana 46714

RECOVERY WELL PUMP PROTECTOR DESIGN CALCULATIONS AND MANUFACTURER INFORMATION FOR PX FACILITY AND LOADING RACK AREA

CATLIN
ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN # : 195-033

Drawn/Calculated by: Jeff Becker
Date: 11/14/02
Reviewed by: VJW

1 Design Pump Protector

Assumptions

- Pump Protector is for ensuring recovery well pumps operate as specified and prevent pump overload and underload.
- 1 pump protector per new recovery well pump

- Model 3PH 230V to be used based on Grundfos submersible pump (selected recovery well pump) Voltage of 230 Volts and 3/4 horsepower size or approved equivalent.

COYOTE

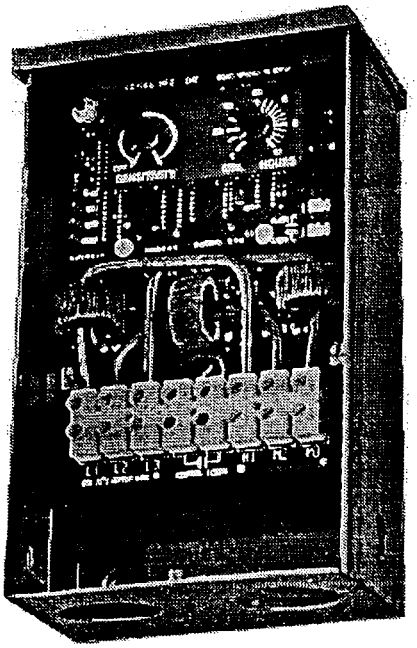
ALL THE PROTECTION YOU WANT FOR THREE PHASE PUMPS AND MOTORS

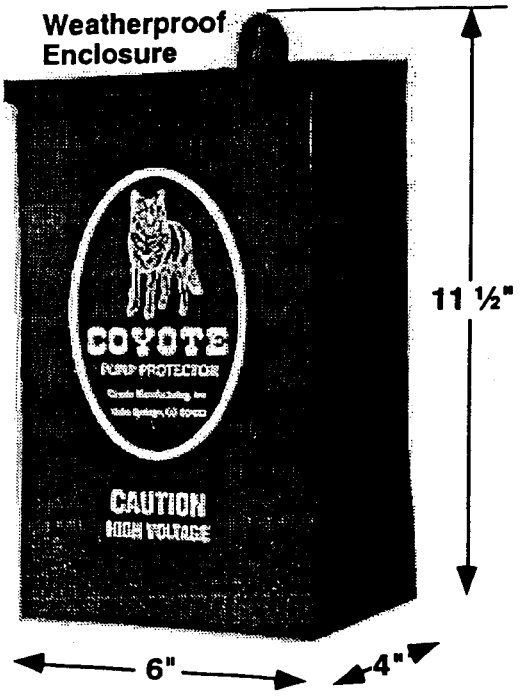
PHASE LOSS
PHASE REVERSAL

LOW VOLTAGE
HIGH VOLTAGE

OVERLOAD
RAPID CYCLING

RUNNING DRY
FROZEN DISCHARGE LINE





RESTARTING AFTER A FAULT

PHASE - restarts one minute after proper power is restored
VOLTAGE - restarts one minute after proper voltage is restored
OVERLOAD - makes up to two attempts one minute apart to restart at normal current; if unsuccessful, waits for problem to be fixed so as not to burn out motor winding
RUN DRY - restarts at the time set on the timer

NO PLUMBING • NO PROBES • FULLY AUTOMATIC

Built-in sensors simplify installation. Just dial sensitivity 'til light comes on and set run-dry timer.

MODEL	U.L. HORSEPOWER RATINGS
3PH208V-ENC	1/2 - 15 HP 230V
3PH230V-ENC	1/2 - 15 HP 230V
3PH380V-ENC	1 - 30 HP 380V
3PH460V-ENC	1 - 40 HP 460V

No need to specify horsepower when ordering. For example, the same Model 3PH460V-ENC operates any motor from 1 to 40 HP.

UL LISTED

COYOTE MANUFACTURING, INC.
7120 WEST 117 AVE UNIT B 4
BROOMFIELD, CO 80020
800-468-1177
FAX 303-635-0135

THREE PHASE COYOTE TECHNICAL DATA

OPERATING RANGE

-20° TO + 70° C temperature
0% to 95% humidity noncondensing

RANDOM START

When energizing Coyote by turning on power at circuit breaker or fused disconnect there is a delay of 4 to 10 seconds before Coyote turns on the pump. This "random start" feature is designed to prevent many pumps served by a single power source from all restarting at the same instant when power is restored after a power outage.

VOLTAGE FAULT

model	low voltage		high voltage	
	trip	reset	reset	trip
3PH208V-ENC	172V	181V	235V	244V
3PH230V-ENC	190V	200V	260V	270V
3PH380V-ENC	320V	330V	430V	440V
3PH460V-ENC	380V	400V	520V	540V

trip delay
2 seconds

reset delay
60 seconds

PHASE LOSS OR REVERSAL

trip delay
1 second

reset delay
60 seconds

OVERLOAD

trip amps
120% of normal

trip delay
1/4 second

reset delay
60 seconds

Tries two times to restart 60 seconds apart. If unsuccessful, Coyote locks out pump and overload light blinks.

UNDERLOAD OR LACK OF FLUID

trip delay
1 second

reset delay
adjustable
1 minute - 12 hours

ALARM

Normally open dry contact closes to activate alarm on any fault condition.

ALL ABOUT THREE PHASE COYOTES

What does it do?

Coyote shuts off the pump:

- If the pump fails to pump fluid because there is no fluid available to it, or because it is gas locked or air locked, or because the inlet is clogged or discharge line frozen;
- If the power supplied to the pump is improper, e.g., phase reversed or missing, voltage too high or too low, etc.;
- If the motor draws excessive current or if there is a broken wire to the motor, or if it is rapid cycling on and off.

How does it work?

Coyote monitors the incoming power and the electrical characteristics of the motor. When the pump quits pumping fluid, those characteristics change, and Coyote shuts it off.

Will it operate on power supplied by generators and phase converters?

Yes.

On what kinds of pumps does it work?

Submersibles, centrifugals, jets, and sumps.

In what kinds of applications?

Water wells, oil wells, booster and lift stations, chemicals transfer, mine dewatering, sewage treatment, solution mining, food processing, construction dewatering, and clean-up of aquifers contaminated by hydrocarbons are the most common.

What about protection from the environment?

The insides of Coyote are sealed in plastic to keep out moisture, insects and blowing sand and dust.

What about power outages?

When the power is out, the pump won't run. When it comes back on, Coyote automatically resets itself. There is no need to touch anything.

What about lightning induced power surges?

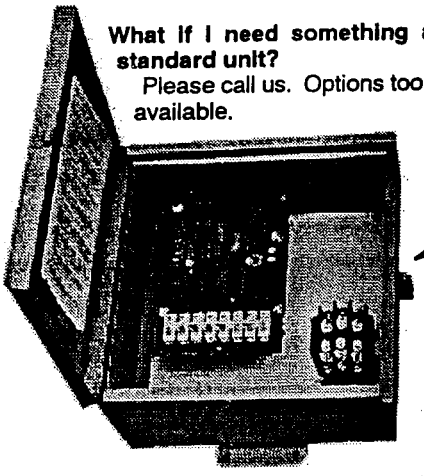
Rugged and effective protection for the electronics of Coyote is built-in.

How is it installed?

Coyote is installed between the circuit breaker and magnetic contactor in minutes with a standard screwdriver.

What if I need something a little different from the standard unit?

Please call us. Options too numerous to detail here are available.



Packaged complete with magnetic contactor in NEMA 3R or NEMA 4 box

Model
3PH208V-MAG
3PH230V-MAG
3PH380V-MAG
3PH460V-MAG

LIMITED WARRANTY

Coyote products are warranted against faulty materials or workmanship for one year from date of manufacture. Coyote's liability under this warranty is limited to repairing, replacing, or at its option issuing credit for any product returned during this period, and provided that any such defect has not been caused by misuse, neglect, improper installation, repair, or alteration. Coyote will not be liable and specifically disclaims responsibility to any party for loss, direct or indirect, for costs, expenses, or for consequential damage of any nature.

SANDER GRAPHICS PRINTING

3.0 REMEDIATION EQUIPMENT TRAILER

The following remediation equipment is to be installed on two trailers: oil/water separator, air stripper, dosing tank and all associated equipment/piping. One trailer is for the PX Facility groundwater remediation system and the other trailer is for the Loading Rack Area groundwater remediation system. The design of each trailer is to consist of the design of the overflow protection/containment and the foundation for the trailer jacks.

3.1 ASSUMPTIONS

- Trailer is to be open top, 50,000 lb. capacity and road ready.
- All equipment is to be provided from one manufacturer.
- All equipment is to be permanently attached to the trailer.
- Containment area shall be provided on the trailer.
- Containment area shall be water tight and compatible with the contaminants of concern for each location.
- The minimum volume to be contained within overflow protection is 110% of the largest volume of either the oil/water separator or the air stripper (based on RCRA requirements).
- Equipment operational volume will be based on the selected equipment.
- Trailer to be sufficient size for equipment, containment and 2 feet separation between other equipment and/or the trailer side walls.
- Trailer is to be selected by equipment manufacturer and approved by CATLIN prior to delivery to the site.

3.2 DESIGN

Due to the uncertainty of the trailer size and weight, CATLIN will design the overflow protection and foundation of trailer during the pre-installation approval process of the recommended trailer.

REMEDIATION EQUIPMENT TRAILER CALCULATIONS

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 195-033

Drawn/Calculated by: JKB
Date: 4/2/03
Reviewed by: WJV

Remediation Equipment Trailer Design

The following remediation equipment is proposed to be installed on a trailer:

1) Oil/Water Separator
2) Air Stripper
3) Dosing Tank
4) All associated equipment/piping.

Design for the following:

1) Overflow protection
2) Foundation for Trailer Jacks

Assumptions

- Trailer to be open top, 50,000 lb capacity, and road ready.
- All equipment is to be provided from one manufacturer fixed on a trailer.
- Containment area shall be water tight and compatible w/ contaminants of concern.
- The minimum volume to be contained within overflow protection is 110% of the largest volume of either the oil/water separator or air stripper (Based on RCRA requirements).
- Equipment Operational Volume for PX Facility / Loading Rack Area
  - Oil/water Separator = 880 gallons / 630 gallons } These may vary by manufr.
  - Air Stripper = 300 gallons / 300 gallons
- Trailer to be of sufficient size for equipment, containment and minimum spacing of 2 ft between equipment and other equipment or wall.
- Equipment manufacturer to select trailer based on assumptions given above. Trailer is to be approved by CATLIN prior to installation of equipment.
- Containment area shall be provided on the trailer

Design

- Due to the uncertainty of trailer size and weight, CATLIN will design overflow protection and foundation of trailer during pre-installation approval of recommended trailer.

OVERFLOW PROTECTION DESIGN CALCULATIONS

4.0 OIL/WATER SEPARATOR

Due to the historic presence of free phase product observed in on-site monitoring and recovery wells, an oil/water separator is planned as part of each groundwater remediation system. This oil/water separator will be designed as discussed below to remove potential free phase product from the influent.

4.1 PX FACILITY

4.1.1 Design of Oil/Water Separator

4.1.1.1 Assumptions

- The maximum flow rate through the system will be 80 gpm.
- The equipment is to be stainless steel.
- Oil/Water Separator to remove free phase product, anticipated to be primarily Paraxylene.
- The specific gravity of Paraxylene is 0.861.
- A 200-gallon pump out tank is required.

4.1.1.2 Selection

The attached oil/water separator design calculations and manufacturer information was used to select the oil/water separator. CATLIN provided the above assumptions to a preferred oil/water separator vendor, JDI, Inc. JDI, Inc. recommended the HQI AG-3SS-200V model manufactured by Hydroquip, Inc. Based on JDI, Inc.'s recommendation, the plan is to utilize the HQI AG-3SS-200V model manufactured by Hydroquip, Inc or approved equivalent for the oil/water separator as part of the groundwater recovery system.

4.2 LOADING RACK AREA

4.2.1 Design of Oil/Water Separator

4.2.1.1 Assumptions

- The maximum flow rate through the system will be 40 gpm.
- The equipment is to be stainless steel.
- Oil/Water Separator to remove free phase product, anticipated to be primarily Paraxylene and/or Diesel fuel.
- The specific gravity of Paraxylene is 0.861.
- The specific gravity of Paraxylene is 0.86.
- A 200-gallon pump out tank is required.

4.2.1.2 Selection

The attached oil/water separator design calculations and manufacturer information was used to select the oil/water separator. CATLIN provided the above assumptions to a preferred oil/water separator vendor, JDI, Inc. JDI, Inc. recommended the HQI AGM2-1H-200V model manufactured by Hydroquip, Inc. Based on JDI, Inc.'s recommendation, the plan is to utilize the HQI AG-4SS-200V model manufactured by Hydroquip, Inc or approved equivalent for the oil/water separator as part of the groundwater recovery system.

OIL/WATER SEPARATOR DESIGN CALCULATIONS
AND MANUFACTURER INFORMATION
FOR
PX FACILITY

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN # : **195-033**

Drawn/Calculated by: Jeff Becker
Date: 10/14/02
Reviewed by: WALSH

Oil/Water Separator Design

Assumptions

Flow = 80 gpm
Equipment to be stainless steel
Free Product if accumulated will be Paraxylene
Specific Gravity of Paraxylene = 0.861
Hold tank of 200 gallon

System to be designed to remove free product if collected.

- Based on information provided by JDI, Inc. and a follow-up conversation, JDI, Inc. guarantees the Hydroquip, Inc. HQI AG-3SS-200V will remove free product of paraxylene with a specific gravity of 0.861 and pumped at a flow rate of 80 gpm or less pending emulsification.

- Specification data sheets on the Hydroquip, Inc. HQI AG-3SS-200V is attached

- If free product is emulsified w/ groundwater, the air stripper should remove the mixed fluid. (Assumption)

JDI, Inc.

Industrial Washing Systems, Recycling, & Fluid Waste Minimization Equipment

Industrial Washing Systems

Solvent Replacement Cleaners/ Degreasers

Parts Washers

Recycling/ Filtering Systems

Ultrafiltration Equipment

Oil Skimmers

Evaporators

Oil/Water Separators

Tanks

June 26, 2002

Mr. Steve Tyler
Catlin Engineers & Scientists
220 Old Dairy Road
Wilmington, NC 28405

Phone: (910) 452-5861
Fax: (910) 452-7563

RE: Oil/Water Separator Systems Quotation

Dear Steve:

As requested, we are pleased to present the following quotation for two Hydroquip, Inc. oil water separator (OWS) systems. The Hydroquip, Inc. AG-3SS-200V parallel plate oil/water separator has a 200 gallon effluent pump out compartment and will be able to handle a continuous flow of 1-80 gallons per minute. The Hydroquip, Inc. AG-4SS-200V parallel plate oil/water separator also has a 200 gallon effluent pump out compartment and will be able to handle a continuous flow of 1-100 gallons per minute. ← Natural gas

Both separators will remove essentially all free and dispersed non-emulsified oil droplets larger than 60 microns in diameter with a specific gravity of 0.84 or less. They are designed for above-grade installation and will be constructed of 12 gauge stainless steel.

We appreciate the opportunity to present this quotation and look forward to working with you again. Enclosed, please find drawings and some background information on the float switch. If you have any questions or desire further information, please give me a call.

Best regards,

Tom

Thomas R. Goodwin
President
JDI, Inc.

Enclosures
Faxed page 1 of 10

(910) 791-1855 • P.O. Box 3821 • Wilmington, NC 28406 • Fax (910) 313-1987
email: jdiinc@wilmington.net webpage: www.jdiinc.com

Oil/Water Separator Pricing Information

Item	Quan	Description and Part Number	Price
1	1	**Hydroquip, Inc. HQI AG-3SS-200V** [redacted]

Parallel Corrugated Plate Oil/Water Separator

* **Design Flow**: 1-80 GPM
* **Approx. Dimensions**: 40" wide x 88" long x 60" high
* **Materials of Construction**: 12 Gauge Stainless Steel
  Internal Pipe Schedule 80 PVC

* **HQI AG-3SS Systems Features Include**:
  * 3" NPT Inlet/Outlet
  * 2" NPT Oil Chamber Outlet
  - Parallel corrugated plate coalescer designed to remove oil droplets greater than 60 microns with a Reynolds Number of less than 500
  * Sludge baffle to capture and contain settleable solids
  - 200 Gallon effluent pump out compartment with 2" NPT fitting and 3 level intrinsically safe float switch
  * Neoprene gasketed removable vapor tight cover for access to chamber compartments

Item	Quan	Description and Part Number	Price
2	1	**Hydroquip, Inc. HQI AG-4SS-200V** [redacted] ← Not used

Parallel Corrugated Plate Oil/Water Separator

* **Design Flow**: 1-100 GPM
* **Approx. Dimensions**: 52" wide x 88" long x 60" high
* **Materials of Construction**: 12 Gauge Stainless Steel
  Internal Pipe Schedule 80 PVC

* **HQI AG-4SS Systems Features Include**:
  * 3" NPT Inlet/Outlet
  * 2" NPT Oil Chamber Outlet
  - Parallel corrugated plate coalescer designed to remove oil droplets greater than 60 microns with a Reynolds Number of less than 500
  * Sludge baffle to capture and contain settleable solids
  - 200 Gallon effluent pump out compartment with 2" NPT fitting and 3 level intrinsically safe float switch
  * Neoprene gasketed removable vapor tight cover for access to chamber compartments

Terms:	Net 30 Days, 1.5% per month Finance Charge after 30 days
Shipping:	F. O. B. Massachusetts
Delivery:	3-4 weeks after receipt of approved drawings
Note:	Any applicable taxes will be in addition to the price quoted
	Offer Valid for 90 Days
Warranty:	One year - Oil/Water Separator Accessories and Treatment Equipment

HYDRO QUIP INC.
Water Treatment Equipment

1.0 INTRODUCTION

Hydro Quip, Inc. (HQI) Oil Water Separator (OWS) Model AG-3SS-150V will remove essentially all free and dispersed, non emulsified oil, and settleable solids from the oil water mixture at a flow rate of 80 GPM at a temperature of 55 degrees F. The design utilizes the difference in specific gravity between oil and water (buoyancy force) enhanced by the use of 18 cubic feet of UNIPACK coalescing plates. The separator is designed to receive oily water by gravity/pumped flow that will not mechanically emulsify the oil and will process it on a once through basis. The tank will be a single wall, rectangular unit installed above grade. It will be constructed of stainless steel. The UNIPACK coalescing plates are manufactured of UV-Resistant PVC material.

2.0 SYSTEM DESCRIPTION AND REQUIREMENTS

2.1 *FABRICATION*: The oil water separator is a special purpose prefabricated parallel corrugated plate, rectangular, gravity displacement, type oil water separator. The separator shall be comprised of a tank containing an inlet compartment, separation chamber, sludge chamber, and clean water outlet chamber.

2.2 *TANK*: The tank shall be a single wall construction 12 gauge stainless steel conforming to ASTM A240 . Welding will be in accordance with AWS D1.1 to provide a watertight tank that will not warp or deform under load. Pipe connections to the exterior shall be as follows:

2.2.1 *PIPE CONNECTIONS*: All connections 3" and smaller are FNPT couplings. All connections 4" and larger are flat face flanges with ANSI 150 pound standard bolt circle. Use flanged piping connections that conform to ANSI B16.5.

2.3 *SEPARATOR COROSION PROTECTION*: (For Carbon Steel Only) After shop hydrostatic test has been successfully completed, a coating system will be applied to the interior and exterior surfaces of the separator. Interior and exterior shall be sandblasted to SSPC-SP10; Interior lined with Tnemec Series 61 liner to 9 mils MDFT; Exterior coated with polyamide epoxy to 6 mils MDFT.

2.4 *LIFTING LUGS*: The tank shall be provided with properly sized lifting lugs for handling and installation.

2.5 *COVERS*: The tank will be provided with a vapor tight covers for vapor control. Gas vents and suitable access openings to each compartment will be provided. The covers shall be constructed of the same material as the

POB 3160 * 63 N. Washington St. * N. Attleboro, MA 02761-3160
PH (508) 695-3640 * F (508) 695-4412 * EMAIL HQIOWS@AOL.COM

tank and will be fastened in place. A gasket shall be provided for vapor tightness. 304 SS Latches will be provided for cover attachment.

2.6 *INLET COMPARTMENT*: The inlet chamber shall be comprised of a non-clog diffuser to distribute the flow across the width of the separation chamber. The inlet compartment shall be of sufficient volume to effectively reduce influent suspended solids, dissipate energy and begin separation. The media will sit elevated on top of a sludge baffle. The sludge baffle will be provided to retain settleble solids and sediment from entering the separation chamber.

2.7 *SEPARATION CHAMBER*: The oil separation chamber shall contain HQI UNIIPACK parallel corrugated plates. The plates shall be at a 60 degree angle with respect to longitudinal axis of the plate corrugations and spaced 1/2" apart for removal of free oil 60 micron in size or greater and settleable solids. Configuration does not promote solids buildup on the plates, which would increase velocities to the point of discharging an effluent of unacceptable quality. Laminar flow with a Reynolds Number of less than 500 at a maximum design flow rate shall be maintained throughout the plate packs including entrance and exit so as to prevent re-entrainment of oils) with water. Flow through the plate packs shall be crossflow perpendicular to plate corrugations so that the oil collects and coalesces at high points of corrugations and rises to the top of pack without clogging due to oil or settleable solids.

2.8 *BAFFLES*: An oil retention & underflow weir, and overflow weir. Position underflow weir to prevent resuspension of settled solids.

2.9 SLUDGE CHAMBER: The sludge chamber shall be located prior to the coalescing compartment for the settling of any solids. It shall also prevent any solids from entering the clean water chamber.

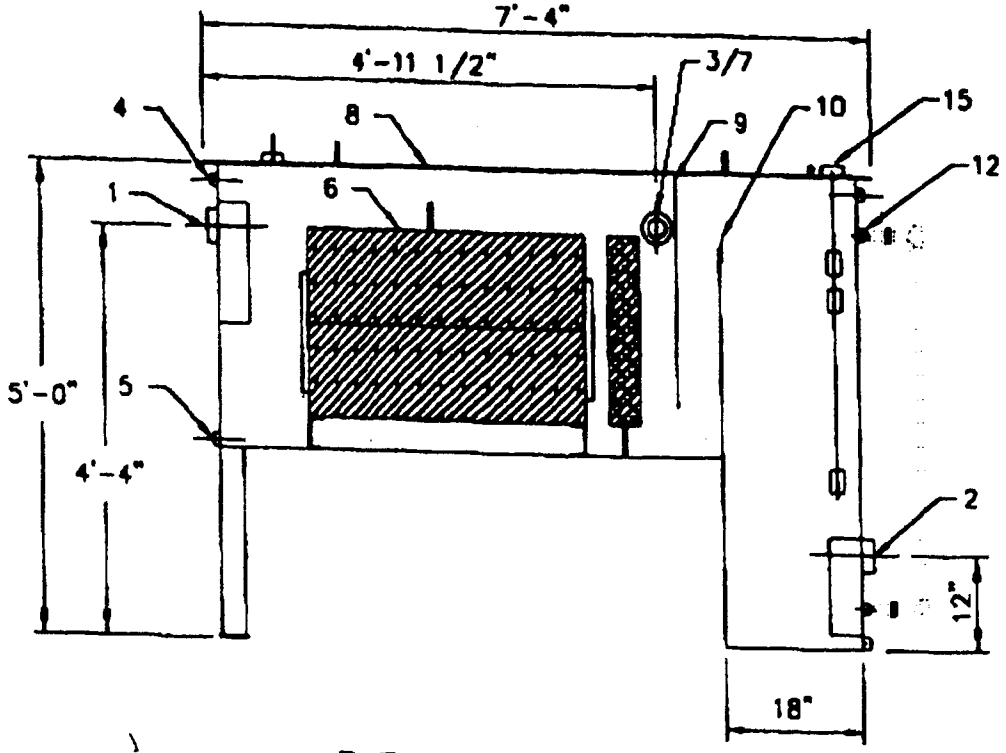
2.10 *OIL SKIMMER* : The oil separation chamber will be provided with a rotatable pipe skimmer for gravity decanting of the separated oil to a product storage tank.

2.11 *CLEAN WATER CHAMBER*: The tank will be provided with a 200 gallon clean water chamber which allows the water to leave the separator by pumped flow through the clean water outlet port.

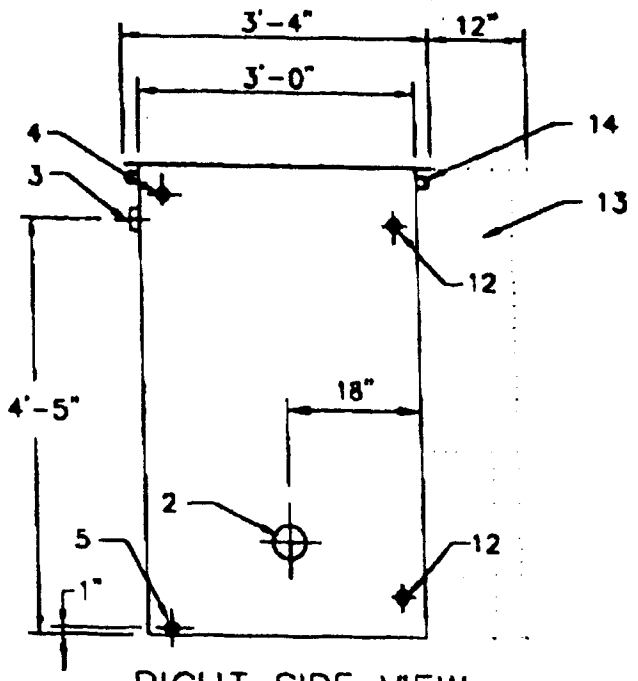
2.12 *VENTS*: 1" vents will be provide with vent piping to atmosphere.

ITEM	QTY	DESCRIPTION	ITEM	QTY	DESCRIPTION
1	1	3" FNPT INLET	9	1	OIL STOP WEIR
2	1	3" FNPT OUTLET	10	1	ADJ. OVERFLOW WEIR
3	1	2" FNPT OIL OUTLET	11	0	OPTIONAL MESH PAD
4	2	1" FNPT VENT	12	0	OPT. SIGHT GLASS PORTS
5	2	1" FNPT DRAIN	13	0	OPTIONAL PRODUCT TANK
6	1	COALESCING PLATES	14	4	LIFTING LUGS
7	1	PVC OIL SKIMMER	15	1	2" FNPT FLOAT SWITCH
8	1	REMOVABLE COVER			

SHIPPING WEIGHT	500 LBS
OPERATING WEIGHT	4570 LBS
SEPARATOR VOLUME	540 GALLONS
EFFLUENT TANK VOLUME	250 GALLONS
SLUDGE VOLUME	20 GALLONS
COALESCING AREA	864 FT²
OPT. PRODUCT TANK VOL	120 GALLONS



ELEVATION



RIGHT SIDE VIEW

NOTES

1. MATERIAL: 12 GAUGE 304SS.
2. GASKET: NEOPRENE.
3. HARDWARE: 18-8 STAINLESS STEEL
4. INTERNAL PIPE SCH 40 PVC

REV.	DESCRIPTION	DATE	APP.

HYDRO QUIP, INC.

Water Treatment Systems

GENERAL ARRANGEMENT
MODEL AG-3SS-150V

DRN. BY: PMD

CHECKED:

PROJECT:

DATE: 11/03/98

REF:

FILE: AG3SS150V

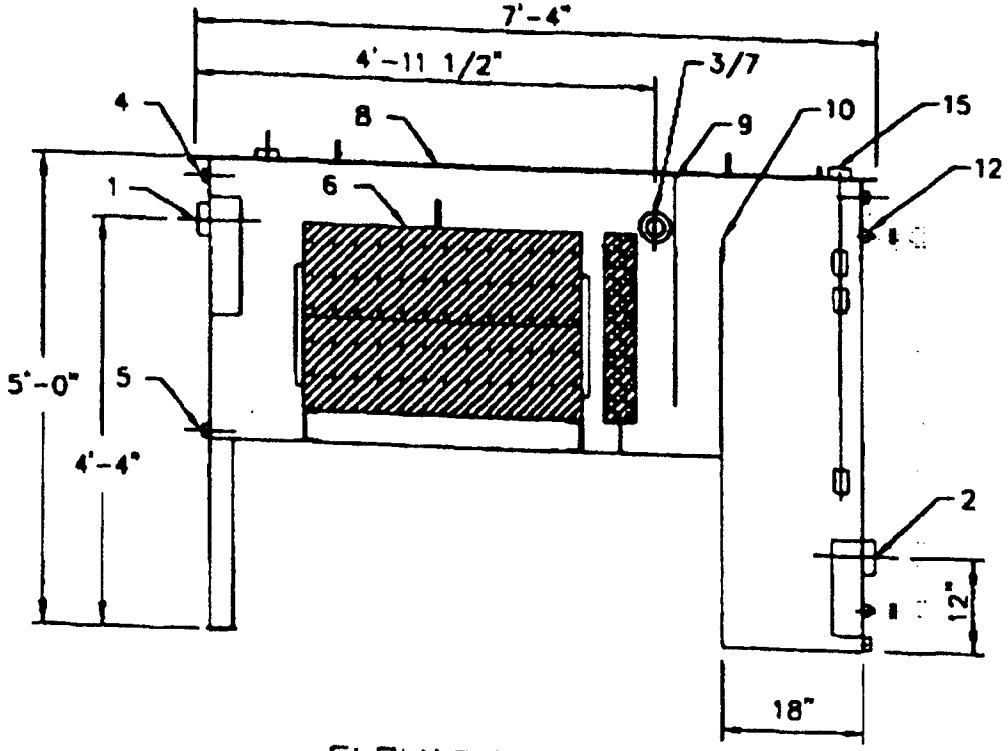
SCALE: 1/4" = 1'

REV: 0

ITEM	QTY	DESCRIPTION
1	1	3" FNPT INLET
2	1	3" FNPT OUTLET
3	1	2" FNPT OIL OUTLET
4	2	1" FNPT VENT
5	2	1" FNPT DRAIN
6	1	COALESCING PLATES
7	1	PVC OIL SKIMMER
8	1	REMOVABLE COVER

ITEM	QTY	DESCRIPTION
9	1	OIL STOP WEIR
10	1	ADJ. OVERFLOW WEIR
11	0	OPTIONAL MESH PAD
12	0	OPT. SIGHT GLASS PORTS
13	0	OPTIONAL PRODUCT TANK
14	4	LIFTING LUGS
15	1	2" FNPT FLOAT SWITCH

SHIPPING WEIGHT	847 LBS
OPERATING WEIGHT	6287 LBS
SEPARATOR VOLUME	680 GALLONS
EFFLUENT TANK VOLUME	150 GALLONS
SLUDGE VOLUME	12 GALLONS
COALESCING AREA	1150 FT²
OPT. PRODUCT TANK VOL	120 GALLONS



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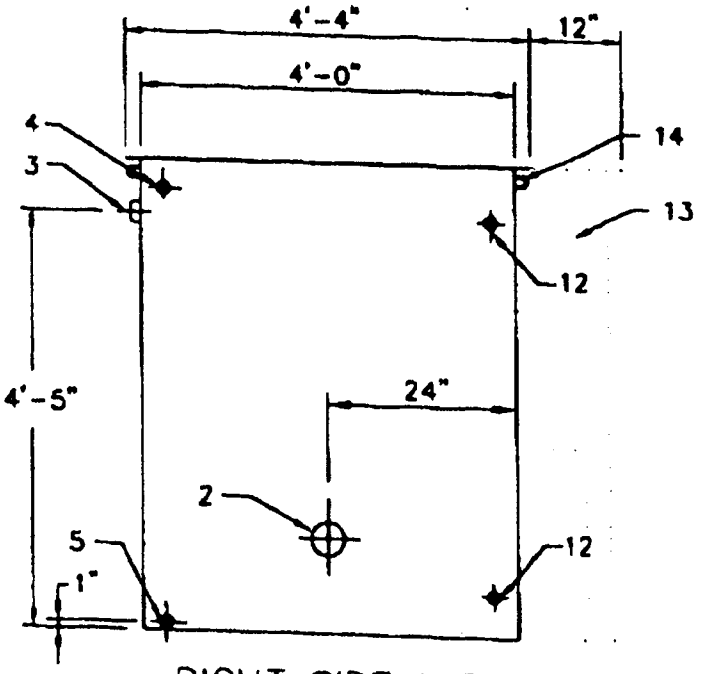


RIGHT SIDE VIEW

NOTES

1. MATERIAL: 11 GAUGE 304SS.
2. GASKET: NEOPRENE.
3. HARDWARE: 18-8 STAINLESS STEEL
4. INTERNAL PIPE SCH 40 PVC

REV.	DESCRIPTION	DATE	BY

HYDRO QUIP, INC.

Water Treatment Systems

GENERAL ARRANGEMENT
MODEL AC-4SS-150V

DRN. BY: PMD

CHKD. BY:

PROJECT:

DATE: 11/03/98

REF:

FILE: AC4SS150V

SCALE: 1/4" = 1'

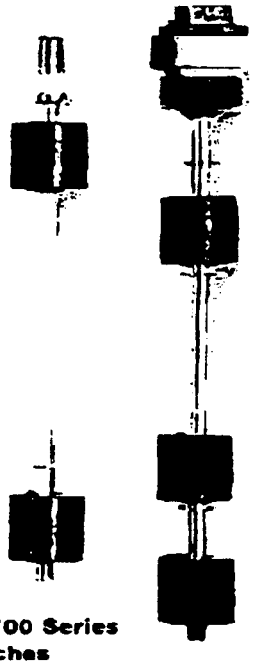
REV: 0

Not Used

ILS-700 Series Custom Switches with a Maximum Length of 4'

The ILS-700 series level switches are individually designed from over 360 component parts to create a custom switch available in lengths of from one foot (304mm) to four feet (1.2m).

To specify, review the choices in mounting types, stem and mounting, float sizes, switching points and electrical specifications that appear on these two pages.



ILS-700 Series Switches

Product Configuration Choices:

Mounting: Up to 12 choices; see table A-1 below.
Materials: Up to 14 choices; see tables A-2 and A-3 below.
Float Size: See table B, opposite page.
Length: 1 foot (304mm) minimum; 4 feet (1.2m) maximum

A. Component Choices:

1. **MOUNTING TYPES**
2. **MOUNTING AND STEM MATERIALS**
3. **FLOAT MATERIALS**
4. **SWITCH TYPES**

4. SWITCH TYPES	3. FLOAT MATERIALS	2. MOUNTING AND STEM MATERIALS	1. MOUNTING TYPES
1. 20 watt SPST	1. Buna-N	1. Brass	1. 1/8" NPT
~~2. 50 watt SPST~~	2. Polypropylene	2. Polypropylene	2. 1/4" NPT
3. 100 watt SPST	3. Kynar	3. Kynar	3. 3/8" NPT
4. 20 watt SPDT	4. PVC	4. PVC	4. 3/8 - 24
	~~5. CPVC~~	~~5. CPVC~~	5. 1/2" NPT
	6. 316 SS	6. 316 SS	6. 3/4" NPT
	~~7. 304 SS~~	~~7. 304 SS~~	7. 1.00" NPT
	8. 321/347 SS	8. 321/347	8. 1.250" NPT
	9. HC-276	9. HC-276	~~9. 1.500" NPT~~
	10. IN 600	10. IN 600	10. 2.000" NPT
	11. CuNi	11. CuNi	~~11. 1.3125"-12UNF-2A~~
	12. Ti 6 Al 4V	12. Ti 6 Al 4V	12. 3.625" dia. flange
	13. Ti Grp 2	13. Ti Grp 2	
		14. Teflon-PFA	

B. Series 700 Components and Operating Parameters (Selected Options Shown)

Mounting Types	Materials		Operating Parameters			Float Dimensions	
	Stem & Mount	Float	Specific Gravity	Temperature	Pressure		
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.	316 SS, Brass, or PVC.	Buna-N	0.65 minimum	H_2O: to +180°F (+82°C) OIL: -40°F to +220°F (-40°C to +104°C)	160 psig (11 Bar)	Part # 1010 BN Diameter: 1.00" (25mm) Height: 1.00" (25mm)	Part # 1117 BN Diameter: 1.1875" (30mm) Height: 1.75" (44mm)
1, 2, 3, 5, 6, 7, 8, 9, 10, 11.		PVC	0.7 minimum	To +140°F (+60° C)	50 psig (3 Bar)	Part # 1010 PV Diameter: 1.00" (25mm) Height: 1.00" (25mm)	
1, 2, 3, 4, 5,. 6, 7, 8, 9, 10, 11, 12.	316 SS	316 SS	0.9 minimum 0.7 minimum	-40°F to +300°F (-40°C to +149°C)	750 psig (52 Bar)	Part # 1012 Diameter: 1.00" (25mm) Height: 1.00" (25mm) Part # 2000 Spherical Diameter: 2.00" (50mm)	

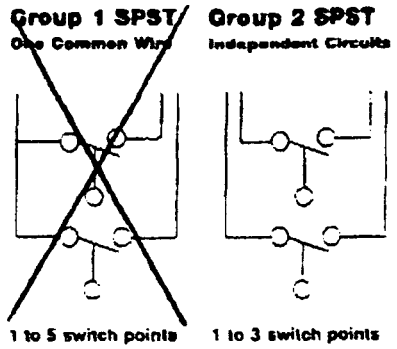
C. Switching Points and Electrical Specifications

Each switching point requires one float. For special applications, a single float can be used to activate two switch points, though these points must have a minimum separation of 1/8" (3mm). The maximum number of actuation levels depends on the wiring type selected.

Ratings: 20VA @ 120 VAC SPST
50VA @ 240 VAC SPST

Connection: 24" Free Leads
#22 AWG, PVC jacketed.

Mounting Attitude: Vertical +/- 30°



Only two actuation points are shown above.

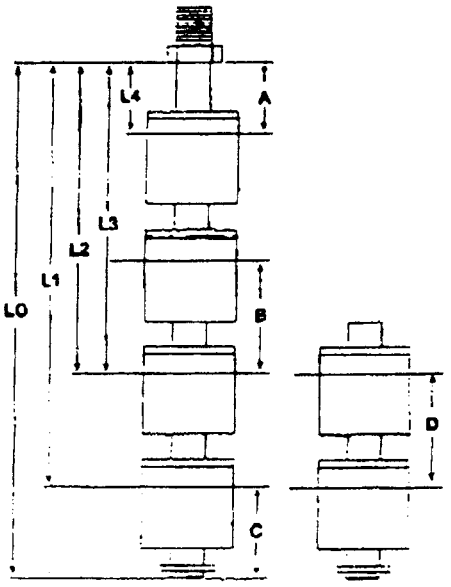
SPST Switch Wire Code

	Group 1	Group 2
Common Wire	Black	None
	NO/NC	SW Com I NO/NC
L1	Red	Red/Red
L2	Yellow	Yellow/Yellow
L3	Blue	Blue/Blue
L4	Brown	
L5	Orange	

D. Actuation Level Dimensions

A = Minimum distance from actuation point to bottom of mounting.
B = Minimum distance between actuation levels.
C = Minimum distance from end of unit to lowest actuation point.
D = Minimum distance between actuation points when a single float is used to actuate two switches.

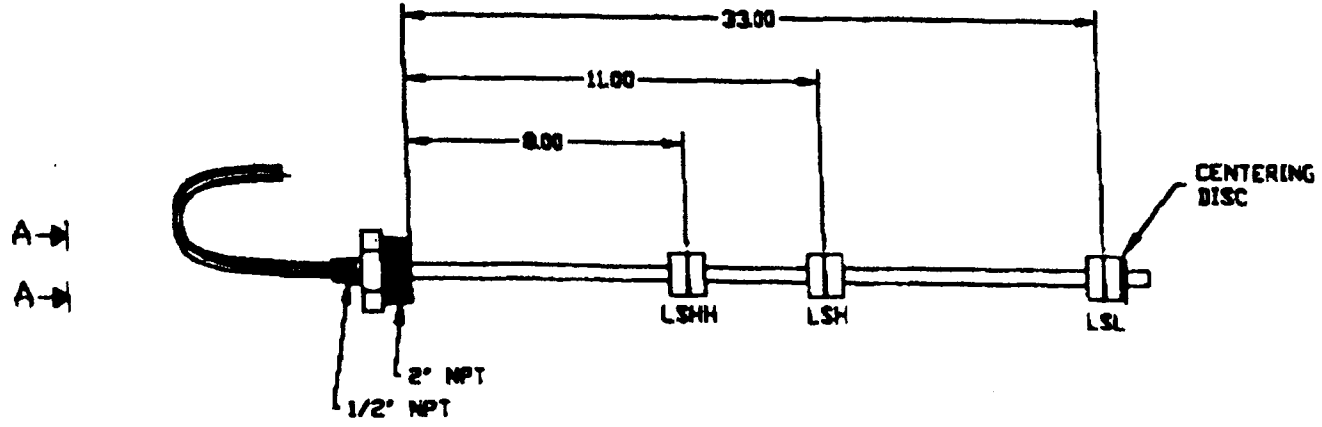
Notes:
1. A, B, and C dimensions are based on a specific gravity of 1.0.
2. One float for two actuation levels can be used only with a 20VA switch.
3. Actuation levels are calibrated on descending fluid level, with water as the fluid, unless otherwise specified.
4. Standard tolerance on actuation levels is +/- 1/8" (3mm).

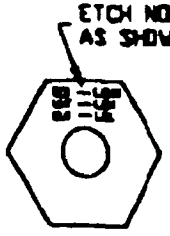


Dimensions

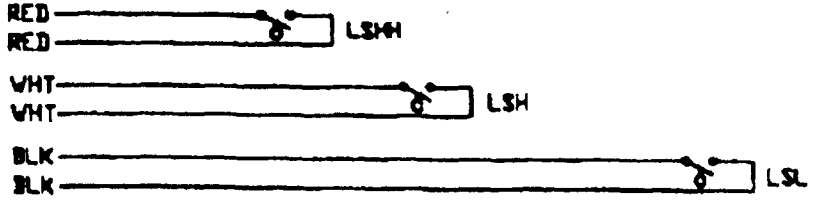
Float Type	A	B	C	D
Buna-N 1" (25mm)	1-1/8" (27mm)	1-1/2" (37mm)	2-3/16" (53mm)	1/8" (3mm)
PVC 1" (25mm)	1-1/8" (27mm)	1-1/2" (37mm)	2-3/16" (53mm)	1/8" (3mm)
SS 1" (25mm)	15/16" (23mm)	1-3/4" (42mm)	2-7/16" (59mm)	1/8" (3mm)
SS 1-3/4" (25mm)	1-1/8" (27mm)	1-1/2" (37mm)	2-3/16" (53mm)	1/8" (3mm)

Innovative Solutions





VIEW A-A



WIRING SCHEMATIC

NOTE:

1. ALL MATERIAL TO BE 316 ST. ST'L.
2. SPECIFIC GRAVITY 0.6.
3. REED SWITCHES RATED AT 50VA, 125V.
4. SWITCH SHOULD BE IN THE DOWN POSITION FOR MEASUREMENT.
5. ALL WIRE TO BE 18 AWG., PVC JACKETED, 24" MIN FREE LENGTH.

Innovative Solutions

3 LEVEL FLOAT SWITCH

OIL/WATER SEPARATOR DESIGN CALCULATIONS
AND MANUFACTURER INFORMATION
FOR
LOADING RACK AREA

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN #: 201-125

Drawn/Calculated by: Jeff Becken
Date: 1/20/03
Reviewed by: Bill Walsh

Oil/water Separator Design

Assumptions

Flow = 40 gpm
Equipment to be stainless steel
Free Product if accumulated will be Paraxylene or Diesel
Specific Gravity of Paraxylene = 0.861
Specific Gravity of Diesel = 0.86
Hold tank of 200 gallon

System to be designed to remove free product if collected.

- Based on information provided by JDI, Inc., the Hydroquip, Inc. HQI AGM2-1H-200V will remove free product of paraxylene or diesel pumped at a flow rate of 40 gpm or less pending emulsification.

- Specification data sheets on the Hydroquip, Inc. HQI AGM2-1H-200V is attached.

- If free product is emulsified w/ groundwater, the air stripper should remove the mixed fluids (Assumption)

JDI, Inc.

Industrial Washing Systems, Recycling, & Fluid Waste Minimization Equipment

Industrial Washing Systems

Solvent Replacement Cleaners/ Degreasers

Parts Washers

Recycling/ Filtering Systems

Ultrafiltration Equipment

Oil Skimmers

Evaporators

Oil/Water Separators

Tanks

January 10, 2003

Mr. Jeff Becken
Catlin Engineers & Scientists
220 Old Dairy Road
Wilmington, NC 28405

Phone: (910) 452-5861
Fax: (910) 452-7563

RE: Oil/Water Separator Systems Quotation

Dear Jeff:

As requested, we are pleased to present the following quotation for a Hydroquip, Inc. oil water separator (OWS) system. The Hydroquip, Inc. AGM2-1H-200V parallel plate oil/water separator has a 200 gallon equalization tank and will be able to process a continuous flow of 40 gallons per minute.

The separator will remove essentially all free and dispersed non-emulsified oil and parazylene droplets larger than 60 microns in diameter with a specific gravity of 0.861 or less. It is designed for above-grade installation and will be constructed of 12 gauge stainless steel.

We appreciate the opportunity to present this quotation and look forward to working with you. If you have any questions or desire further information, please give me a call.

Best regards,

Tom

Thomas R. Goodwin
President
JDI, Inc.

Enclosures
Faxed page 1 of 2

(910) 791-1855 • P.O. Box 3821 • Wilmington, NC 28406 • Fax (910) 313-1987
email: sales@jdiinc.com webpage: www.jdiinc.com

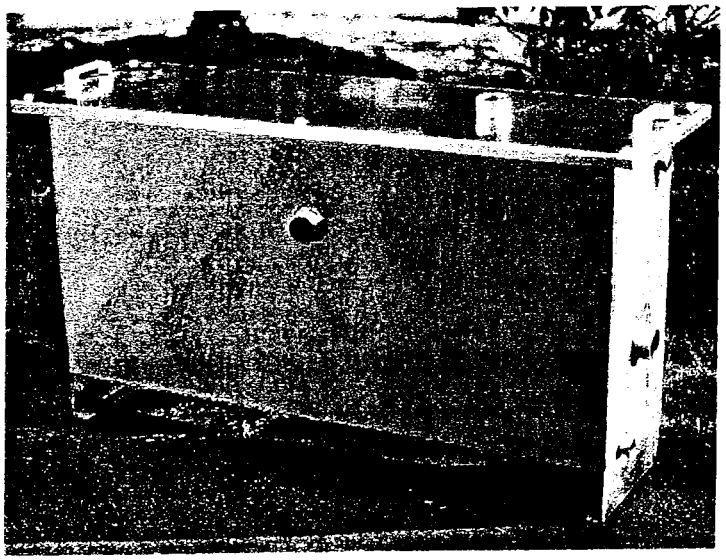
Oil/Water Separator Pricing Information

Item	Quan	Description and Part Number	Price
1	1	**Hydroquip, Inc. HQI AGM-2SS-1H-200V** [redacted] **Parallel Corrugated Plate Oil/Water Separator** * **Design Flow:** 40 GPM * **Approx. Dimensions:** 2' wide x 5' long x 3' high * **Materials of Construction:** 12 Gauge Stainless Steel Internal Pipe Schedule 80 PVC * **HQI AGM-2SS Systems Features Include:** * 3" NPT Inlet/Outlet * 2" NPT Oil Chamber Outlet • Parallel corrugated plate coalescer designed to remove oil and parazylene droplets greater than 60 microns with a Reynolds Number of less than 500 * Sludge baffle to capture and contain settleable solids * 200 Gallon effluent pump out compartment * Neoprene gasketed removable vapor tight cover for access to chamber compartments	

Terms:	Net 30 Days, 1.5% per month Finance Charge after 30 days
Shipping:	F. O. B. Massachusetts
Delivery:	3-4 weeks after receipt of approved drawings
Note:	Any applicable taxes will be in addition to the price quoted Offer Valid for 90 Days
Warranty:	One year - Oil/Water Separator Accessories and Treatment Equipment

HYDRO QUIP **Water Treatment Equipment**

RECTANGULAR OIL WATER SEPARATORS



FEATURES & BENEFITS

- Low maintenance cost
- Easily cleaned through the removable vapor tight cover(s)
- No moving parts
- No power consumption
- No consumable wearing elements
- No chemicals, absorbent or filter cartridges to remove, replace or dispose of
- Compact size
- Solids storage
- Optional integral oil storage

Operation

The separator shall be a special purpose prefabricated parallel corrugated plate gravity displacement type oil/water separator designed to remove free and dispersed non-emulsified oil and settlable solids, in accordance with API 421. The separator shall be comprised of a tank containing;

INLET COMPARTMENT

The inlet chamber will be comprised of a non-clog diffuser pipe to distribute the flow across the width of the separator chamber. The inlet compartment shall be of sufficient volume to effectively reduce influent suspended solids, dissipate energy and begin separation. A sludge baffle will be provided to prevent settlable solids and sediment from entering the separation chamber.

SEPARATION CHAMBER

The separation chamber will contain parallel corrugated plates for enhanced oil/water separation. The UNIPACK plates will be spaced for optimum removal of free oil and settlable solids, and the corrugations will have a 45 to 60 degree angle with respect to the horizontal. Flow through the plate pack will be in a cross-flow configuration. This allows the oil to collect and coalesce in the high points of the corrugations while the solids collect at the low points. This also allows oil to rise without interfering with the falling solids, reducing the possibility of clogging. Plates shall be enclosed in a stainless steel frame to facilitate installation and removal.

SEDIMENT CHAMBER

The sediment chamber will be located prior to the separation chamber and will provide an adequate volume and baffling for the settling of any solids.

OIL COLLECTION

The oil will be collected at the end of the separation chamber by a fixed weir trough or rotatable skimmer. Either collection method will provide for automatic decant of the separated oil through gravity outlet(s) on the side(s) of the separator. The type of oil collector depends upon the application.

INTEGRAL OIL STORAGE COMPARTMENT

An integral oil storage compartment can be provided for storing separated oil. The compartment adjacent to the coalescing compartment would collect and store the oil discharged from the oil collector.

CLEAN WATER CHAMBER

The water will pass under the oil retention baffle and over the adjustable effluent weir, which maintains the liquid level throughout the separator, and exit through the outlet provided at the end of the separator.

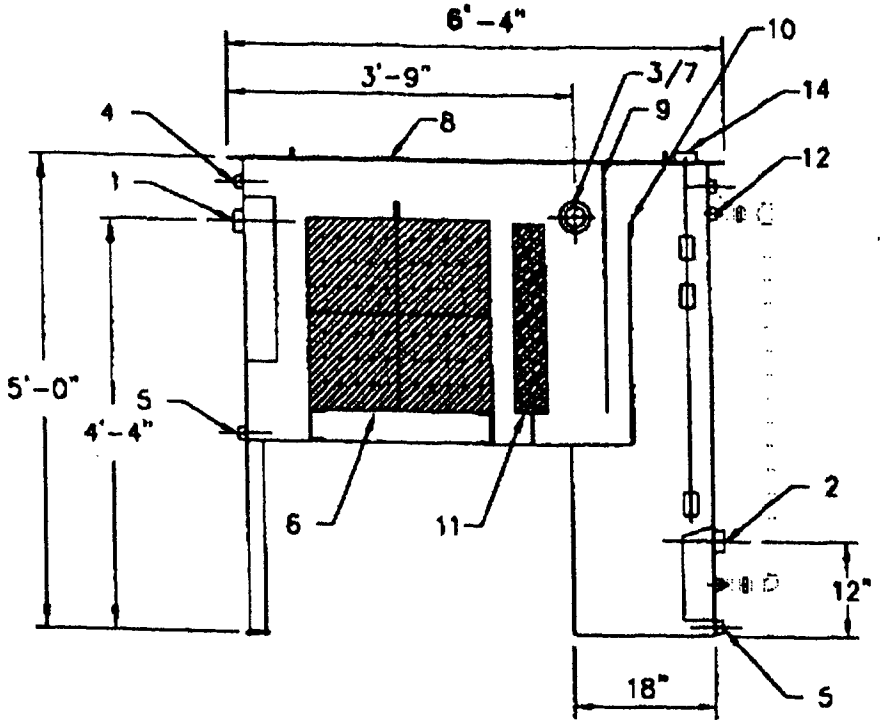
COVERS

The separator is provided with a vapor tight cover that can easily be removed for service and maintenance.

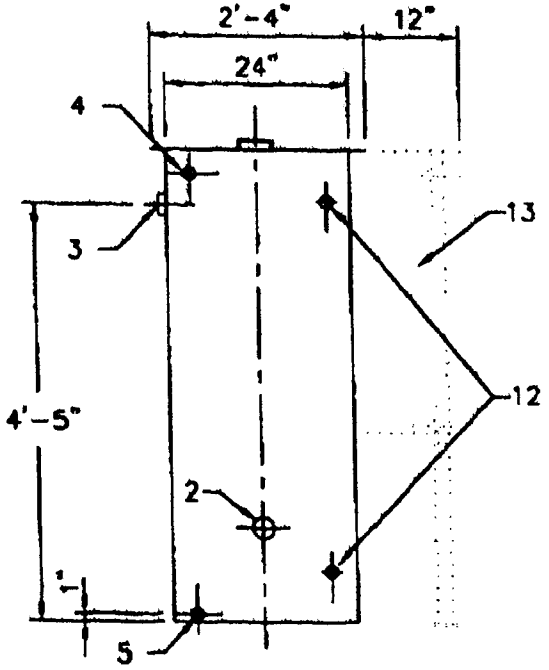
POB 3160 * 63 N. Washington St. * N. Attleboro, MA 02761-3160
Ph: (508) 695-3640 * Fax (508) 695-4412 EMAIL: HQI@OWS.COM

ITEM	QTY	DESCRIPTION	ITEM	QTY	DESCRIPTION
1	1	2" FNPT INLET	8	1	REMOVABLE COVER
2	1	2" FNPT OUTLET	9	1	OIL STOP WEIR
3	1	2" FNPT OIL OUTLET	10	1	ADJ. OVERFLOW WEIR
4	2	1" FNPT VENT	11	0	OPTIONAL MESH PAD
5	2	1" FNPT DRAIN	12	0	OPT. SIGHT GLASS PORTS
6	1	COALESCING PLATES	13	0	OPTIONAL PRODUCT TANK
7	1	PVC OIL SKIMMER	14	1	2" NPT FLOAT SWITCH

SHIPPING WEIGHT	440 LBS
OPERATING WEIGHT	3072 LBS
SEPARATOR VOLUME	317 GALLONS
EFFLUENT TANK VOLUME	200 GALLONS
SLUDGE VOLUME	4 GALLONS
COALESCING AREA	8 CUBIC FEET
OPT. PRODUCT TANK VOL	108 GALLONS



ELEVATION



RIGHT SIDE VIEW

NOTES

1. MATERIAL: 12 GAUGE 304SS.
2. GASKET: NEOPRENE.
3. HARDWARE: 18-8 STAINLESS STEEL
4. INTERNAL PIPE SCH 40 PVC

REV.	DESCRIPTION	DATE	APP.

HYDRO QUIP. INC.

Water Treatment Systems

GENERAL ARRANGEMENT

Model AGM-2SS-200V-1H

DRN. BY: PMD

CHKD. BY:

PROJECT:

DATE: 3/14/06

REF:

FILE: AGM2SS1H

SCALE: 1/2" = 1'

REV: B

5.0 AIR STRIPPER

The primary equipment selected for the treatment of contaminated groundwater to NCAC T15A:02L Groundwater Quality Standards is a tray-type air stripper. The following sections address the design of the air stripper, the associated blower, and the associated feed pump.

5.1 PX FACILITY

5.1.1 Design of Feed Pump

5.1.1.1 Assumptions

- The maximum pumping rate will be 80 gpm.
- The pump will be required to pump groundwater from the oil/water separator to the air stripper through a 3-inch PVC pipe. Maximum length of pipe will be 20 feet.
- The air stripper sits on a platform, which is 4 feet above the ground surface.
- The air stripper is 6.75 feet tall.
- The effluent discharge outlet for the oil/water separator is one foot above the ground surface.

5.1.1.2 Selection

The attached air stripper design calculations and manufacturer information were used to select the feed pump. Based on the design calculations the minimum pump size must maintain a maximum flow rate of 80 gpm with an approximate total head loss of 20 feet. The plan is to utilize the feed pump to be provided by the air stripper manufacturer or an approved equivalent.

5.1.2 Design of Air Stripper

5.1.2.1 Assumptions

- The maximum flow rate through the system will be 80 gpm.
- The maximum concentrations of the contaminants of concern are 170,000 ppb for paraxylene and 1,100 ppb for MTBE.
- The concentration levels of the treated groundwater must meet NCAC T15A:02L Groundwater Quality Standards. The NCAC T15A:02L Groundwater Quality Standards are 530 ppb for paraxylene and 200 ppb for MTBE.
- The air stripper is to be a shallow tray type air stripper.
- The blower size is based on the minimum size determined by the manufacturer to allow the proposed air stripper to treat to the concentration levels discussed above.

- The manufacturer has considered the minimum accessories to guarantee proper operation of the air stripper provided on Sheet 7 of the Construction Plans.

5.1.2.2 Selection

The attached air stripper design calculations and manufacturer information were used to select the air stripper and the associated components previously discussed. CATLIN provided the above assumptions to a preferred air stripper manufacturer, North East Environmental Products, Inc. (NEEP Systems). NEEP Systems recommended their Shallow Tray Model 3641 air stripper.

In order to verify the air stripper size recommended by NEEP Systems, we conducted two methods of verification. The first method involved a hand calculation method utilizing the US Army Corps of Engineers Design Guide DG1110-1-3, Appendix C, October 2001 document to verify the number of shallow trays and the minimum surface area of each tray of the manufacturer's recommended air stripper. The second method involved the use of the excel model program provided by NEEP Systems for their air stripper design. Calculation sheets for both methods have been attached. Based on the positive results of the two methods of verification, the plan is to install the NEEP System Shallow Tray Model 3641 air stripper or an approved equivalent as part of the groundwater recovery system.

5.2 LOADING RACK AREA

5.2.1 Design of Feed Pump

5.2.1.1 Assumptions

- The maximum pumping rate will be 40 gpm.
- The pump will be required to pump groundwater from the oil/water separator to the air stripper through a 2-inch PVC pipe. Maximum length of pipe will be 20 feet.
- The air stripper sits on a platform, which is 4 feet above the ground surface.
- The air stripper is 6.75 feet tall.
- The effluent discharge outlet for the oil/water separator is one foot above the ground surface.

5.2.1.2 Selection

The attached air stripper design calculations and manufacturer information were used to select the feed pump. Based on the design calculations the minimum pump size must maintain a maximum flow rate of 40 gpm with an approximate total head loss of 20 feet. The plan is to utilize the feed pump to be provided by the air stripper manufacturer or an approved equivalent.

5.2.2 Design of Air Stripper

5.2.2.1 Assumptions

- The maximum flow rate through the system will be 40 gpm.
- The maximum concentrations of the contaminants of concern are as follows: 6,200 ppb for Benzene, 260 ppb for sec-Butylbenzene, 2,800 ppb for Ethyl Benzene, 3,900 ppb for MTBE, 540 ppb for Naphthalene, 360 ppb for Propylbenzene, 1,100 ppb for Toluene, 1,000 ppb for 1,2,4-Trimethylbenzene, and 37,500 ppb for Xylenes (assumed to be paraxylene). These concentrations are based on the maximum concentrations in the Loading Rack area during the preparation of the CAPA.
- The concentration levels of the treated groundwater must meet NCAC T15A:02L Groundwater Quality Standards. The NCAC T15A:02L Groundwater Quality Standards are as follows: 1 ppb for Benzene, 70 ppb for sec-Butylbenzene, 29 ppb for Ethyl Benzene, 200 ppb for MTBE, 6 ppb for Naphthalene, 70 ppb for Propylbenzene, 1,000 ppb for Toluene, 350 ppb for 1,2,4-Trimethylbenzene, and 530 ppb for Xylenes.
- The air stripper is to be a shallow tray type air stripper.
- The blower size is based on the minimum size determined by the manufacturer to allow the proposed air stripper to meet the concentration levels discussed above.
- The manufacturer has considered the minimum accessories to guarantee proper operation of the air stripper provided on Sheet 7 of the Construction Plans.

5.2.2.2 Selection

The attached air stripper design calculations and manufacturer information were used to select the air stripper and the associated components previously discussed. CATLIN provided the above assumptions to a preferred air stripper manufacturer, North East Environmental Products, Inc. (NEEP Systems). NEEP Systems recommended their Shallow Tray Model 2641 air stripper.

In order to verify the air stripper size recommended by NEEP Systems, we conducted two methods of verification. The first method involved a hand calculation method utilizing the US Army Corps of Engineers Design Guide DG1110-1-3, Appendix C, October 2001 document to verify the number of shallow trays and the minimum surface area of each tray of the manufacturer's recommended air stripper. The second method involved the use of the excel model program provided by NEEP Systems for their air stripper design. Calculation sheets for both methods have been attached. Based on the positive results of the two methods of verification, the plan is to install the NEEP System Shallow Tray Model 2641 air stripper or an approved equivalent as part of the groundwater recovery system.

AIR STRIPPER DESIGN CALCULATIONS AND MANUFACTURER INFORMATION FOR PX FACILITY

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 195-033

Drawn/Calculated by: Jeff Becker
Date: 11/18/02
Reviewed by: WALSH

Design Air Stripper

- Assumptions for Air Stripper Design

  - The preferred manufacturer is NEEP Systems. The system recommended by NEEP is attached. Alternate 2 system is preferred. Need to verify system is adequate.
  - Flow rate of system is 80 gpm
  - Concentrations of contaminants of concern are 170,000 ppb for paraxylene and 1,100 ppb for MTBE.
  - Level of treatment is 530 ppb for paraxylene and 200 for MTBE

Verify System Components Meet System Requirements

- NEEP provided a list of basic equipment and optional equipment. The following items need to be verified for sizing requirements:

  1) Feed Pump Size
  2) Air Stripper Size

- Assume all other equipment specified by manufacturer is sized properly with air stripper to guarantee treatment concentrations are met.

- Effluent pipe design is covered in Effluent Dosing Tank Design

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 195-033

Drawn/Calculated by: Jeff Becken
Date: 11/18/02
Reviewed by: WJN

Design Air Stripper (cont.)

Verify Size of Feed Pump

Assumptions
- Pump required to pump water from oil/water separator to air stripper.
- Inflow rate = 80 gpm
- Air Stripper sits on platform 4.0 feet above ground surface
- Air Stripper is 6.75 feet tall
- Line connected to feed pump is a 3 inch schedule 80 PVC pipe (20 feet)
- Minor losses are 20% of velocity head

Elevation Head Loss

= Height of air stripper + platform height

= 6.75' + 4.0'

= 10.75 feet

Head Loss of PVC

- Using Hazen + Williams formula

$$h = 0.2083\left(\frac{100}{C}\right)^{1.852} \times \frac{Q^{1.852}}{d^{4.8655}}$$

where C = wall roughness = 150 for PVC
d = pipe diameter = 3 in.
h = head loss per 100 ft
Q = Flow Rate = 80 gpm

$$h = 0.2083\left(\frac{100}{150}\right)^{1.852} \times \frac{80^{1.852}}{3^{4.8655}}$$

$$h = 1.57 \text{ psi} \times 2.308 \frac{\text{ft water}}{\text{psi}} = 3.62 \text{ ft of } H_2O$$

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN # : 195-033

Drawn/Calculated by: Jeff Becker
Date: 11/18/02
Reviewed by: WASH

Design Air Stripper (cont.)

Verify Size of Feed Pump (cont.)

Velocity Head Loss

$$= \left[\frac{\text{Friction head loss}}{100\,LF} \times \text{Total Length}\right] \times \text{Minor Losses}$$

$$= \left[\left(\frac{3.62\,ft}{100\,LF}\right) \times 20\,ft\right] \times 1.2$$

$$= 0.87 \text{ feet}$$

Total Head Loss

= Elevation + velocity

= 10.75 feet + 0.87 feet

= 11.62 feet

Use 20 feet

NEEP is providing a feed pump that will pump at a maximum pumping rate of 80 gpm at a total head loss of 20 feet. This pump appears to meet the design requirements discussed above.

CATLIN
ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN # : 195-033

Drawn/Calculated by: Jeff Backen
Date: 11/18/02
Reviewed by: WASH

Design Air Stripper (cont.)

Verify Air Stripper Size

- Air Stripper verified by 2 methods:

1) Hand calculations - Using US Army Corps of Engineers Design Guide DG1110-1-3, Appendix C, October 2001, verify the number of air stripper trays required and the surface area of the trays

2) Computer modelling - Using NEEP Systems excel program model to verify size, completed by CATLIN inputting the influent data to achieve desired output.

- Each Method is provided on the attached data sheets.

∴ Air Stripper model 3641 recommended by manufacturer appears to be suitable based on attached calculation sheets.

AIR STRIPPER - HAND CALCULATIONS
FOR
PX FACILITY

U.S. ARMY CORPS OF ENGINEERS DESIGN GUIDE
DG 1110-1-3 APPENDIX C (OCTOBER 2001)

JOB: FHR NORTH TERMINAL COMPUTED BY: NJV DATE: 11-11-02

DESCRIPTION: AIR STRIPPER DESIGN CHECKED BY: NKB DATE: 11/11/02

VERIFY AIR STRIPPER DESIGN

FROM US ARMY CORPS OF ENGINEERS DESIGN GUIDE DG 1110-1-3, APPENDIX C, OCTOBER 31, 2001:

$$N_{THEORETICAL} = \frac{Log\left[\frac{\left[X_o - \frac{Y_{n+1}}{m}\right]}{\left[X_n - \frac{Y_{n+1}}{m}\right]}\left(1 - \frac{1}{S}\right) + \frac{1}{S}\right]}{Log\ S}$$

WHERE,

X_o = CONCENTRATION of CONTAMINANT (MTBE) IN INLET WATER: 1100 ppb

X_n = CONCENTRATION of CONTAMINANT (MTBE) IN TREATED WATER: 200 ppb ← RI STANDARDS

N = NUMBER of THEORETICAL PLATES. ASSUMES THE LIQUID ON EACH PLATE IS COMPLETELY MIXED AND THE VAPOR LEAVING THE PLATES IS IN EQUILIBRIUM WITH THE LIQUID.

H = HENRY'S CONSTANT (ATM)

m = Slope of EQUILIBRIUM CURVE (H/P_t)

G = lb-moles air/min (Air Flow of Proposed Blower = 900 cfm)

L = lb-moles of water/min (Water Flow of Proposed System = 80 gpm)

S = Stripping Factor (mG/L)

P_t = Ambient PRESSURE (atm)

Y_{n+1} = CONCENTRATION OF VOLATILES IN AIR ENTERING THE AIR STRIPPER

NOTE: FOR AIR STRIPPING, $Y_{n+1} = 0$ ⇒ assumed clean air inflow

$$\therefore N_{THEORETICAL} = \frac{Log\left[\left(\frac{Y_o}{X_n}\right)\left(1 - \frac{1}{S}\right) + \frac{1}{S}\right]}{Log\ S}$$

CATLIN ENGINEERS and SCIENTISTS

JOB: FHR NORTH TERMINAL COMPUTED BY: WJW DATE: 11-11-02

DESCRIPTION: AIR STRIPPER DESIGN CHECKED BY: JKB DATE: 11/11/02

X_o = 1100 ppb MTBE

X_n = 200 ppb MTBE

H = 5.5×10^{-4} atm · m³/mol @ 25 °C FOR MTBE FROM USEPA, TECHNICAL INFORMATION REVIEW, OFFICE OF POLLUTION PREVENTION AND TOXICS, USEPA, WASHINGTON D.C.

= 5.5×10^{-4} atm · m³/mol $\left(55600 \frac{atm}{atm \cdot m^3/mol}\right)$ = 30.58 atm

P_t = 1 atm

$m = \frac{H}{P_t} = (30.58 \text{ atm})/1 \text{ atm} = 30.58$

$$G = \left(\frac{900 \text{ ft}^3}{\text{min}}\right)\left(\frac{\text{lb-mol air}}{380 \text{ ft air}}\right) = 2.37 \frac{\text{lb-mole air}}{\text{min}}$$

$$L = \left(\frac{80 \text{ gal}}{\text{min}}\right)\left(\frac{8.34 \text{ lb } H_2O}{\text{gal } H_2O}\right)\left(\frac{\text{lb-mole } H_2O}{18 \text{ lb}}\right) = 37.07 \frac{\text{-mole } H_2O}{\text{min}}$$

$$S = 30.58 \left(\frac{2.37}{37.07}\right) = 1.95$$

$$N_{THEOR} = \frac{\text{Log}\left[\left(\frac{1100}{200}\right)\left(1 - \frac{1}{1.95}\right) + \frac{1}{1.95}\right]}{\text{Log } 1.95} = 1.735$$

$$N_{ACTUAL} = \frac{N_{THEOR}}{E}$$

WHERE E = TRAY EFFICIENCY (.5 ASSUMED)

$$\therefore N_{ACTUAL} = \frac{1.735}{.5} = 3.47$$

USE 4 TRAYS

CATLIN ENGINEERS and SCIENTISTS

JOB: FHR NORTH TERMINAL COMPUTED BY: WJV DATE: 11-11-02

DESCRIPTION: AIR STRIPPER DESIGN CHECKED BY: JKB DATE: 11/11/02

ESTIMATE SIZE OF THE PERFORATED PLATE SECTION OF EACH TRAY

$$A = Q_{AIR}\left(\frac{1 ft^2}{60 cfm}\right)$$

WHERE:

A = CROSS-SECTIONAL AREA OF PERFORATED PLATE SECTION OF EACH TRAY (MINIMUM) (ft^2)

Q_{AIR} = AIR FLOW RATE (900 cfm)

NOTE: RATIO of $1 ft^2/60$ cfm obtained from USACE DG 1110-1-3, APPENDIX C.

$$A = (900 cfm)\left(\frac{1 ft^2}{60 cfm}\right)$$

$$\boxed{A = 15 ft^2}$$

IN SUMMARY

FOR 80 gpm of 1100 ppb MTBE INFLUENT USE AN AIR STRIPPER WITH:

- 4 TRAYS (MINIMUM OF 15 ft^2 PERFORATED SECTIONS)
- BLOWER CAPABLE of PROVIDING 900 CFM OF AIR.

- Stripper recommended by manufacturer meets these requirements. Model 3641 - NEEPSystem

Note:

- Paraxylene is other contaminant of concern; however, paraxylene is more volatile as evident by manufacturer's air stripper modelling program.

CATLIN ENGINEERS and SCIENTISTS

AIR STRIPPER COMPUTER MODELING BY CATLIN
FOR
PX FACILITY

NEEP SYSTEMS EXCEL MODEL PROGRAM

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Paraxylene Facility
CATLIN's verification calcs

Series chosen:	3600	
Water Flow Rate:	80 gpm	18.2 m3/hr
Air Flow Rate:	900 scfm	1530 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	100 °F	38 °C
A/W Ratio:	84 :1	
Safety Factor:	0%	

SELECTED MODEL

Contaminant	Untreated Influent / Effluent Target	Model 3611 Effluent	Model 3621 Effluent	Model 3631 Effluent	Model 3641 Effluent	Model 3651 Effluent
		lbs/hr ppmv %removal	lbs/hr ppmv %removal	lbs/hr ppmv %removal	lbs/hr ppmv %removal	lbs/hr ppmv %removal
p-Xylene Solubility 175 ppm Mwt 106.16	170000 ppb 530 ppb	17477 ppb 6.12 404.87 89.72%	1797 ppb 6.75 446.50 98.94%	185 ppb 6.82 450.78 99.89%	19 ppb 6.82 451.21 99.99%	2 ppb 6.83 451.26 100.00%
MTBE Solubility 43,000 ppm Mwt 88.15	1100 ppb 200 ppb	629 ppb 0.02 1.51 42.84%	359 ppb 0.03 2.37 67.32%	205 ppb 0.04 2.86 81.32%	117 ppb 0.04 3.14 89.32%	67 ppb 0.04 3.30 93.90%
Total ppb	171100 ppb	18106 ppb	2156 ppb	390 ppb	136 ppb	69 ppb
Total VOC lbs/hr - ppmv		6.14 406.38	6.78 448.86	6.85 453.63	6.86 454.36	6.87 454.56
Total		89.42%	98.74%	99.77%	99.92%	99.96%

The influent concentration of this compound exceeds its solubility factor. Contact your NEEP representative for further detai

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Paraxylene Facility
CATLIN's verification calcs

Series chosen:	3600	
Water Flow Rate:	80 gpm	18.2 m3/hr
Air Flow Rate:	900 scfm	1530 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	75 °F	24 °C
A/W Ratio:	84 :1	
Safety Factor:	0%	

Contaminant	Untreated Influent / Effluent Target	Model 3611 Effluent lbs/hr / ppmv / %removal	Model 3621 Effluent lbs/hr / ppmv / %removal	Model 3631 Effluent lbs/hr / ppmv / %removal	SELECTED MODEL Model 3641 Effluent lbs/hr / ppmv / %removal	Model 3651 Effluent lbs/hr / ppmv / %removal
p-Xylene Solubility 175 ppm Mwt 106.16	170000 ppb 530 ppb	17781 ppb 6.11 404.07 89.54%	1860 ppb 6.75 446.33 98.91%	195 ppb 6.82 450.75 99.89%	20 ppb 6.82 451.21 99.99%	2 ppb 6.83 451.26 100.00%
MTBE Solubility 43,000 ppm Mwt 88.15	1100 ppb 200 ppb	633 ppb 0.02 1.49 42.49%	364 ppb 0.03 2.35 66.92%	209 ppb 0.04 2.85 80.97%	120 ppb 0.04 3.13 89.06%	69 ppb 0.04 3.30 93.71%
Total ppb	171100 ppb	18413 ppb	2224 ppb	404 ppb	141 ppb	71 ppb
Total VOC lbs/hr - ppmv		6.13 405.56	6.78 448.68	6.85 453.60	6.86 454.34	6.87 454.55
Total		89.24%	98.70%	99.76%	99.92%	99.96%

The influent concentration of this compound exceeds its solubility factor. Contact your NEEP representative for further detai

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Paraxylene Facility
CATLIN's verification calcs

Series chosen:	3600	
Water Flow Rate:	80 gpm	18.2 m3/hr
Air Flow Rate:	900 scfm	1530 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	50 °F	10 °C
A/W Ratio:	84 :1	
Safety Factor:	0%	

Contaminant	Untreated Influent / Effluent Target	Model 3611 Effluent lbs/hr / ppmv / %removal	Model 3621 Effluent lbs/hr / ppmv / %removal	Model 3631 Effluent lbs/hr / ppmv / %removal	SELECTED MODEL Model 3641 Effluent lbs/hr / ppmv / %removal	Model 3651 Effluent lbs/hr / ppmv / %removal
p-Xylene	170000 ppb	18090 ppb	1925 ppb	205 ppb	22 ppb	2 ppb
Solubility 175 ppm	530 ppb	6.10 403.25	6.75 446.16	6.82 450.72	6.82 451.21	6.83 451.26
Mwt 106.16		89.36%	98.87%	99.88%	99.99%	100.00%
MTBE	1100 ppb	637 ppb	368 ppb	213 ppb	123 ppb	71 ppb
Solubility 43,000 ppm	200 ppb	0.02 1.48	0.03 2.34	0.04 2.84	0.04 3.12	0.04 3.29
Mwt 88.15		42.13%	66.51%	80.62%	88.79%	93.51%
Total ppb	171100 ppb	18726 ppb	2293 ppb	418 ppb	145 ppb	74 ppb
Total VOC lbs/hr - ppmv		6.12 404.73	6.78 448.49	6.85 453.56	6.86 454.33	6.87 454.55
Total		89.06%	98.66%	99.76%	99.92%	99.96%

The influent concentration of this compound exceeds its solubility factor. Contact your NEEP representative for further detai

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Paraxylene Facility
CATLIN's verification calcs

Series chosen:	3600	
Water Flow Rate:	80 gpm	18.2 m3/hr
Air Flow Rate:	900 scfm	1530 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	20 °F	-7 °C
A/W Ratio:	84 :1	
Safety Factor:	0%	

Contaminant	Untreated Influent / Effluent Target	Model 3611 Effluent lbs/hr / ppmv / %removal	Model 3621 Effluent lbs/hr / ppmv / %removal	Model 3631 Effluent lbs/hr / ppmv / %removal	SELECTED MODEL Model 3641 Effluent lbs/hr / ppmv / %removal	Model 3651 Effluent lbs/hr / ppmv / %removal
p-Xylene Solubility 175 ppm Mwt 106.16	170000 ppb 530 ppb	18467 ppb 6.08 402.24 89.14%	2006 ppb 6.75 445.94 98.82%	218 ppb 6.82 450.69 99.87%	24 ppb 6.82 451.20 99.99%	3 ppb 6.83 451.26 100.00%
MTBE Solubility 43,000 ppm Mwt 88.15	1100 ppb 200 ppb	641 ppb 0.02 1.47 41.71%	374 ppb 0.03 2.32 66.02%	218 ppb 0.04 2.82 80.19%	127 ppb 0.04 3.11 88.45%	74 ppb 0.04 3.28 93.27%
Total ppb Total VOC lbs/hr - ppmv Total	171100 ppb	19109 ppb 6.10 403.71 88.83%	2380 ppb 6.77 448.26 98.61%	436 ppb 6.85 453.51 99.75%	151 ppb 6.86 454.31 99.91%	77 ppb 6.87 454.54 99.96%

The influent concentration of this compound exceeds its solubility factor. Contact your NEEP representative for further detai

AIR STRIPPER RECOMMENDED BY NEEP SYSTEMS
FOR
PX FACILITY

ShallowTray®
low profile air strippers

System Performance Estimate
Client and Proposal Information:

Catlin Engrs & Scientists: Jeff Becken
FHR North Terminal, Wilmington, NC
#602912-3: 2L Removal

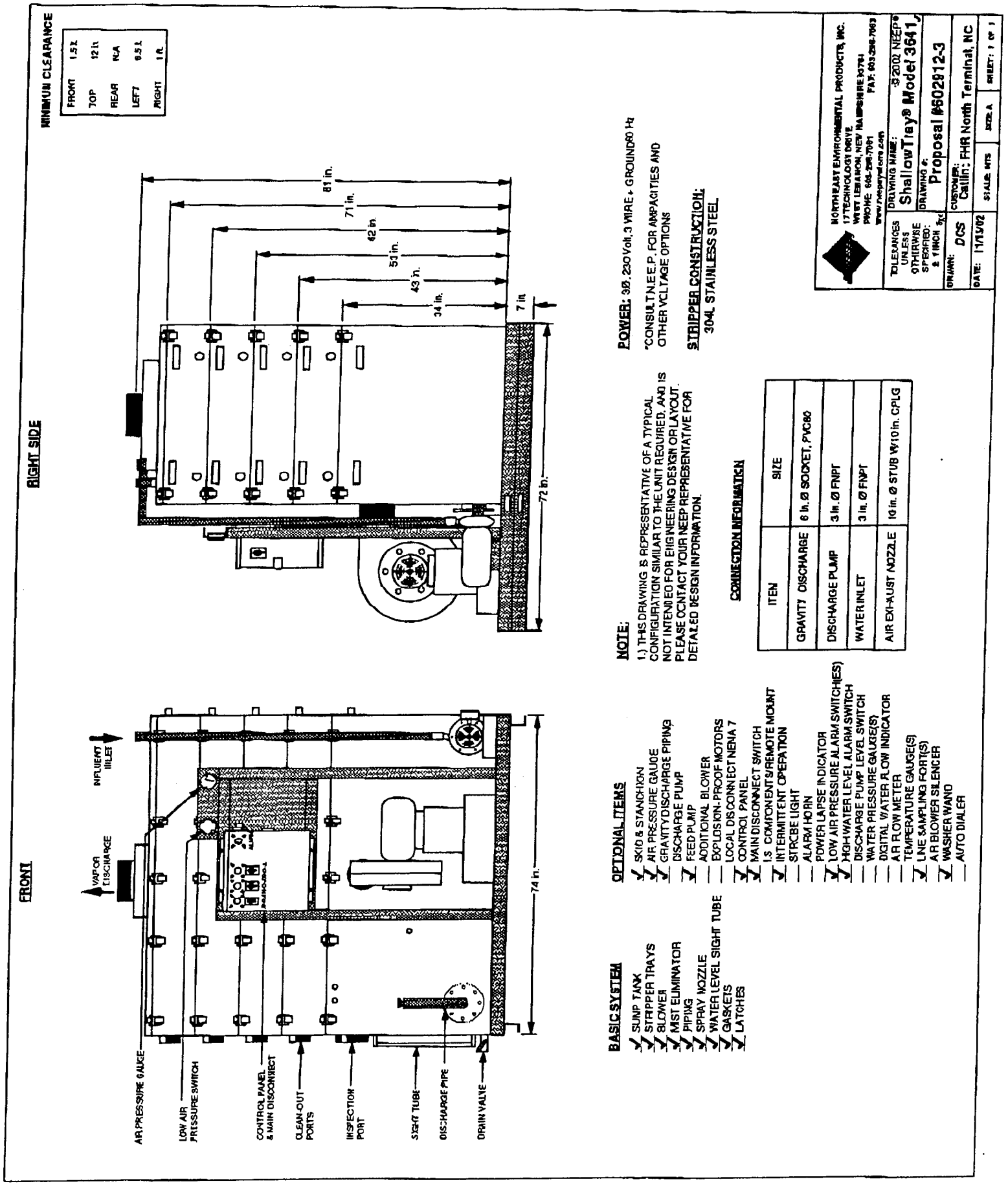
Series chosen:	3600	
Water Flow Rate:	80.0 gpm	18.2 m3/hr
Air Flow Rate:	900 scfm	1530 m3/hr
Water Temp:	69 °F	21 °C
Air Temp:	40 °F	4 °C
A/W Ratio:	84	84
Safety Factor:	None	

Contaminant	Untreated Influent / Effluent Target	Model 3611 Effluent lbs/hr PPMv %removal	Model 3621 Effluent lbs/hr PPMv %removal	Model 3631 Effluent lbs/hr PPMv %removal	Model 3641 Effluent lbs/hr PPMv %removal	Model 3651 Effluent lbs/hr PPMv %removal
* p-Xylene Solubility 175 ppm Mwt 106.16	170000 ppb 530 ppb	17252 ppb 6.13 405.5 89.8519%	1751 ppb 6.76 446.6 98.9702%	178 ppb 6.82 450.8 99.8955%	18 ppb 6.82 451.2 99.9894%	2 ppb 6.83 451.3 99.9989%
MTBE Solubility 43,000 ppm Mwt 88.15	1100 ppb 200 ppb	626 ppb 0.02 1.5 43.0981%	356 ppb 0.03 2.4 67.6218%	203 ppb 0.04 2.9 81.5762%	115 ppb 0.04 3.1 89.5165%	66 ppb 0.04 3.3 94.0347%
Total ppb Total VOC lbs/hr - PPMv Total %removal	171100 ppb	17878 6.15 407.0 89.55%	2107 6.79 449.0 98.77%	380 6.85 453.7 99.78%	133 6.86 454.4 99.92%	67 6.87 454.6 99.96%

*** This influent concentration exceeds the solubility factor. Contact your ShallowTray® representative for details.**

This report has been generated by ShallowTray Modeler software version Ev2.2. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. (NEEP) is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment.

Report Generated: 10/15/02 Modeler Ev2.3 ppmv


MINIMUM CLEARANCE
FRONT 1.5 ft
TOP 12 in
REAR N/A
LEFT 0.5 ft
RIGHT 1 ft
RIGHT SIDE
81 in.
71 in.
62 in.
53 in.
43 in.
34 in.
7 in.
72 in.
FRONT
INFLUENT INLET
VAPOR DISCHARGE
74 in.
AIR PRESSURE GAUGE
LOW AIR PRESSURE SWITCH
CONTROL PANEL & MAIN DISCONNECT
CLEAN-OUT PORTS
INSPECTION PORT
SIGHT TUBE
DISCHARGE PIPE
DRAIN VALVE
POWER: 3Ø, 230 Volt, 3 WIRE + GROUND 60 Hz
*CONSULT N.E.E.P. FOR AMPACITIES AND OTHER VOLTAGE OPTIONS
STRIPPER CONSTRUCTION:
304L STAINLESS STEEL
NOTE:
1.) THIS DRAWING IS REPRESENTATIVE OF A TYPICAL CONFIGURATION SIMILAR TO THE UNIT REQUIRED, AND IS NOT INTENDED FOR ENGINEERING DESIGN OR LAYOUT. PLEASE CONTACT YOUR NEEP REPRESENTATIVE FOR DETAILED DESIGN INFORMATION.
CONNECTION INFORMATION
ITEM | SIZE
GRAVITY DISCHARGE | 6 in. Ø SOCKET, PVC80
DISCHARGE PUMP | 3 in. Ø FNPT
WATER INLET | 3 in. Ø FNPT
AIR EXHAUST NOZZLE | 10 in. Ø STUB W/10 in. CPLG
BASIC SYSTEM
SUMP TANK
STRIPPER TRAYS
BLOWER
MIST ELIMINATOR
PIPING
SPRAY NOZZLE
WATER LEVEL SIGHT TUBE
GASKETS
LATCHES
OPTIONAL ITEMS
SKID & STANCHION
AIR PRESSURE GAUGE
GRAVITY DISCHARGE PIPING
DISCHARGE PUMP
FEED PUMP
ADDITIONAL BLOWER
EXPLOSION-PROOF MOTORS
LOCAL DISCONNECT NEMA 7
CONTROL PANEL
MAIN DISCONNECT SWITCH
I.S. COMPONENTS/REMOTE MOUNT
INTERMITTENT OPERATION
STROBE LIGHT
ALARM HORN
POWER LAPSE INDICATOR
LOW AIR PRESSURE ALARM SWITCH(ES)
HIGH WATER LEVEL ALARM SWITCH
DISCHARGE PUMP LEVEL SWITCH
WATER PRESSURE GAUGE(S)
DIGITAL WATER FLOW INDICATOR
A.R. FLOW METER
TEMPERATURE GAUGE(S)
LINE SAMPLING PORT(S)
A.R. BLOWER SILENCER
WASHER WAND
AUTO DIALER
NORTHEAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063
www.neepsystems.com
TOLERANCES UNLESS OTHERWISE SPECIFIED: ± 1/16 INCH
DRAWING NAME: ©2002 NEEP® ShallowTray® Model 3641
DRAWING #: Proposal #602812-3
DRAWN: DCS
CUSTOMER: Catlin: FHR North Terminal, NC
DATE: 11/15/02
SCALE: NTS
SIZE: A
SHEET: 1 OF 1

AIR STRIPPER DESIGN CALCULATIONS AND MANUFACTURER INFORMATION FOR LOADING RACK AREA

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 210-125

Drawn/Calculated by: Jeff Backen
Date: 1/8/03
Reviewed by: Bill Wash

Design Air Stripper

- Assumptions for Air Stripper design
  - The preferred manufacturer is NEEP systems. The system recommended by NEEP is attached. Need to verify system is adequate.
  - Flow rate of system is 40 gpm
  - Concentrations and level of treatment of contaminants are below:

Analyte	Current Worst Case Levels *	Treatment Levels - ZL
Benzene	6,200 ppb	1 ppb
sec-Butylbenzene	260 ppb	70 ppb
Ethyl Benzene	2,800 ppb	29 ppb
MTBE	3,900 ppb	200 ppb
Naphthalene	540 ppb	6 ppb
Propylbenzene	360 ppb	70 ppb
Toluene	1,100 ppb	1,000 ppb
1,2,4-Trimethylbenzene	1,000 ppb	350 ppb
Xylenes	37,500 ppb	530 ppb

* Based on CAPA dated August 9, 2002.

Verify System Components Meet System Requirements

- NEEP provided a list of basic equipment and optional equipment. The following items need to be verified for sizing requirements:
  1) Feed Pump Size
  2) Air Stripper Size
- Assume all other equipment specified by manufacturer is sized properly because items are miscellaneous items associated with system operation guaranteed by the manufacturer
- Effluent Pipe Design is covered in Effluent Dosing Tank Design

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 210-125

Drawn/Calculated by: Jeff Becker
Date: 1/8/03
Reviewed by: Bill Wasil

Design Air Stripper (cont.)

Verify Size of Feed Pump

Assumptions

- Pump required to pump water from oil/water separator to air stripper
- Inflow rate = 40 gpm
- Air stripper sits on platform 4.0 feet above ground surface
- Air stripper is 6.67 feet tall
- Line connected to feed pump is a 2 inch schedule 80 PVC pipe (20 feet)
- minor losses are 20% of velocity head

Elevation Head Loss

= Height of air stripper plus platform height

= 6.7' + 4.0'

= 10.7 feet

Head Loss of PVC

- Using Hazen + Williams Form. 1a

$$h = \frac{10.44(L)(Q)^{1.852}}{C^{1.852}(d)^{4.8655}}$$

Where: L = Length of pipe = 20 feet X 1.2 minor losses = 24 feet
C = wall roughness = 150 for PVC
d = pipe diameter = 2 inches
h = head loss per 100 feet
Q = Flow rate = 40 gpm

$$h = \frac{(10.44)(20ft)(40gpm)^{1.852}}{(150^{1.852})(2)^{4.8655}}$$

h = 0.74 feet

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN # : 210-125

Drawn/Calculated by: Jeff Becker
Date: 1/8/03
Reviewed by: Eric Glass

Design Air Stripper (cont.)

Verify Size of Feed Pump (cont.)

Velocity Head Loss

$= \left[\frac{\text{Friction head Loss}}{100\,LF} \times \text{Total Length}\right] \times \text{minor losses}$

$= \left[\frac{0.74\,ft}{100\,LF} \times 20\,\text{feet}\right] \times 1.2$

$= 0.18$ feet ✓

Total Head Loss

= Elevation + velocity

= 10.7 feet + 0.18 feet

= 10.88 feet

Use 20 feet ✓

∴ Feed pump must be able to maintain a flow of 40 gpm or greater with 20 ft of HEAD.

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN # : 210-125

Drawn/Calculated by: Jeff Becken
Date: 1/8/03
Reviewed by: Bill Wash

Design Air Stripper

Verify Air Stripper Size

- Air stripper verified by 2 methods:

1) Hand calculations - Using US Army Corp of Engineers Design Guide DG1110-1-3, Appendix C, October 2001; Verify the number of air stripper trays required and the surface area of the trays.

2) Computer modeling - Using NEEP Systems excel program model to verify size, completed by CATLIN inputting the influent data to achieve desired output results.

- Each method is provided on the attached data sheets.

- Air Stripper model 2641 recommended by manufacturer appears to be suitable based on attached calculation sheets

AIR STRIPPER - HAND CALCULATIONS
FOR
LOADING RACK AREA

U.S. ARMY CORPS OF ENGINEERS DESIGN GUIDE
DG 1110-1-3 APPENDIX C (OCTOBER 2001)

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN #: 20/~~210~~-125

Drawn/Calculated by: Jeff Becken
Date: 1/13/03
Reviewed by: Bill Wilson

Ver. of Air Stripper Design

From US Army Corps of Engineers Design Guide DG 1110-1-3, Appendix S October 31, 2001:

$$\text{Log}\left[\frac{\left[X_o - \frac{Y_{n+1}}{m}\right]}{\left[X_n - \frac{Y_{n+1}}{m}\right]}\left(1 - \frac{1}{S}\right) + \frac{1}{S}\right] = N_{THEORETICAL}$$

$$\text{Log } S$$

Where; MTBE Contaminant driving size of air stripper per NEEP

X_o = Concentration of Contaminant (MTBE) in Inlet Water: 3,900 ppb (Current)

X_n = Concentration of Contaminant (MTBE) in Treated Water: 200ppb ← 2L Standards

N = Number of theoretical trays. Assumes the liquid on each tray is completely mixed and the vapor leaving the tray is in equilibrium with the liquid.

H = Henry's Constant (ATM)

M = Slope of equilibrium curve (H/Pt)

G = lb-moles air/min (Air Flow of proposed blower = 600scfm)

L = lb-moles of water/min (Water flow of proposed system = 40gpm)

S = Stripping Factor (mG/L)

Pt = Ambient Pressure (atm)

Y_{n+1} = Concentration of volatiles in air entering the air stripper

Note: For air stripping, $Y_{n+1} = 0$ ⇒ assumed clean air inflow

$$\therefore N_{THEORETICAL} = \frac{\text{Log}\left[\left(\frac{X_o}{X_n}\right)\left(1 - \frac{1}{S}\right) + \frac{1}{S}\right]}{\text{Log } S}$$

CATLIN ENGINEERS and SCIENTISTS WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: ~~210~~ Cat-125

Drawn/Calculated by: Jeff Becker
Date: 1/13/03
Reviewed by: Bill Walsh

Verify Air Stripper Design (cont.)

X_o = 3,900 ppb for MTBE
X_n = 200 ppb for MTBE
H = 5.5×10^{-4} atm·m³/mol @ 25°C for MTBE from USEPA, Technical Information Review, Office of Pollution Prevention and Toxics, USEPA, Washington D.C.
= 5.5×10^{-4} atm·m³/mol $\left(\frac{5,600 \frac{atm}{atm \cdot m^3/mol}}{}\right)$ = 30.58 atm ✓
P_t = 1 atm
$m = H/P_t$ = 30.58 atm / 1 atm = 30.58 ✓

$G = \left(\frac{600 ft^3}{min}\right)\left(\frac{1 lb\text{-}mol\ air}{380 ft^3\ air}\right) = 1.58 \frac{lb\text{-}mole\ air}{min}$ ✓

$L = \left(\frac{40 gal}{min}\right)\left(\frac{8.34 lb\ H_2O}{gal\ H_2O}\right)\left(\frac{1 lb\text{-}mole\ H_2O}{18 lb}\right) = 18.53 \frac{mole\text{-}H_2O}{min}$ ✓

$S = 30.58\left(\frac{1.58}{18.53}\right) = 2.61$ ✓

$N_{THEOR} = \frac{Log\left[\left(\frac{3900}{200}\right)\left(1 - 1/2.61\right) + 1/2.61\right]}{Log\ 2.61} = 2.63$

$N_{actual} = \frac{N_{theor}}{E}$

Where E = Tray efficiency (0.5 assumed)

∴ N_{actual} = 2.63/0.5 = 5.26 say 5

Use 5 Trays

CATLIN ENGINEERS and SCIENTISTS WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: ~~240~~ 201-125

Drawn/Calculated by: Jeff Becken
Date: 1/13/03
Reviewed by: Bill Walsh

Estimate Size of the Perforated Plate Section of Each Tray

$$A = Q_{Air}\left(\frac{1 ft^2}{60 cfm}\right)$$

Where:

A = Cross-sectional area of perforated plate section of each tray (minimum ft^2)

Q_{Air} = Air Flow Rate (600 CFM)

Note: Ratio of $1 ft^2/60 CFM$ obtained from USACE DG 1110-1-3, Appendix C.

$$A = (600 CFM)(1 ft^2/60 CFM)$$

$$\boxed{A = 10 ft^2}$$

In Summary

- For 40 gpm of 3,900 ppb MTBE influent use an air stripper with:
  - Minimum of 5 trays with $10 ft^2$ of perforated sections
  - Blower capable of providing 600 CFM of air
- Air stripper model 2641 recommended by NEEP appears to meet these requirements with assumption 5 trays are available.
- Note: Other contaminants of concern are present, however, the other contaminants are more volatile as evident by NEEP's modelling.

AIR STRIPPER COMPUTER MODELING BY CATLIN
FOR
LOADING RACK AREA

NEEP SYSTEMS EXCEL MODEL PROGRAM

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Loading Rack Area
CATLIN's verification calcs

Series chosen:	2600	
Water Flow Rate:	40 gpm	9.1 m3/hr
Air Flow Rate:	600 scfm	1020 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	100 °F	38 °C
A/W Ratio:	112 :1	
Safety Factor:	0%	

SELECTED MODEL

Contaminant	Untreated Influent / Effluent Target	Model 2611 Effluent lbs/hr / ppmv / %removal	Model 2621 Effluent lbs/hr / ppmv / %removal	Model 2631 Effluent lbs/hr / ppmv / %removal	Model 2641 Effluent lbs/hr / ppmv / %removal	Model 2651 Effluent lbs/hr / ppmv / %removal
Benzene	6200 ppb	370 ppb	22 ppb	1 ppb	<1 ppb	<1 ppb
Solubility 1,780 ppm	1 ppb	0.12 15.77	0.12 16.71	0.12 16.77	0.12 16.77	0.12 16.77
Mwt 78.12		94.04%	99.64%	99.98%	100.00%	100.00%
sec-Butylbenzene	260 ppb	4 ppb	<1 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 70 ppm	70 ppb	0.01 0.40	0.01 0.41	0.01 0.41	0.01 0.41	0.01 0.41
Mwt 134.22		98.41%	99.97%	100.00%	100.00%	100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Ethyl Benzene	2800 ppb	151 ppb	8 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 152 ppm	29 ppb	0.05 5.27	0.06 5.56	0.06 5.57	0.06 5.57	0.06 5.57
Mwt 106.16		94.61%	99.71%	99.98%	100.00%	100.00%
MTBE	3900 ppb	1580 ppb	640 ppb	259 ppb	105 ppb	43 ppb
Solubility 43,000 ppm	200 ppb	0.05 5.56	0.07 7.82	0.07 8.73	0.08 9.10	0.08 9.25
Mwt 88.15		59.50%	83.59%	93.35%	97.31%	98.91%
Naphthalene	540 ppb	79 ppb	11 ppb	2 ppb	<1 ppb	<1 ppb
Solubility 30 ppm	6 ppb	0.01 0.76	0.01 0.87	0.01 0.89	0.01 0.89	0.01 0.89
Mwt 128.16		85.42%	97.87%	99.69%	99.95%	99.99%
Propylbenzene	360 ppb	19 ppb	<1 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 60 ppm	70 ppb	0.01 0.60	0.01 0.63	0.01 0.63	0.01 0.63	0.01 0.63
Mwt 120.19		94.77%	99.73%	99.99%	100.00%	100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Toluene	1100 ppb	74 ppb	5 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 515 ppm	1000 ppb	0.02 2.35	0.02 2.51	0.02 2.52	0.02 2.52	0.02 2.52
Mwt 92.13		93.27%	99.55%	99.97%	100.00%	100.00%
1,2,4-Trimethylbenzene	1000 ppb	111 ppb	12 ppb	1 ppb	<1 ppb	<1 ppb
Solubility 57 ppm	350 ppb	0.02 1.55	0.02 1.73	0.02 1.75	0.02 1.75	0.02 1.75
Mwt 120.9		88.89%	98.76%	99.86%	99.98%	100.00%
Xylenes	37500 ppb	2177 ppb	126 ppb	7 ppb	<1 ppb	<1 ppb
Solubility 175 ppm	530 ppb	0.71 70.43	0.75 74.52	0.75 74.76	0.75 74.77	0.75 74.77
Mwt 106		94.19%	99.66%	99.98%	100.00%	100.00%
Total ppb	53660 ppb	4564 ppb	826 ppb	272 ppb	106 ppb	43 ppb
Total VOC lbs/hr - ppmv		0.99 102.71	1.06 110.76	1.07 112.03	1.08 112.42	1.08 112.57
Total		91.49%	98.46%	99.49%	99.80%	99.92%

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Loading Rack Area
CATLIN's verification calcs

Series chosen:	2600	
Water Flow Rate:	40 gpm	9.1 m3/hr
Air Flow Rate:	600 scfm	1020 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	75 °F	24 °C
A/W Ratio:	112 :1	
Safety Factor:	0%	

Contaminant	Untreated Influent / Effluent Target	Model 2611 Effluent lbs/hr / ppmv / %removal	Model 2621 Effluent lbs/hr / ppmv / %removal	Model 2631 Effluent lbs/hr / ppmv / %removal	SELECTED MODEL Model 2641 Effluent lbs/hr / ppmv / %removal	Model 2651 Effluent lbs/hr / ppmv / %removal
Benzene	6200 ppb	380 ppb	23 ppb	1 ppb	<1 ppb	<1 ppb
Solubility 1,780 ppm	1 ppb	0.12 15.74	0.12 16.71	0.12 16.77	0.12 16.77	0.12 16.77
Mwt 78.12		93.86%	99.62%	99.98%	100.00%	100.00%
sec-Butylbenzene	260 ppb	4 ppb	<1 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 70 ppm	70 ppb	0.01 0.40	0.01 0.41	0.01 0.41	0.01 0.41	0.01 0.41
Mwt 134.22		98.35%	99.97%	100.00%	100.00%	100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Ethyl Benzene	2800 ppb	155 ppb	9 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 152 ppm	29 ppb	0.05 5.27	0.06 5.56	0.06 5.57	0.06 5.57	0.06 5.57
Mwt 106.16		94.45%	99.69%	99.98%	100.00%	100.00%
MTBE	3900 ppb	1601 ppb	657 ppb	270 ppb	111 ppb	45 ppb
Solubility 43,000 ppm	200 ppb	0.05 5.51	0.07 7.78	0.07 8.70	0.08 9.09	0.08 9.24
Mwt 88.15		58.96%	83.16%	93.09%	97.16%	98.84%
Naphthalene	540 ppb	81 ppb	12 ppb	2 ppb	<1 ppb	<1 ppb
Solubility 30 ppm	6 ppb	0.01 0.76	0.01 0.87	0.01 0.89	0.01 0.89	0.01 0.89
Mwt 128.16		84.98%	97.74%	99.66%	99.95%	99.99%
Propylbenzene	360 ppb	19 ppb	1 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 60 ppm	70 ppb	0.01 0.60	0.01 0.63	0.01 0.63	0.01 0.63	0.01 0.63
Mwt 120.19		94.61%	99.71%	99.98%	100.00%	100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Toluene	1100 ppb	76 ppb	5 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 515 ppm	1000 ppb	0.02 2.35	0.02 2.51	0.02 2.52	0.02 2.52	0.02 2.52
Mwt 92.13		93.08%	99.52%	99.97%	100.00%	100.00%
1,2,4-Trimethylbenzene	1000 ppb	114 ppb	13 ppb	1 ppb	<1 ppb	<1 ppb
Solubility 57 ppm	350 ppb	0.02 1.55	0.02 1.73	0.02 1.75	0.02 1.75	0.02 1.75
Mwt 120.9		88.60%	98.70%	99.85%	99.98%	100.00%
Xylenes	37500 ppb	2240 ppb	134 ppb	8 ppb	<1 ppb	<1 ppb
Solubility 175 ppm	530 ppb	0.71 70.30	0.75 74.50	0.75 74.75	0.75 74.77	0.75 74.77
Mwt 106		94.03%	99.64%	99.98%	100.00%	100.00%
Total ppb	53660 ppb	4671 ppb	854 ppb	283 ppb	112 ppb	45 ppb
Total VOC lbs/hr - ppmv		0.98 102.48	1.06 110.70	1.07 112.00	1.08 112.41	1.08 112.57
Total		91.29%	98.41%	99.47%	99.79%	99.92%

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Loading Rack Area
CATLIN's verification calcs

Series chosen:	2600	
Water Flow Rate:	40 gpm	9.1 m3/hr
Air Flow Rate:	600 scfm	1020 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	50 °F	10 °C
A/W Ratio:	112 :1	
Safety Factor:	0%	

Contaminant	Untreated Influent / Effluent Target	Model 2611 Effluent lbs/hr / ppmv / %removal	Model 2621 Effluent lbs/hr / ppmv / %removal	Model 2631 Effluent lbs/hr / ppmv / %removal	SELECTED MODEL Model 2641 Effluent lbs/hr / ppmv / %removal	Model 2651 Effluent lbs/hr / ppmv / %removal
Benzene Solubility 1,780 ppm Mwt 78.12	6200 ppb 1 ppb	391 ppb 0.12 15.71 93.69%	25 ppb 0.12 16.71 99.60%	2 ppb 0.12 16.77 99.97%	<1 ppb 0.12 16.77 100.00%	<1 ppb 0.12 16.77 100.00%
sec-Butylbenzene Solubility 70 ppm Mwt 134.22	260 ppb 70 ppb	4 ppb 0.01 0.40 98.29%	<1 ppb 0.01 0.41 99.97%	<1 ppb 0.01 0.41 100.00%	<1 ppb 0.01 0.41 100.00%	<1 ppb 0.01 0.41 100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Ethyl Benzene Solubility 152 ppm Mwt 106.16	2800 ppb 29 ppb	160 ppb 0.05 5.26 94.29%	9 ppb 0.06 5.56 99.67%	<1 ppb 0.06 5.57 99.98%	<1 ppb 0.06 5.57 100.00%	<1 ppb 0.06 5.57 100.00%
MTBE Solubility 43,000 ppm Mwt 88.15	3900 ppb 200 ppb	1622 ppb 0.05 5.46 58.42%	674 ppb 0.06 7.73 82.71%	280 ppb 0.07 8.68 92.81%	117 ppb 0.08 9.07 97.01%	48 ppb 0.08 9.23 98.76%
Naphthalene Solubility 30 ppm Mwt 128.16	540 ppb 6 ppb	84 ppb 0.01 0.75 84.53%	13 ppb 0.01 0.87 97.61%	2 ppb 0.01 0.89 99.63%	<1 ppb 0.01 0.89 99.94%	<1 ppb 0.01 0.89 99.99%
Propylbenzene Solubility 60 ppm Mwt 120.19	360 ppb 70 ppb	20 ppb 0.01 0.60 94.46%	1 ppb 0.01 0.63 99.69%	<1 ppb 0.01 0.63 99.98%	<1 ppb 0.01 0.63 100.00%	<1 ppb 0.01 0.63 100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Toluene Solubility 515 ppm Mwt 92.13	1100 ppb 1000 ppb	78 ppb 0.02 2.34 92.88%	6 ppb 0.02 2.51 99.49%	<1 ppb 0.02 2.52 99.96%	<1 ppb 0.02 2.52 100.00%	<1 ppb 0.02 2.52 100.00%
1,2,4-Trimethylbenzene Solubility 57 ppm Mwt 120.9	1000 ppb 350 ppb	117 ppb 0.02 1.54 88.31%	14 ppb 0.02 1.72 98.63%	2 ppb 0.02 1.75 99.84%	<1 ppb 0.02 1.75 99.98%	<1 ppb 0.02 1.75 100.00%
Xylenes Solubility 175 ppm Mwt 106	37500 ppb 530 ppb	2305 ppb 0.71 70.17 93.85%	142 ppb 0.75 74.49 99.62%	9 ppb 0.75 74.75 99.98%	<1 ppb 0.75 74.77 100.00%	<1 ppb 0.75 74.77 100.00%
Total ppb	53660 ppb	4782 ppb	883 ppb	295 ppb	118 ppb	49 ppb
Total VOC lbs/hr - ppmv		0.98 102.25	1.06 110.63	1.07 111.97	1.07 112.39	1.08 112.56
Total		91.09%	98.35%	99.45%	99.78%	99.91%

This report has been generated by ShallowTray Modeler software version 6.12e. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. (NEEP Systems) is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment. This software is © Copyright North East Environmental Products, Inc., 2001.

Report Generated: 1/13/2003

Modeler V6.12e 5/24/2001

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Loading Rack Area
CATLIN's verification calcs

Series chosen:	2600	
Water Flow Rate:	40 gpm	9.1 m3/hr
Air Flow Rate:	600 scfm	1020 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	20 °F	-7 °C
A/W Ratio:	112 :1	
Safety Factor:	0%	

Contaminant	Untreated Influent / Effluent Target	Model 2611 Effluent lbs/hr / ppmv / %removal	Model 2621 Effluent lbs/hr / ppmv / %removal	Model 2631 Effluent lbs/hr / ppmv / %removal	SELECTED MODEL Model 2641 Effluent lbs/hr / ppmv / %removal	Model 2651 Effluent lbs/hr / ppmv / %removal
Benzene	6200 ppb	405 ppb	26 ppb	2 ppb	<1 ppb	<1 ppb
Solubility 1,780 ppm	1 ppb	0.12 15.68	0.12 16.70	0.12 16.77	0.12 16.77	0.12 16.77
Mwt 78.12		93.46%	99.57%	99.97%	100.00%	100.00%
sec-Butylbenzene	260 ppb	5 ppb	<1 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 70 ppm	70 ppb	0.01 0.40	0.01 0.41	0.01 0.41	0.01 0.41	0.01 0.41
Mwt 134.22		98.21%	99.97%	100.00%	100.00%	100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Ethyl Benzene	2800 ppb	165 ppb	10 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 152 ppm	29 ppb	0.05 5.25	0.06 5.55	0.06 5.57	0.06 5.57	0.06 5.57
Mwt 106.16		94.09%	99.65%	99.98%	100.00%	100.00%
MTBE	3900 ppb	1647 ppb	696 ppb	294 ppb	124 ppb	52 ppb
Solubility 43,000 ppm	200 ppb	0.05 5.40	0.06 7.68	0.07 8.65	0.08 9.05	0.08 9.23
Mwt 88.15		57.76%	82.16%	92.46%	96.82%	98.66%
Naphthalene	540 ppb	87 ppb	14 ppb	2 ppb	<1 ppb	<1 ppb
Solubility 30 ppm	6 ppb	0.01 0.75	0.01 0.87	0.01 0.89	0.01 0.89	0.01 0.89
Mwt 128.16		83.96%	97.43%	99.59%	99.93%	99.99%
Propylbenzene	360 ppb	21 ppb	1 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 60 ppm	70 ppb	0.01 0.60	0.01 0.63	0.01 0.63	0.01 0.63	0.01 0.63
Mwt 120.19		94.26%	99.67%	99.98%	100.00%	100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Toluene	1100 ppb	81 ppb	6 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 515 ppm	1000 ppb	0.02 2.34	0.02 2.51	0.02 2.52	0.02 2.52	0.02 2.52
Mwt 92.13		92.63%	99.46%	99.96%	100.00%	100.00%
1,2,4-Trimethylbenzene	1000 ppb	120 ppb	15 ppb	2 ppb	<1 ppb	<1 ppb
Solubility 57 ppm	350 ppb	0.02 1.54	0.02 1.72	0.02 1.75	0.02 1.75	0.02 1.75
Mwt 120.9		87.95%	98.55%	99.83%	99.98%	100.00%
Xylenes	37500 ppb	2386 ppb	152 ppb	10 ppb	<1 ppb	<1 ppb
Solubility 175 ppm	530 ppb	0.70 70.01	0.75 74.47	0.75 74.75	0.75 74.77	0.75 74.77
Mwt 106		93.64%	99.60%	99.97%	100.00%	100.00%
Total ppb	53660 ppb	4917 ppb	920 ppb	310 ppb	126 ppb	53 ppb
Total VOC lbs/hr - ppmv		0.98 101.96	1.06 110.55	1.07 111.94	1.07 112.37	1.08 112.55
Total		90.84%	98.29%	99.42%	99.77%	99.90%

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Loading Rack Area
CATLIN's verification calcs

Series chosen:	2600	
Water Flow Rate:	40 gpm	9.1 m3/hr
Air Flow Rate:	600 scfm	1020 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	100 °F	38 °C
A/W Ratio:	112 :1	
Safety Factor:	10%	

SELECTED MODEL

Contaminant	Untreated Influent / Effluent Target	Model 2611 Effluent lbs/hr / ppmv / %removal	Model 2621 Effluent lbs/hr / ppmv / %removal	Model 2631 Effluent lbs/hr / ppmv / %removal	Model 2641 Effluent lbs/hr / ppmv / %removal	Model 2651 Effluent lbs/hr / ppmv / %removal
Benzene Solubility 1,780 ppm Mwt 78.12	6200 ppb 1 ppb	407 ppb 0.12 / 15.67 93.44%	27 ppb 0.12 / 16.70 99.57%	2 ppb 0.12 / 16.77 99.97%	<1 ppb 0.12 / 16.77 100.00%	<1 ppb 0.12 / 16.77 100.00%
sec-Butylbenzene Solubility 70 ppm Mwt 134.22	260 ppb 70 ppb	5 ppb 0.01 / 0.40 98.25%	<1 ppb 0.01 / 0.41 99.97%	<1 ppb 0.01 / 0.41 100.00%	<1 ppb 0.01 / 0.41 100.00%	<1 ppb 0.01 / 0.41 100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Ethyl Benzene Solubility 152 ppm Mwt 106.16	2800 ppb 29 ppb	166 ppb 0.05 / 5.24 94.07%	10 ppb 0.06 / 5.55 99.65%	<1 ppb 0.06 / 5.57 99.98%	<1 ppb 0.06 / 5.57 100.00%	<1 ppb 0.06 / 5.57 100.00%
MTBE Solubility 43,000 ppm Mwt 88.15	3900 ppb 200 ppb	1738 ppb 0.04 / 5.18 55.44%	774 ppb 0.06 / 7.49 80.15%	345 ppb 0.07 / 8.52 91.15%	154 ppb 0.08 / 8.98 96.06%	68 ppb 0.08 / 9.19 98.24%
Naphthalene Solubility 30 ppm Mwt 128.16	540 ppb 6 ppb	87 ppb 0.01 / 0.75 83.96%	14 ppb 0.01 / 0.87 97.43%	2 ppb 0.01 / 0.89 99.59%	<1 ppb 0.01 / 0.89 99.93%	<1 ppb 0.01 / 0.89 99.99%
Propylbenzene Solubility 60 ppm Mwt 120.19	360 ppb 70 ppb	21 ppb 0.01 / 0.60 94.24%	1 ppb 0.01 / 0.63 99.67%	<1 ppb 0.01 / 0.63 99.98%	<1 ppb 0.01 / 0.63 100.00%	<1 ppb 0.01 / 0.63 100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Toluene Solubility 515 ppm Mwt 92.13	1100 ppb 1000 ppb	81 ppb 0.02 / 2.34 92.60%	6 ppb 0.02 / 2.51 99.45%	<1 ppb 0.02 / 2.52 99.96%	<1 ppb 0.02 / 2.52 100.00%	<1 ppb 0.02 / 2.52 100.00%
1,2,4-Trimethylbenzene Solubility 57 ppm Mwt 120.9	1000 ppb 350 ppb	122 ppb 0.02 / 1.53 87.77%	15 ppb 0.02 / 1.72 98.51%	2 ppb 0.02 / 1.74 99.82%	<1 ppb 0.02 / 1.75 99.98%	<1 ppb 0.02 / 1.75 100.00%
Xylenes Solubility 175 ppm Mwt 106	37500 ppb 530 ppb	2395 ppb 0.70 / 70.00 93.61%	153 ppb 0.75 / 74.47 99.59%	10 ppb 0.75 / 74.75 99.97%	<1 ppb 0.75 / 74.77 100.00%	<1 ppb 0.75 / 74.77 100.00%
Total ppb	53660 ppb	5021 ppb	1000 ppb	362 ppb	155 ppb	69 ppb
Total VOC lbs/hr - ppmv		0.98 / 101.72	1.06 / 110.36	1.07 / 111.81	1.07 / 112.30	1.08 / 112.51
Total		90.64%	98.14%	99.33%	99.71%	99.87%

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Loading Rack Area
CATLIN's verification calcs

Series chosen:	2600	
Water Flow Rate:	40 gpm	9.1 m3/hr
Air Flow Rate:	600 scfm	1020 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	20 °F	-7 °C
A/W Ratio:	112 :1	
Safety Factor:	10%	

SELECTED MODEL

Contaminant	Untreated Influent / Effluent Target	Model 2611 Effluent lbs/hr / ppmv / %removal	Model 2621 Effluent lbs/hr / ppmv / %removal	Model 2631 Effluent lbs/hr / ppmv / %removal	Model 2641 Effluent lbs/hr / ppmv / %removal	Model 2651 Effluent lbs/hr / ppmv / %removal
Benzene Solubility 1,780 ppm Mwt 78.12	6200 ppb 1 ppb	446 ppb 0.12 15.57 92.81%	32 ppb 0.12 16.69 99.48%	2 ppb 0.12 16.77 99.96%	<1 ppb 0.12 16.77 100.00%	<1 ppb 0.12 16.77 100.00%
sec-Butylbenzene Solubility 70 ppm Mwt 134.22	260 ppb 70 ppb	5 ppb 0.01 0.40 98.03%	<1 ppb 0.01 0.41 99.96%	<1 ppb 0.01 0.41 100.00%	<1 ppb 0.01 0.41 100.00%	<1 ppb 0.01 0.41 100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Ethyl Benzene Solubility 152 ppm Mwt 106.16	2800 ppb 29 ppb	182 ppb 0.05 5.21 93.50%	12 ppb 0.06 5.55 99.58%	<1 ppb 0.06 5.57 99.97%	<1 ppb 0.06 5.57 100.00%	<1 ppb 0.06 5.57 100.00%
MTBE Solubility 43,000 ppm Mwt 88.15	3900 ppb 200 ppb	1812 ppb 0.04 5.01 53.54%	842 ppb 0.06 7.33 78.41%	391 ppb 0.07 8.41 89.97%	182 ppb 0.07 8.91 95.34%	84 ppb 0.08 9.15 97.83%
Naphthalene Solubility 30 ppm Mwt 128.16	540 ppb 6 ppb	95 ppb 0.01 0.73 82.36%	17 ppb 0.01 0.86 96.89%	3 ppb 0.01 0.89 99.45%	<1 ppb 0.01 0.89 99.90%	<1 ppb 0.01 0.89 99.98%
Propylbenzene Solubility 60 ppm Mwt 120.19	360 ppb 70 ppb	23 ppb 0.01 0.59 93.69%	1 ppb 0.01 0.63 99.60%	<1 ppb 0.01 0.63 99.97%	<1 ppb 0.01 0.63 100.00%	<1 ppb 0.01 0.63 100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Toluene Solubility 515 ppm Mwt 92.13	1100 ppb 1000 ppb	89 ppb 0.02 2.32 91.89%	7 ppb 0.02 2.51 99.34%	<1 ppb 0.02 2.52 99.95%	<1 ppb 0.02 2.52 100.00%	<1 ppb 0.02 2.52 100.00%
1,2,4-Trimethylbenzene Solubility 57 ppm Mwt 120.9	1000 ppb 350 ppb	133 ppb 0.02 1.52 86.75%	18 ppb 0.02 1.72 98.24%	2 ppb 0.02 1.74 99.77%	<1 ppb 0.02 1.75 99.97%	<1 ppb 0.02 1.75 100.00%
Xylenes Solubility 175 ppm Mwt 106	37500 ppb 530 ppb	2625 ppb 0.70 69.54 93.00%	184 ppb 0.75 74.40 99.51%	13 ppb 0.75 74.74 99.97%	<1 ppb 0.75 74.77 100.00%	<1 ppb 0.75 74.77 100.00%
Total ppb	53660 ppb	5409 ppb	1113 ppb	413 ppb	184 ppb	85 ppb
Total VOC lbs/hr - ppmv		0.97 100.89	1.05 110.10	1.07 111.69	1.07 112.23	1.08 112.47
Total		89.92%	97.93%	99.23%	99.66%	99.84%

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ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Loading Rack Area
CATLIN's verification calcs

Series chosen:	2600	
Water Flow Rate:	40 gpm	9.1 m3/hr
Air Flow Rate:	600 scfm	1020 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	50 °F	10 °C
A/W Ratio:	112 :1	
Safety Factor:	10%	

SELECTED MODEL

Contaminant	Untreated Influent / Effluent Target	Model 2611 Effluent lbs/hr / ppmv / %removal	Model 2621 Effluent lbs/hr / ppmv / %removal	Model 2631 Effluent lbs/hr / ppmv / %removal	Model 2641 Effluent lbs/hr / ppmv / %removal	Model 2651 Effluent lbs/hr / ppmv / %removal
Benzene Solubility 1,780 ppm Mwt 78.12	6200 ppb 1 ppb	431 ppb 0.12 15.61 93.05%	30 ppb 0.12 16.69 99.52%	2 ppb 0.12 16.77 99.97%	<1 ppb 0.12 16.77 100.00%	<1 ppb 0.12 16.77 100.00%
sec-Butylbenzene Solubility 70 ppm Mwt 134.22	260 ppb 70 ppb	5 ppb 0.01 0.40 98.12%	<1 ppb 0.01 0.41 99.96%	<1 ppb 0.01 0.41 100.00%	<1 ppb 0.01 0.41 100.00%	<1 ppb 0.01 0.41 100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Ethyl Benzene Solubility 152 ppm Mwt 106.16	2800 ppb 29 ppb	176 ppb 0.05 5.22 93.72%	11 ppb 0.06 5.55 99.61%	<1 ppb 0.06 5.57 99.98%	<1 ppb 0.06 5.57 100.00%	<1 ppb 0.06 5.57 100.00%
MTBE Solubility 43,000 ppm Mwt 88.15	3900 ppb 200 ppb	1784 ppb 0.04 5.07 54.26%	816 ppb 0.06 7.39 79.08%	373 ppb 0.07 8.46 90.43%	171 ppb 0.07 8.94 95.62%	78 ppb 0.08 9.16 98.00%
Naphthalene Solubility 30 ppm Mwt 128.16	540 ppb 6 ppb	92 ppb 0.01 0.74 82.98%	16 ppb 0.01 0.86 97.10%	3 ppb 0.01 0.89 99.51%	<1 ppb 0.01 0.89 99.92%	<1 ppb 0.01 0.89 99.99%
Propylbenzene Solubility 60 ppm Mwt 120.19	360 ppb 70 ppb	22 ppb 0.01 0.59 93.90%	1 ppb 0.01 0.63 99.63%	<1 ppb 0.01 0.63 99.98%	<1 ppb 0.01 0.63 100.00%	<1 ppb 0.01 0.63 100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Toluene Solubility 515 ppm Mwt 92.13	1100 ppb 1000 ppb	86 ppb 0.02 2.33 92.17%	7 ppb 0.02 2.51 99.39%	<1 ppb 0.02 2.52 99.95%	<1 ppb 0.02 2.52 100.00%	<1 ppb 0.02 2.52 100.00%
1,2,4-Trimethylbenzene Solubility 57 ppm Mwt 120.9	1000 ppb 350 ppb	129 ppb 0.02 1.52 87.14%	17 ppb 0.02 1.72 98.35%	2 ppb 0.02 1.74 99.79%	<1 ppb 0.02 1.75 99.97%	<1 ppb 0.02 1.75 100.00%
Xylenes Solubility 175 ppm Mwt 106	37500 ppb 530 ppb	2536 ppb 0.70 69.71 93.24%	171 ppb 0.75 74.43 99.54%	12 ppb 0.75 74.75 99.97%	<1 ppb 0.75 74.77 100.00%	<1 ppb 0.75 74.77 100.00%
Total ppb	53660 ppb	5260 ppb	1069 ppb	393 ppb	172 ppb	78 ppb
Total VOC lbs/hr - ppmv		0.97 101.21	1.06 110.20	1.07 111.74	1.07 112.26	1.08 112.49
Total		90.20%	98.01%	99.27%	99.68%	99.85%

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

FHR-North
Loading Rack Area
CATLIN's verification calcs

Series chosen:	2600	
Water Flow Rate:	40 gpm	9.1 m3/hr
Air Flow Rate:	600 scfm	1020 m3/hr
Water Temp:	67 °F	19 °C
Air Temp:	75 °F	24 °C
A/W Ratio:	112 :1	
Safety Factor:	10%	

Contaminant	Untreated Influent / Effluent Target	Model 2611 Effluent lbs/hr / ppmv / %removal	Model 2621 Effluent lbs/hr / ppmv / %removal	Model 2631 Effluent lbs/hr / ppmv / %removal	SELECTED MODEL Model 2641 Effluent lbs/hr / ppmv / %removal	Model 2651 Effluent lbs/hr / ppmv / %removal
Benzene	6200 ppb	418 ppb	28 ppb	2 ppb	<1 ppb	<1 ppb
Solubility 1,780 ppm	1 ppb	0.12 15.64	0.12 16.70	0.12 16.77	0.12 16.77	0.12 16.77
Mwt 78.12		93.25%	99.54%	99.97%	100.00%	100.00%
sec-Butylbenzene	260 ppb	5 ppb	<1 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 70 ppm	70 ppb	0.01 0.40	0.01 0.41	0.01 0.41	0.01 0.41	0.01 0.41
Mwt 134.22		98.19%	99.97%	100.00%	100.00%	100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Ethyl Benzene	2800 ppb	171 ppb	10 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 152 ppm	29 ppb	0.05 5.23	0.06 5.55	0.06 5.57	0.06 5.57	0.06 5.57
Mwt 106.16		93.90%	99.63%	99.98%	100.00%	100.00%
MTBE	3900 ppb	1761 ppb	795 ppb	359 ppb	162 ppb	73 ppb
Solubility 43,000 ppm	200 ppb	0.04 5.13	0.06 7.45	0.07 8.49	0.08 8.96	0.08 9.18
Mwt 88.15		54.86%	79.62%	90.80%	95.85%	98.13%
Naphthalene	540 ppb	89 ppb	15 ppb	2 ppb	<1 ppb	<1 ppb
Solubility 30 ppm	6 ppb	0.01 0.74	0.01 0.87	0.01 0.89	0.01 0.89	0.01 0.89
Mwt 128.16		83.48%	97.27%	99.55%	99.93%	99.99%
Propylbenzene	360 ppb	21 ppb	1 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 60 ppm	70 ppb	0.01 0.60	0.01 0.63	0.01 0.63	0.01 0.63	0.01 0.63
Mwt 120.19		94.08%	99.65%	99.98%	100.00%	100.00%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Toluene	1100 ppb	84 ppb	6 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 515 ppm	1000 ppb	0.02 2.33	0.02 2.51	0.02 2.52	0.02 2.52	0.02 2.52
Mwt 92.13		92.39%	99.42%	99.96%	100.00%	100.00%
1,2,4-Trimethylbenzene	1000 ppb	125 ppb	16 ppb	2 ppb	<1 ppb	<1 ppb
Solubility 57 ppm	350 ppb	0.02 1.53	0.02 1.72	0.02 1.74	0.02 1.75	0.02 1.75
Mwt 120.9		87.46%	98.43%	99.80%	99.98%	100.00%
Xylenes	37500 ppb	2464 ppb	162 ppb	11 ppb	<1 ppb	<1 ppb
Solubility 175 ppm	530 ppb	0.70 69.86	0.75 74.45	0.75 74.75	0.75 74.77	0.75 74.77
Mwt 106		93.43%	99.57%	99.97%	100.00%	100.00%
Total ppb	53660 ppb	5139 ppb	1034 ppb	377 ppb	164 ppb	73 ppb
Total VOC lbs/hr - ppmv		0.97 101.46	1.06 110.28	1.07 111.78	1.07 112.28	1.08 112.50
Total		90.42%	98.07%	99.30%	99.70%	99.86%

AIR STRIPPER RECOMMENDED BY NEEP SYSTEMS
FOR
LOADING RACK AREA

1002908-1 xlm.v 40 gpm

ShallowTray®
low profile air strippers

System Performance Estimate
Client and Proposal Information:

Catlin Engrs & Scientists: Jeff Becken
fax#910-452-7563
FHR North Loading Rack, Wilmington, NC
#1002908-1: 2L Removal, 40 GPM

Series chosen:	2600	
Water Flow Rate:	40.0 gpm	9.1 m3/hr
Air Flow Rate:	600 scfm	1020 m3/hr
Water Temp:	69 °F	21 °C
Air Temp:	40 °F	4 °C
A/W Ratio:	112	112
Safety Factor:	15%	

Contaminant	Untreated Influent / Effluent Target	Model 2611 Effluent lbs/hr PPMv %removal	Model 2621 Effluent lbs/hr PPMv %removal	Model 2631 Effluent lbs/hr PPMv %removal	Model 2641 Effluent lbs/hr PPMv %removal	Model 2651 Effluent lbs/hr PPMv %removal
Benzene	6200 ppb	426 ppb	29 ppb	2 ppb	<1 ppb	<1 ppb
Solubility 1,780 ppm	1 ppb	0.12 15.6	0.12 16.7	0.12 16.8	0.12 16.8	0.12 16.8
Mwt 78.12		93.1317%	99.5283%	99.9676%	99.9978%	99.9998%
sec-Butylbenzene	260 ppb	5 ppb	<1 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 70 ppm	70 ppb	0.01 0.4	0.01 0.4	0.01 0.4	0.01 0.4	0.01 0.4
Mwt 134.22		98.1675%	99.9664%	99.9994%	100.0000%	100.0000%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Ethyl Benzene	2800 ppb	174 ppb	11 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 152 ppm	29 ppb	0.05 5.2	0.06 5.6	0.06 5.6	0.06 5.6	0.06 5.6
Mwt 106.16		93.7905%	99.6144%	99.9761%	99.9985%	99.9999%
MTBE	3900 ppb	1818 ppb	847 ppb	395 ppb	184 ppb	86 ppb
Solubility 43,000 ppm	200 ppb	0.04 5.0	0.06 7.3	0.07 8.4	0.07 8.9	0.08 9.1
Mwt 88.15		53.3853%	78.2707%	89.8710%	95.2784%	97.7990%
Naphthalene	540 ppb	91 ppb	15 ppb	3 ppb	<1 ppb	<1 ppb
Solubility 30 ppm	6 ppb	0.01 0.7	0.01 0.9	0.01 0.9	0.01 0.9	0.01 0.9
Mwt 128.16		83.2056%	97.1795%	99.5263%	99.9204%	99.9866%
Propylbenzene	360 ppb	22 ppb	1 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 60 ppm	70 ppb	0.01 0.6	0.01 0.6	0.01 0.6	0.01 0.6	0.01 0.6
Mwt 120.19		93.9724%	99.6367%	99.9781%	99.9987%	99.9999%
Based on theoretical data only, CONSULT NEEP REPRESENTATIVE FOR WARRANTY						
Toluene	1100 ppb	85 ppb	7 ppb	<1 ppb	<1 ppb	<1 ppb
Solubility 515 ppm	1000 ppb	0.02 2.3	0.02 2.5	0.02 2.5	0.02 2.5	0.02 2.5
Mwt 92.13		92.2538%	99.4000%	99.9535%	99.9964%	99.9997%
1,2,4-Trimethylbenzene	1000 ppb	128 ppb	16 ppb	2 ppb	<1 ppb	<1 ppb
Solubility 57 ppm	350 ppb	0.02 1.5	0.02 1.7	0.02 1.7	0.02 1.7	0.02 1.7
Mwt 120.9		87.2004%	98.3617%	99.7803%	99.9732%	99.9966%
Xylenes	37500 ppb	2508 ppb	168 ppb	11 ppb	<1 ppb	<1 ppb
Solubility 175 ppm	530 ppb	0.70 69.8	0.75 74.4	0.75 74.7	0.75 74.8	0.75 74.8
Mwt 106		93.3132%	99.5529%	99.9701%	99.9980%	99.9999%
Total ppb	53660 ppb	5256	1095	414	186	86
Total VOC lbs/hr - PPMv		0.97 101.2	1.06 110.1	1.07 111.7	1.07 112.2	1.08 112.5
Total %removal		90.21%	97.96%	99.23%	99.65%	99.84%

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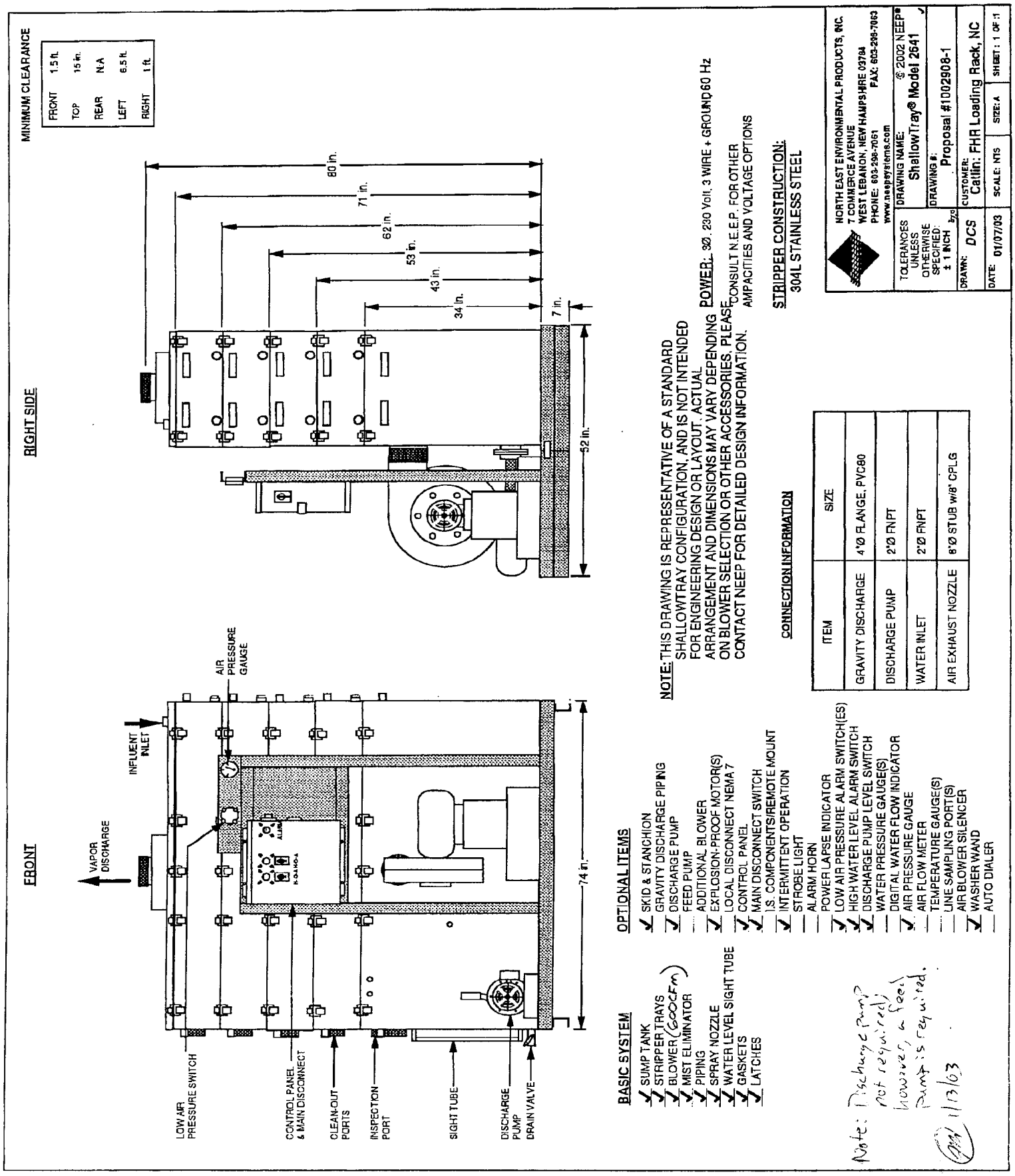
Report Generated: 1/7/03 Modeler Ev2.3 ppmv


MINIMUM CLEARANCE
FRONT 1.5 ft.
TOP 15 in.
REAR N.A
LEFT 6.5 ft.
RIGHT 1 ft.
RIGHT SIDE
80 in.
71 in.
62 in.
53 in.
43 in.
34 in.
7 in.
52 in.
FRONT
VAPOR DISCHARGE
INFLUENT INLET
AIR PRESSURE GAUGE
74 in.
LOW AIR PRESSURE SWITCH
CONTROL PANEL & MAIN DISCONNECT
CLEAN-OUT PORTS
INSPECTION PORT
SIGHT TUBE
DISCHARGE PUMP
DRAIN VALVE
NOTE: THIS DRAWING IS REPRESENTATIVE OF A STANDARD SHALLOWTRAY CONFIGURATION, AND IS NOT INTENDED FOR ENGINEERING DESIGN OR LAYOUT. ACTUAL ARRANGEMENT AND DIMENSIONS MAY VARY DEPENDING ON BLOWER SELECTION OR OTHER ACCESSORIES. PLEASE CONTACT NEEP FOR DETAILED DESIGN INFORMATION.
POWER: 3Ø, 230 Volt, 3 WIRE + GROUND 60 Hz
CONSULT N.E.E.P. FOR OTHER AMPACITIES AND VOLTAGE OPTIONS
STRIPPER CONSTRUCTION:
304L STAINLESS STEEL
CONNECTION INFORMATION
ITEM | SIZE
GRAVITY DISCHARGE | 4"Ø FLANGE, PVC80
DISCHARGE PUMP | 2"Ø FNPT
WATER INLET | 2"Ø FNPT
AIR EXHAUST NOZZLE | 8"Ø STUB w/8" CPLG
BASIC SYSTEM
✓ SUMP TANK
✓ STRIPPER TRAYS
✓ BLOWER (600CFM)
✓ MIST ELIMINATOR
✓ PIPING
✓ SPRAY NOZZLE
✓ WATER LEVEL SIGHT TUBE
✓ GASKETS
✓ LATCHES
OPTIONAL ITEMS
✓ SKID & STANCHION
✓ GRAVITY DISCHARGE PIPING
✓ DISCHARGE PUMP
— FEED PUMP
— ADDITIONAL BLOWER
✓ EXPLOSION-PROOF MOTOR(S)
✓ LOCAL DISCONNECT NEMA 7
✓ CONTROL PANEL
✓ MAIN DISCONNECT SWITCH
— I.S. COMPONENTS/REMOTE MOUNT
✓ INTERMITTENT OPERATION
— STROBE LIGHT
— ALARM HORN
— POWER LAPSE INDICATOR
✓ LOW AIR PRESSURE ALARM SWITCH(ES)
✓ HIGH WATER LEVEL ALARM SWITCH
✓ DISCHARGE PUMP LEVEL SWITCH
— WATER PRESSURE GAUGE(S)
— DIGITAL WATER FLOW INDICATOR
✓ AIR PRESSURE GAUGE
— AIR FLOW METER
— TEMPERATURE GAUGE(S)
— LINE SAMPLING PORT(S)
— AIR BLOWER SILENCER
✓ WASHER WAND
— AUTO DIALER
Note: Discharge Pump not required; however, a float is required. Pump is required.
1/13/03
NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
7 COMMERCE AVENUE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063
www.neepsystems.com
© 2002 NEEP®
TOLERANCES UNLESS OTHERWISE SPECIFIED: ± 1 INCH
DRAWING NAME: ShallowTray® Model 2641
DRAWING #: Proposal #1002908-1
DRAWN: DCS
CUSTOMER: Catlin: FHR Loading Rack, NC
DATE: 01/07/03
SCALE: NTS
SIZE: A
SHEET: 1 OF 1

6.0 EFFLUENT TANK

An effluent tank has been selected to allow sediments/particulates that pass through the air stripper to settle. The following sections address the design of the effluent tanks and the associated influent and effluent lines.

6.1 PX FACILITY

6.1.1 Design of Influent Line

6.1.1.1 Assumptions

- Treated groundwater is to gravity flow from the air stripper to the effluent tank at a maximum flow rate of 80 gpm.
- The maximum distance between the air stripper and the effluent tank is approximately 10 feet.
- The maximum difference of water elevation in the air stripper effluent and the dosing tank influent is 1 foot.
- The pipe is to be made of schedule 80 PVC material.

6.1.1.2 Selection

Based on the assumptions above and the attached influent pipe design calculations, a minimum influent pipe size between the air stripper and the effluent tank will be 3-inches.

6.1.2 Design of Effluent Tank

6.1.2.1 Assumptions

- Tank is to be manufactured from polypropylene material.
- Minimum holding time of treated groundwater inside the tank is 30 min.
- Tank shape is to be elliptical or horizontal.
- The maximum flow rate into and through the effluent tank is 80 gpm.

6.1.2.2 Selection

Based on the assumptions above and the attached effluent tank design calculations and manufacturer information, a 3,135 gallon elliptical tank manufactured by NORWESCO or approved equivalent is planned to be used as the effluent tank. An elevated outfall pipe is also planned to be installed within the tank as part of the effluent line to allow a minimum elevation head of 4 feet of water within the effluent tank.

6.1.3 Design of Effluent Line

6.1.3.1 Assumptions

- Treated groundwater is to gravity flow from the effluent tank to the infiltration gallery at a maximum flow rate of 80 gpm.
- The maximum distance between the effluent tank and the infiltration gallery is approximately 20 feet.
- The maximum difference of water elevation in the effluent tank and the infiltration gallery is 5 feet.
- The pipe is to be made of schedule 80 PVC material.

6.1.3.2 Selection

Based on the assumptions above and the attached effluent pipe design calculations, a minimum effluent pipe size between the effluent tank and the infiltration gallery will be 3-inches.

6.2 LOADING RACK AREA

6.2.1 Design of Influent Line

6.2.1.1 Assumptions

- Treated groundwater is to gravity flow from the air stripper to the effluent tank at a maximum flow rate of 40 gpm.
- The maximum distance between the air stripper and the effluent tank is approximately 10 feet.
- The maximum difference of water elevation in the air stripper effluent and the dosing tank influent is 1 foot.
- The pipe is to be made of schedule 80 PVC material.

6.2.1.2 Selection

Based on the assumptions above and the attached influent pipe design calculations, a minimum influent pipe size between the air stripper and the effluent tank will be 3-inches.

6.2.2 Design of Effluent Tank

6.2.2.1 Assumptions

- Tank is to be manufactured from polypropylene material.
- Minimum holding time of treated groundwater inside the tank is 30 min.

- Tank shape is to be elliptical or horizontal.
- The maximum flow rate into and through the effluent tank is 40 gpm.

6.2.2.2 Selection

Based on the assumptions above and the attached effluent tank design calculations and manufacturer information, a 3,135 gallon elliptical leg tank manufactured by NORWESCO or approved equivalent is plan to be used as the effluent tank. An elevated outfall pipe is also planned to be installed within the tank as part of the effluent line to allow a minimum elevation head of 2.75 feet of water within the effluent tank.

6.2.3 Design of Effluent Line

6.2.3.1 Assumptions

- Treated groundwater is to gravity flow from the effluent tank to the infiltration gallery at a maximum flow rate of 40 gpm.
- The maximum distance between the effluent tank and the infiltration gallery is approximately 35 feet.
- The maximum difference of water elevation in the effluent tank and the infiltration gallery is 3.75 feet.
- The pipe is to be made of schedule 80 PVC material.

6.2.3.2 Selection

Based on the assumptions above and the attached effluent pipe design calculations, a minimum effluent pipe size between the effluent tank and the infiltration gallery will be 3-inches.

EFFLUENT TANK INFLUENT PIPE DESIGN CALCULATIONS
FOR
PX FACILITY

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

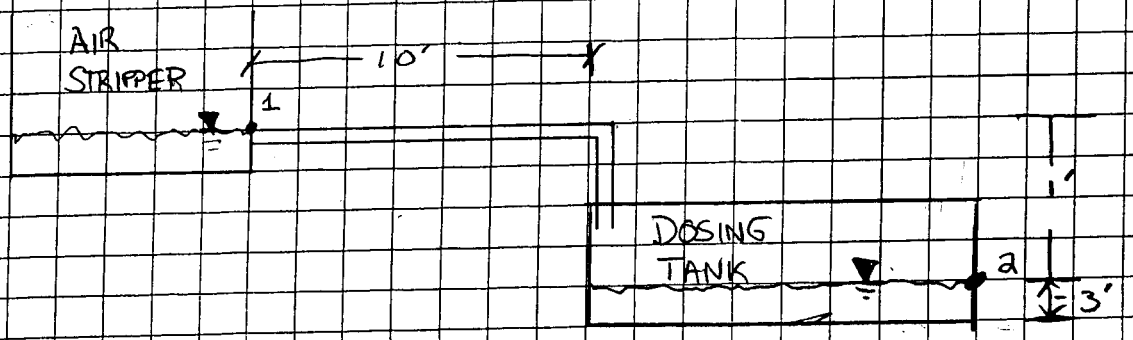
SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN # : 195-033

Drawn/Calculated by: Jeff Becken
Date: 11/14/02
Reviewed by: MW

Dosing Tank Influent Line Design

The following is sketch of Influent Line location



USING THE FOLLOWING FORMULA:

$$\frac{P_1}{\gamma_1} + \frac{V_1^2}{2} + Z_1 g = \frac{P_2}{\gamma_2} + \frac{V_2^2}{2} + Z_2 g + h_f$$

Where:

P = Pressure
γ = Density of water
V = velocity of water
Z = elevation
g = gravitational acceleration = 32.2 ft/s^2
h_f = head loss due to friction

Assume: $P_1 = P_2 = \emptyset$
$V_1 = \emptyset$
$Z_2 = \emptyset$

Therefore:

$$Z_1 g = \frac{V_2^2}{2} + h_f$$

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 195-033

Drawn/Calculated by: Jeff Becken
Date: 11/14/02
Reviewed by: WSW

Dosing Tank Influent Line Design (cont.)

$$Z_1 g = \frac{V_2^2}{2} + h_f$$

Where:

$$h_f = \frac{f L V^2}{2D}$$

Therefore:

$$Z_1 g = \frac{V_2^2}{2} + f\frac{L}{D}\frac{V_2^2}{2}$$

$$Z_1 g = \left[\left(f\frac{L}{D}\right) + 1\right]\frac{V_2^2}{2}$$

Solve For V:

$$V = \sqrt{\frac{2 Z_1 g}{f(L/D)+1}}$$

- Solve for V using various diameter pipes. This was done using excel spreadsheet. See attached results.

Determine the flow for each diameter pipe using the following formula

$$Q = V \cdot A$$

Where:

$$A = 1/4\,\pi d^2$$

Therefore:

$$Q = (V)(1/4)(\pi)(d^2)$$

- See attached spreadsheet for results

PIPE SIZING SPREADSHEET FOR DOSING TANK INFLUENT LINE

Flint Hills Resources, LP
North Terminal
Paraxylene Facility
CATLIN Project Number: 195-033

ASSUMPTIONS

g =	32.2 ft/s2
z1 =	1 ft
f =	0.02
L =	10 ft

CALCULATIONS

Pipe Diameter (in)		Flow (gpm)
4		248.48
3		131.77
2		52.98
1.9		47.14
1.8		41.67
1.79		41.14
1.78		40.61
1.77		40.09
1.76		39.58
1.75		39.07
1.5		27.41
1.25		17.96
1		10.65
0.5		2.04
0.25		0.38

CATLIN
ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN # : 195-033

Drawn/Calculated by: Jeff Becken
Date: 11/14/02
Reviewed by: WJW

Dosing Tank Influent Line Design (cont.)

- Based on pipe diameter and flow calculations on page 3, the minimum pipe size for the dosing tank influent line at a flow of 80 gpm is 3 inches.

∴ Air Stripper Outlet connection is 3 in. diameter therefore the outlet can be a 3in diameter pipe.

EFFLUENT TANK DESIGN CALCULATIONS AND MANUFACTURER INFORMATION FOR PX FACILITY

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 195-033

Drawn/Calculated by: Jeff Becken
Date: 11/14/02
Reviewed by: WJW

Effluent Dosing Tank Design

Assumptions

- Tank Material = Polypropylene
- Minimum Holding time = 30 min.
- Tank Shape - Elliptical / Horizontal

Determine min. Size of Tank

Flow Rate = 80 gallons/minute (Design Flow Rate)

Size = 80 gpm x 30 min.

= 2,400 gallons ← minimum size

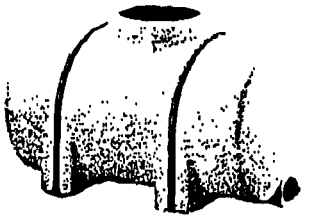
Per our discussion w/ Agri-Supply, Wesley Rogers, largest available tank they have is a 3,135 gallon tank by NORWESCO. Agri-Supply also carries a 2635 gallon tank, however, for safety factor and longer holding time available we are specifing the 3,135 gallon tank be required.

- Tank may require steel bands by the manufacturer to guarantee integrity of tanks. Otherwise bands are not needed to hold tank in-place.
- Tank will have an elevated outfall pipe to maintain an elevation head of 4 feet.

- Also included w/ this design is the size of the influent and effluent pipes.

Horizontal Leg Tanks

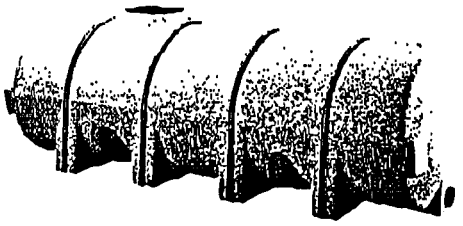
With the broadest leg tank line available, NORWESCO manufactures a size that will fit your needs. Used primarily for transport and nursing applications, NORWESCO's leg tanks feature molded-in baffles to reduce sloshing when the tank is in motion. Please refer to page 4 for support bands.



325 Gallon Horizontal Leg

Gallon Capacity	Diameter	Length	Fill Opening	Outlet/Drain Specification	No. of Bands	Premium Weight Part No. White	Heavy Weight Part No. Blue
35 ∞	20"	29"	5"	¾"	2 optional	60318	—
65 ∞	23"	43"	5"	¾"	2 optional	61739	—
125	32"	41"	8"	2"	2 optional	40298	—
225	38"	49"	8"	2"	2 optional	40299	—
325	38"	68"	16"	2"	2 optional	40217	—
525	49"	71"	16"	2"	2 optional	40181	40193
725 *	49"	101"	16"	2"	3 required	40180	40194
1025 *	49"	139"	16"	2"	4 required	40089	40131

∞ Within UPS dimensional limits
*Require full length support and bands



1025 Gallon Horizontal Leg

Drainable Leg Tanks

When complete drainage is necessary, these are the tanks of choice. They are designed primarily for use on fertilizer and chemical nurse trailers. Please refer to page 4 for support bands.

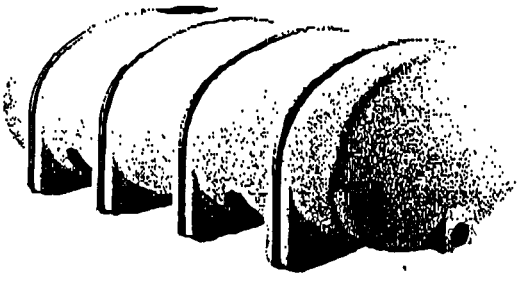
1010 Gallon Drainable Leg

Gallon Capacity	Width	Height	Length	Fill Opening	Outlet/Drain Specification	No. of Bands	Premium Weight Part No. White	Heavy Weight Part No. Blue
710*	47"	47"	104"	16"	2"	3 required	40655	40657
1010*	47"	47"	140"	16"	2"	4 required	40393	40395
1610*(elliptical)	69"	63"	140"	16"	—	4 required	40806	40808

*Require full length support and bands

Elliptical Leg Tanks

This elliptical tank style is designed to provide the greatest capacity with the lowest center of gravity, making it the best design available for transporting larger volumes. NORWESCO elliptical tanks feature molded-in legs and flow-through baffles which work together to reduce sloshing and provide increased stability during transport. All NORWESCO elliptical leg tanks require full length bottom support as well as support bands. Please refer to information on page 4.



2035 Gallon Elliptical Leg

Gallon Capacity	Width	Height	Length	Fill Opening	Outlet/Drain Specification	Premium Weight Part No. White	Heavy Weight Part No. Blue
1035	79"	53"	89"	16"	2"	40191	—
1235	65"	52"	128"	16"	2"	40239	—
1635	71"	57"	142"	16"	2"	40387	40388
2035	84"	55"	142"	16"	2"	40618	40623
2635	90"	71"	140"	16"	3"/2"	40547	40283
3195	88"	76"	151"	16"	3"/2"	40686	40688

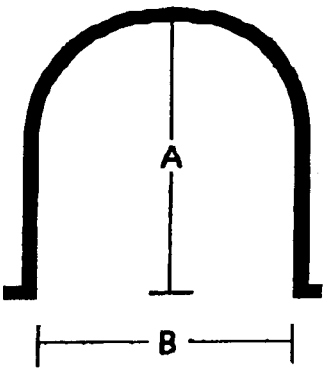
Biggest horizatal tank we carry.
$2284.95

- Holds upto 12lb/gal liquid :- Assume water will weigh 8.34 lbs/gal, thus acceptable.

PLEASE NOTE: Tank availability may vary according to manufacturing location. Please contact Norwesco Customer Service or your Norwesco distributor for specific details.

Steel Supports and Accessories

NORWESCO bands are custom fabricated to support the NORWESCO tanks and are galvanized for added corrosion protection. Whether using the tank in a stationary position or for transport, bands are necessary to ensure that the tank retains its shape and integrity.



Bands are to be used only if manufacturer requires them for warranty of integrity Otherwise bands are not needed to hold tank in place because tank will always have water in it.

Horizontal Leg Tank Bands

Tank Size (Gallon)	A	B	No. of Bands	Part No.
35 —	18½"	18½"	2 optional	60520
65 ∞	22"	22"	2 optional	61745
125 ∞	30⅛"	30¾"	2 optional	61744
225 ∞	36¼"	36¾"	2 optional	60478
325 ∞	36¼"	36¾"	2 optional	60478
525	47½"	47¾"	2 optional	60057
725	47½"	47¾"	3 required	60057
1025	47½"	47¾"	4 required	60057

— Within UPS dimensional limits

Drainable Leg Tank Bands

Tank Size (Gallon)	A	B	No. of Bands	Part No.
710	45"	46¼"	3 required	60584 short
1010 *	45"	46¼"	2 required	60584 short
1010 *	45"	48"	2 required	60585 long
1610	66"	49"	4 required	62434

* 2 short and 2 long bands are required for 1 tank

Elliptical Leg Tank Bands

Tank Size (Gallon)	A	B	No. of Bands	Part No.
1035	77"	47¼"	3 required	60325
1235	64¾"	47¾"	4 required	60477
1635	68"	51"	4 required	60586
2035	81½"	51¼"	4 required	62079
2635	87¼"	65¼"	4 required	60353
3135	85½"	75¼"	4 required	62097

$156.95 ea if needed

Ladder

Description	Tank Size (Gallon)	Part No.
Ladder (optional)	2635 & 3135	60354
Adaptor kit for ladder Δ	3135	62301

Δ This kit is required when using the ladder on the 3135 gallon tank

PLEASE NOTE: Tank availability may vary according to manufacturing location. Please contact Norwesco Customer Service or your Norwesco distributor for specific details.

EFFLUENT TANK EFFLUENT PIPE DESIGN CALCULATIONS
FOR
PX FACILITY

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

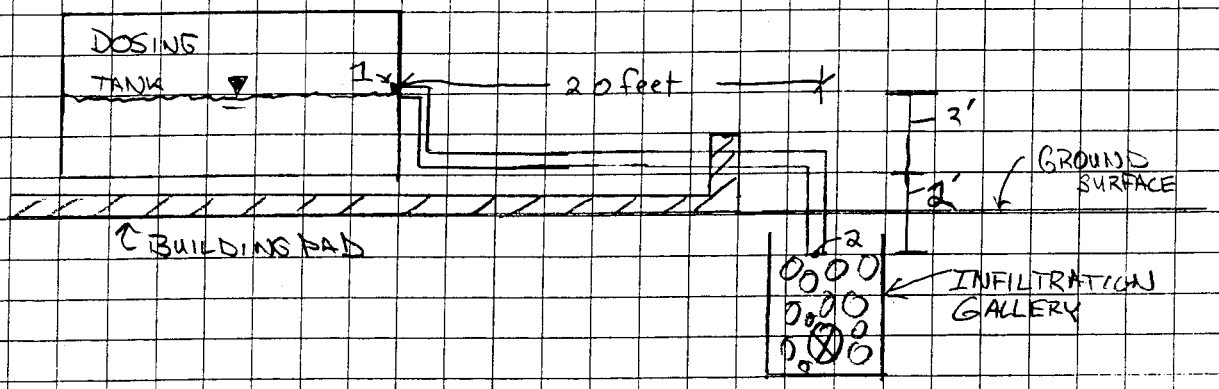
SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN # : 195-033

Drawn/Calculated by: Jeff Becken
Date: 11/14/02
Reviewed by: VARSH

Dosing Tank Effluent Line Design

The following is a sketch of effluent line location



Using the formula derived in the Dosing Tank Influent Line Design,

$$V = \sqrt{\frac{2Z_1 g}{f(L/D)+1}}$$

- Solve for v using various diameter pipes. This was done using excel spreadsheet. See attached results.

Determine the flow using the formula derived in the Dosing Tank Influent Line Design,

$$Q = (v)(1/4)(\pi)(d^2)$$

- See attached spreadsheet for results

PIPE SIZING SPREADSHEET FOR DOSING TANK EFFLUENT LINE

Flint Hills Resources, LP
North Terminal
Paraxylene Facility
CATLIN Project Number: 195-033

ASSUMPTIONS

g =	32.2 ft/s2
z1 =	5 ft
f =	0.02
L =	20 ft

CALCULATIONS

Pipe Diameter (in)		Flow (gpm)
4		473.82
3		245.17
2		95.29
1.9		84.44
1.8		74.32
1.79		73.35
1.78		72.38
1.77		71.43
1.76		70.48
1.75		69.53
1.5		48.22
1.25		31.20
1		18.24
0.5		3.37
0.25		0.61

CATLIN
ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN # : 195-033

Drawn/Calculated by: Jeff Becken
Date: 11/14/02
Reviewed by: VAGA

Dosing Tank Effluent Line Design (cont.)

- Based on pipe diameter and flow calculations on page 3, the minimum pipe size for the dosing tank effluent line at a flow of 80 gpm is 2 inches.

∴ Dosing Tank Effluent connection can be 2 or 3 inches in size; therefore, 3 in. minimum is recommended.

EFFLUENT TANK EFFLUENT PIPE DESIGN CALCULATIONS
FOR
LOADING RACK AREA

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

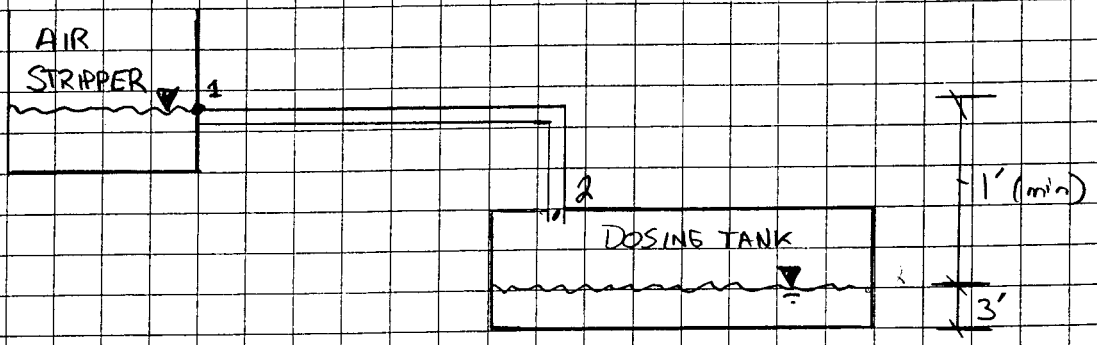
SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: ~~210~~ 201-125

Drawn/Calculated by: Jeff Becker
Date: 1/8/03
Reviewed by: NAASH

Dosing Tank Influent Line Design

The following is a sketch of Influent line location



USING THE FOLLOWING FORMULA:

$$\frac{P_1}{\rho} + \frac{V_1^2}{2} + Z_1 g = \frac{P_2}{\rho} + \frac{V_2^2}{2} + Z_2 g + h_f$$

Where:

P = Pressure
ρ = Density of water
V = velocity of water
Z = elevation
g = gravitational acceleration = 32.2 ft/s^2
h_f = head loss due to friction

Assume:

$P_1 = P_2 = \emptyset$
$V_1 = \emptyset$
$Z_2 = \emptyset$

Therefore:

$$Z_1 g = \frac{V_2^2}{2} + h_f$$

CATLIN ENGINEERS and SCIENTISTS WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: ~~210~~ 201-125

Drawn/Calculated by: Jeff Becken
Date: 1/8/03
Reviewed by: WALSH

Dosing Tank Influent Line Design (cont)

$$Z_1 g = \frac{V_2^2}{2} + h_f$$

Where:

$$h_f = \frac{f L V^2}{2D}$$

Therefore:

$$Z_1 g = \frac{V_2^2}{2} + f \frac{L}{D} \frac{V_2^2}{2}$$

$$Z_1 g = \left[(f)\left(\frac{L}{D}\right) + 1\right] \frac{V_2^2}{2}$$

Solve for V:

$$V = \sqrt{\frac{2(Z_1 g)}{f(L/D) + 1}}$$

- Solve for V using various diameter pipes. This was done using excel spreadsheet. See attached results.

Determine the flow for each diameter pipe using the following formula:

$$Q = V \cdot A$$

Where:

$$A = 1/4 \pi d^2$$

Therefore:

$$Q = (V)(1/4)(\pi)(d^2)$$

- See attached spreadsheet for results.

PIPE SIZING SPREADSHEET FOR DOSING TANK INFLUENT LINE

Flint Hills Resources, LP
North Terminal
Loading Rack Area
CATLIN Project Number: 201-125

ASSUMPTIONS

g =	32.2 ft/s2
z1 =	1 ft
f =	0.02
L =	10 ft

CALCULATIONS

Pipe Diameter (in)		Flow (gpm)
4		248.48
3		131.77
2		52.98 ✓
1.9		47.14
1.8		41.67
1.79		41.14
1.78		40.61
1.77		40.09
1.76		39.58
1.75		39.07
1.5		27.41
1.25		17.96
1		10.65
0.5		2.04
0.25		0.38

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN # : ~~210~~ 201-125

Drawn/Calculated by: Jeff Becken
Date: 1/8/03
Reviewed by: JWJV

Dosing Tank Influent Line Design

- Based on diameter and flow calculations on page 3, the minimum pipe size for the dosing tank influent line at a flow of 40gpm is 2 inches.

- To provide a safety factor, recommend a 3 inch minimum pipe size for the dosing tank influent line. The air stripper outlet may not be 3 inches, therefore, outlet may need to be reduced or enlarged to connect to 3 in pipe.

EFFLUENT TANK DESIGN CALCULATIONS AND MANUFACTURER INFORMATION FOR LOADING RACK AREA

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 201 ~~210~~ 125

Drawn/Calculated by: Jeff Becken
Date: 1/9/03
Reviewed by: WJW

Effluent Dosing Tank Design

Assumptions

- Tank material = polypropylene
- Minimum holding time = 30 min.
- Tank Shape = Elliptical / Horizontal
- Tank will be approximately 3/4 full during system operation

Determine Min. Size of Tank

Flow rate = 40 gallons/minute (Design Flow Rate)

Size = 40 gpm x 30 min.

= 1,200 gallons ← minimum volume in tank

- Per attached information provided by Agri-Supply, an elliptical tank of 1,635 gallons is available

Volume of water in tank if 3/4 full
= 1,635 x 0.75
= 1,226 gallons > 1,200 gallon (min. size)

However, to provide a factor of safety and the ability to possibly add volume to the system, we recommend the 2,035 gallon tank. To maintain min. hold time of 30 min, approximately 1,200 gallons must be stored within the tank.

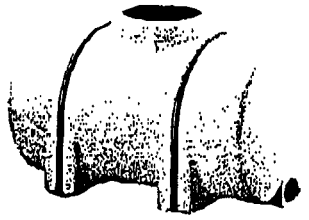
1,200 gallons / 2,035 gallons = 60% of total

- Height of tank is 55" or 4.58 feet
× 60% = 2.75 feet ← Note 60% of height is slightly more than 60% of volume due to tank shape.

∴ Therefore, an outfall pipe elevation of 2.75 feet is recommended. Steel bands may also be required by manufacturer to guarantee the integrity of tank.

Horizontal Leg Tanks

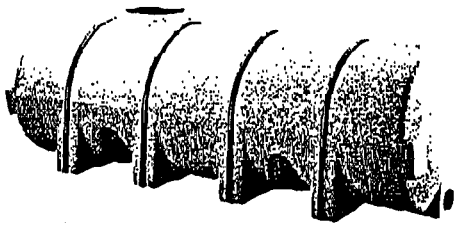
With the broadest leg tank line available, NORWESCO manufactures a size that will fit your needs. Used primarily for transport and nursing applications, NORWESCO's leg tanks feature molded-in baffles to reduce sloshing when the tank is in motion. Please refer to page 4 for support bands.



325 Gallon Horizontal Leg

Gallon Capacity	Diameter	Length	Fill Opening	Outlet/Drain Specification	No. of Bands	Premium Weight Part No. White	Heavy Weight Part No. Blue
35 ∞	20"	29"	5"	¾"	2 optional	60318	—
65 ∞	23"	43"	5"	¾"	2 optional	61739	—
125	32"	41"	8"	2"	2 optional	40298	—
225	38"	49"	8"	2"	2 optional	40299	—
325	38"	66"	16"	2"	2 optional	40217	—
525	49"	71"	16"	2"	2 optional	40181	40193
725 *	49"	101"	16"	2"	3 required	40180	40194
1025 *	49"	139"	16"	2"	4 required	40089	40131

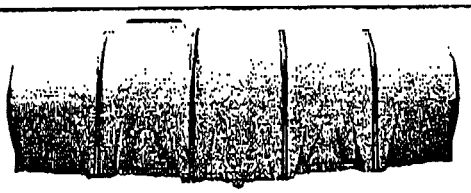
∞ Within UPS dimensional limits
*Require full length support and bands



1025 Gallon Horizontal Leg

Drainable Leg Tanks

When complete drainage is necessary, these are the tanks of choice. They are designed primarily for use on fertilizer and chemical nurse trailers. Please refer to page 4 for support bands.



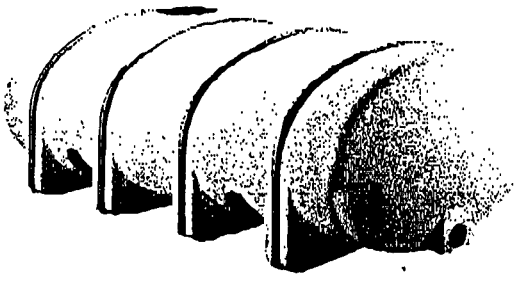
1010 Gallon Drainable Leg

Gallon Capacity	Width	Height	Length	Fill Opening	Outlet/Drain Specification	No. of Bands	Premium Weight Part No. White	Heavy Weight Part No. Blue
710*	47"	47"	104"	16"	2"	3 required	40655	40657
1010*	47"	47"	140"	16"	2"	4 required	40393	40395
1610* (elliptical)	69"	63"	140"	16"	—	4 required	40806	40808

*Require full length support and bands

Elliptical Leg Tanks

This elliptical tank style is designed to provide the greatest capacity with the lowest center of gravity, making it the best design available for transporting larger volumes. NORWESCO elliptical tanks feature molded-in legs and flow-through baffles which work together to reduce sloshing and provide increased stability during transport. All NORWESCO elliptical leg tanks require full length bottom support as well as support bands. Please refer to information on page 4.



2035 Gallon Elliptical Leg

Gallon Capacity	Width	Height	Length	Fill Opening	Outlet/Drain Specification	Premium Weight Part No. White	Heavy Weight Part No. Blue
1035	79"	53"	89"	16"	2"	40191	—
1235	65"	52"	128"	16"	2"	40239	—
1635	71"	57"	142"	16"	2"	40387	40388
2035	84"	55"	142"	16"	2"	40618	40623
2635	90"	71"	140"	16"	3"/2"	40547	40283
3135	88"	76"	151"	16"	3"/2"	40686	40688

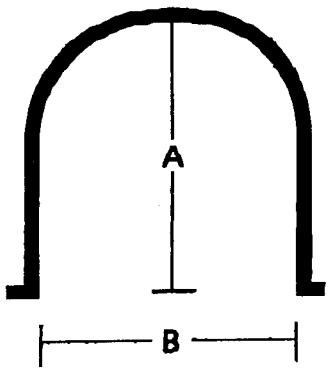
↑ Biggest horizatal tank we carry.
$2284.95

– Holds upto 12lb/gal liquid :– Assume water will weigh 8.34 lbs/gal, thus acceptable.

PLEASE NOTE: Tank availability may vary according to manufacturing location. Please contact Norwesco Customer Service or your Norwesco distributor for specific details.

Steel Supports and Accessories

NORWESCO bands are custom fabricated to support the NORWESCO tanks and are galvanized for added corrosion protection. Whether using the tank in a stationary position or for transport, bands are necessary to ensure that the tank retains its shape and integrity.



Bands are to be used only if manufacturer requires them for warranty of integrity Otherwise bands are not needed to hold tank in place because tank will always have water in it.

Horizontal Leg Tank Bands

Tank Size (Gallon)	A	B	No. of Bands	Part No.
35 —	18½"	18½"	2 optional	60520
65 ∞	22"	22"	2 optional	61745
125 ∞	30½"	30¾"	2 optional	61744
225 ∞	36½"	36¾"	2 optional	60478
325 ∞	36½"	36¾"	2 optional	60478
525	47½"	47¾"	2 optional	60057
725	47½"	47¾"	3 required	60057
1025	47½"	47¾"	4 required	60057

— Within UPS dimensional limits

Drainable Leg Tank Bands

Tank Size (Gallon)	A	B	No. of Bands	Part No.
710	45"	46¼"	3 required	60584 short
1010 *	45"	46¼"	2 required	60584 short
1010 *	45"	48"	2 required	60585 long
1610	66"	49"	4 required	62434

* 2 short and 2 long bands are required for 1 tank

Elliptical Leg Tank Bands

Tank Size (Gallon)	A	B	No. of Bands	Part No.
1035	77"	47¼"	3 required	60325
1235	64½"	47¾"	4 required	60477
1635	68"	51"	4 required	60586
2035	81½"	51¼"	4 required	62079
2635	87½"	65¼"	4 required	60353
3135	85½"	75¼"	4 required	62097

$156.95 ea if needed

Ladder

Description	Tank Size (Gallon)	Part No.
Ladder (optional)	2635 & 3135	60354
Adaptor kit for ladder Δ	3135	62301

Δ This kit is required when using the ladder on the 3135 gallon tank

PLEASE NOTE: Tank availability may vary according to manufacturing location. Please contact Norwesco Customer Service or your Norwesco distributor for specific details.

EFFLUENT TANK INFLUENT PIPE DESIGN CALCULATIONS
FOR
LOADING RACK AREA

CATLIN ENGINEERS and SCIENTISTS WILMINGTON, NORTH CAROLINA

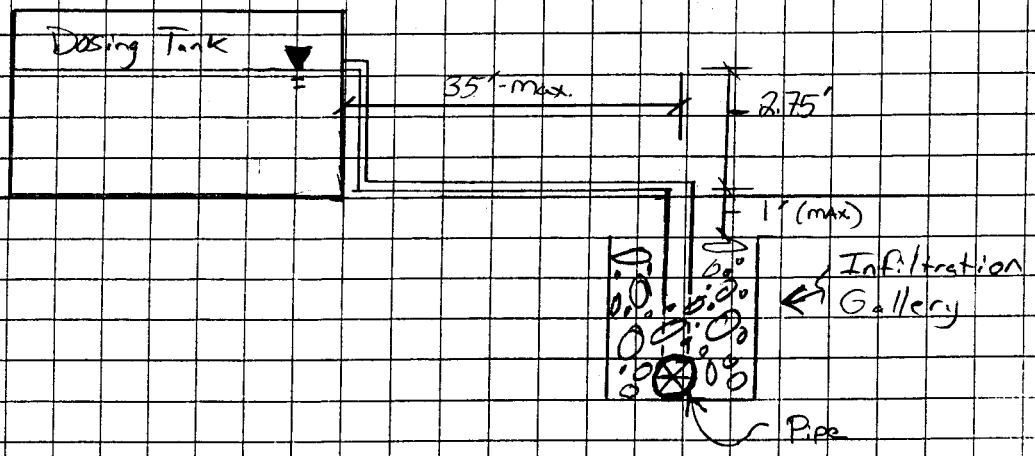
SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN #: 201 ~~210~~-125

Drawn/Calculated by: Jeff Becker
Date: 1/13/03
Reviewed by: NJV

Dosing Tank Effluent Line Design

The following is a sketch of effluent line location



Using the formula derived in the Dosing Tank Influent Line Design,

$$V = \sqrt{\frac{2E_v g}{f(L/D)+1}}$$

- Solve for v using various diameter pipes. This was done using excel spreadsheets. See attached results.

Determine the flow using the formula derived in the Dosing Tank Influent Line Design

$$Q = (v)(1/4)(\pi)(d^2)$$

- See attached spreadsheet for results.

PIPE SIZING SPREADSHEET FOR DOSING TANK EFFLUENT LINE

Flint Hills Resources, LP
North Terminal
Paraxylene Facility
CATLIN Project Number: 195-033

ASSUMPTIONS

g =	32.2 ft/s2
z1 =	3.75 ft
f =	0.02
L =	35 ft

CALCULATIONS

Pipe Diameter (in)		Flow (gpm)
4		345.68
3		175.63
2		66.73
1.9		58.98
1.8		51.77
1.79		51.08
1.78		50.40
1.77		49.72
1.76		49.04
1.75		48.37
1.5		33.32
1.25		21.39
1		12.41
0.5		2.25
0.25		0.40

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN # : 210-125

Drawn/Calculated by: Jeff Becken
Date: 1/13/03
Reviewed by: WJW

Dosing Tank Effluent Line Design (cont.)

- Based on pipe diameter and flow calculations on Page 3, the minimum pipe size for the dosing tank effluent line at a flow of 40 gpm is 1.75 inches. Therefore use 2 inch as minimum pipe size.

∴ To provide a safety factor recommend a 3 inch minimum pipe size for the dosing tank effluent line. The tank outlet size should also be a minimum of 3 inches

7.0 INFILTRATION GALLERY

7.1 PX FACILITY

7.1.1 Design of Infiltration Gallery

7.1.1.1 Pilot Test Activities

CATLIN conducted a pilot test to assist with the design of the infiltration gallery referenced in this section. The pilot test activities were summarized in a Summary of Pilot Test Activities for Infiltration Gallery at Paraxylene Facility. A copy of this summary is provided in Attachment A3 of the Non-Discharge Permit Application. The pilot test findings indicated that an infiltration gallery of 1,231 square feet (assumed to be 10 feet by 123 feet) would need to be constructed to accept the anticipated maximum flow rate of 80 gpm of treated groundwater from the proposed groundwater remediation system. See the attached summary for a more detailed description of the activities and explanation of the determination of the size of the infiltration gallery.

It is important to note that the pilot test location was based on the location discussed within the CAPA. Since the performance of the pilot test, the proposed infiltration gallery has been moved and design based on the location illustrated on the Construction Plans.

7.1.1.2 Assumptions

- The pilot test data is applicable to the design of the infiltration gallery. Therefore, the infiltration gallery will be 10 feet wide by 123 feet long.
- Depth to the groundwater table is approximately 11 feet in the area of the proposed infiltration gallery.
- The maximum flow rate into the infiltration gallery is 80 gpm.
- The infiltration gallery pipe is to be 4-inch Single Wall Perforated Polyethylene manufactured by Advanced Drainage Systems (ADS) or approved equivalent.
- A minimum of one foot of head of water above the invert of the infiltration gallery pipe will be present.
- The stone material is to be No. 57 granite stone.
- The geotextile material is to be a non-woven material.
- The proposed infiltration gallery location will not have heavy vehicular traffic loads.

7.1.1.3 Selection

Based on the pilot test data, a 10 feet wide by 123 feet long infiltration gallery would be required to accept the anticipated maximum flow rate of 80 gpm. The pilot test was based on a 5 feet deep trench. It is our understanding that the Non-Discharge Permit requires a minimum 12 inches vertical separation between the infiltration gallery trench bottom and the mean seasonal high water table. Therefore, a 5 feet deep infiltration gallery will be acceptable. The preferred pipe manufacturer, ADS, provided Specifications for the 4-inch Single Wall Perforated Polyethylene. A copy of these Specifications is attached. Based on the attached Technical Note from Pipe Manufacturer, CATLIN verified that 123 linear feet of pipe would be sufficient to discharge the treated groundwater into the infiltration gallery with a maximum flow rate of 80 gpm.

Based on the pilot test data, assumptions listed above and the information provided in this section, the infiltration gallery is planned to be constructed as detailed on the Construction Plans using the assumed pipe.

7.2 LOADING RACK AREA

7.2.1 Design of Infiltration Gallery

7.2.1.1 Pilot Test Activities

CATLIN conducted a pilot test to assist with the design of the infiltration gallery referenced in this section. The pilot test activities were summarized in a Summary of Pilot Test Activities for Infiltration Gallery at Paraxylene Facility. A copy of this summary is provided in Attachment A3 of the Non-Discharge Permit Application. The pilot test findings indicated that an infiltration gallery of 1,060 square feet would need to be constructed to accept the anticipated maximum flow rate of 40 gpm of treated groundwater from the proposed groundwater remediation system. See the attached summary for a more detailed description of the activities and explanation of the determination of the size of the infiltration gallery.

It is important to note that the pilot test location was based on the location discussed within the CAPA. Since the performance of the pilot test, the proposed infiltration gallery has been moved and design based on the location illustrated on the Construction Plans.

7.2.1.2 Assumptions

- The pilot test data is applicable to the design of the infiltration gallery. Therefore, the infiltration gallery will be 1,060 square feet.
- Depth to the groundwater table is approximately 3.5 feet in the area of the proposed infiltration gallery.
- The maximum flow rate into the infiltration gallery is 40 gpm.
- The infiltration gallery pipe is to be 4-inch Single Wall Perforated Polyethylene manufactured by Advanced Drainage Systems (ADS) or approved equivalent.
- A minimum of one foot of head of water above the invert of the infiltration gallery pipe will be present.
- The stone material is to be No. 57 granite stone.
- The geotextile material is to be a non-woven material.
- The proposed infiltration gallery location will not have heavy vehicular traffic loads.

7.2.1.3 Selection

Based on the pilot test data, a 1,060 square feet infiltration gallery would be required to accept the anticipated maximum flow rate of 40 gpm. The pilot test was based on a 2.5 feet deep trench. It is our understanding that the Non-Discharge Permit requires a minimum 12 inches vertical separation between the infiltration gallery trench bottom and the mean seasonal high water table. Therefore, a 2.5 feet deep infiltration gallery will be acceptable. The preferred pipe manufacturer, ADS, provided Specifications for the 4-inch Single Wall Perforated Polyethylene. A copy of these Specifications is attached. Based on the attached Technical Note from Pipe Manufacturer, CATLIN verified that 107 linear feet of pipe would be sufficient to discharge the treated groundwater into the infiltration gallery with a maximum flow rate of 40 gpm.

Based on the pilot test data, assumptions listed above and the information provided in this section, the infiltration gallery is planned to be constructed as detailed on the Construction Plans using the assumed pipe.

INFILTRATION GALLERY DESIGN CALCULATIONS
AND MANUFACTURER INFORMATION
FOR
PX FACILITY

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT: FHR North Terminal
CATLIN # : 195-033

Drawn/Calculated by: Jeff Backen
Date: 11/18/02
Reviewed by: WMUSH

Design Infiltration Gallery

Assumptions

- Based on Summary of Pilot test activities an infiltration gallery of 1,231 square feet (Assumed 10'x123') will be required to handle an anticipated 80gal./min flow rate. See attached summary for calculation and data sheets used for determining the size of the infiltration gallery.

- 5 feet of head of water above invert of pipe in the infiltration gallery is assumed. However, for conservative design, assume only 1 foot of head will be present.

Determine if Length Pipe in Infiltration Gallery is sufficient for Design Flow

- Design Flow = 80gpm
- Pipe 4" Single Wall Perforated Pipe (See attached Specifications)
- Use attached Technical Note 2.105 provided by ADS for Tests Conducted to determine Outflow from Perforated Pipe (ADS manufacturer of proposed pipe)
  - Equation determined from tests to use for determining flow is

$$Q = A_0 + A_1 H + A_2 H^2$$

Where:
Q = Flow (gpm/ft)
H = Head of water above pipe invert (inches) = 12"
A_0, A_1, A_2 are equation coefficients → See ADS Technical Note

Using Table provided in Technical Note from Tests

$Q = 28.77$ GPM/FT $\times$ 123 ft

$Q = 3,538$ GPM $>$ 80 gpm ← Sufficient length of pipe

SUMMARY OF PILOT TEST ACTIVITIES FOR INFILTRATION GALLERY FOR PX FACILITY

(SEE ATTACHMENT A3 OF THE NON-DISCHARGE PERMIT APPLICATION FOR A COPY)

SPECIFICATIONS PROVIDED BY MANUFACTURER OF PROPOSED INFILTRATION GALLERY PIPE FOR PX FACILITY

Product Notes

ADS

Product Note 3.120
Re: Specification for Single Wall Corrugated Polyethylene Pipe
Date: February 2000

This specification applies to high density corrugated polyethylene pipe, Type C. Nominal sizes for which this specification is acceptable are 75 – 600 mm (3 – 24 inch) diameters. Requirements for test methods, dimensions and markings are found in AASHTO designation M-252 and M-294.

Pipe and fittings shall be made of virgin PE compounds that conform with the requirements of cell classification 335420C as defined and described in ASTM D-3350. Compounds that have higher cell classifications in one or more properties are acceptable provided product requirements are met.

The minimum parallel plate stiffness values when tested in accordance with D-2412 shall be as follows:

Diameter (nominal)	Pipe Stiffness (minimum)	Diameter (nominal)	Pipe Stiffness (minimum)
75 mm (3")	240 kN/m^2 (35 pii)	250 mm (10")	240 kN/m^2 (35 pii)
100 mm (4")	240 kN/m^2 (35 pii)	300 mm (12")	345 kN/m^2 (50 pii)
125 mm (5")	240 kN/m^2 (35 pii)	375 mm (15")	290 kN/m^2 (42 pii)
150 mm (6")	240 kN/m^2 (35 pii)	450 mm (18")	275 kN/m^2 (40 pii)
200 mm (8")	240 kN/m^2 (35 pii)	600 mm (24")	235 kN/m^2 (34 pii)

The pipe and fittings shall be free of foreign inclusions and visible defects. For pipe sizes 300 mm (12 inch) diameter and greater, designed drainage perforations shall be permitted in corrugation valleys only. All holes of any kind in the corrugation crests or sidewalls shall be considered unacceptable. Standard perforations for 75 - 250 mm (3 - 10 inch) shall be AASHTO M-252 Class 2 and for 300 - 600 mm (12 - 24 inch) shall be AASHTO M-294 Class 2. The ends of the pipe shall be cut squarely and cleanly so as not to adversely affect joining.

The nominal size for the pipe and fittings is based on the nominal inside diameter of the pipe. Corrugated fittings may be either molded or fabricated by the manufacturer. Fittings supplied by manufacturers other than the supplier of the pipe shall not be permitted without approval of the Project Engineer.

Joints for 75 – 150 mm (3 – 6 inch) shall be made with snap couplings. Joints for 200 – 600 mm (8 – 24 inch) shall be made with split couplings to engage the pipe corrugations.

Installation shall be in accordance with ASTM Recommended Practice D-2321 or as specified by the Project Engineer or local approval agency.

A manufacturer's certification that the product was manufactured, tested and supplied in accordance with this specification shall be furnished to the Project Engineer upon request.

3300 RIVERSIDE DRIVE COLUMBUS, OH 43221 (614) 457-3051 http://www.ADS-pipe.com

ADS SINGLE WALL PRODUCT INFORMATION SHEET

Nominal Diameter	Inside Diameter, Average	Outside Diameter, Average	Minimum Pipe Stiffness @ 5% Deflection	Weight kg/6m (lbs./20 ft.)	Area mm^2/mm	"I" cm^4/cm	"C" mm
75 mm	79 mm	93 mm	240 kN/m^2	1.97 kg	1.88	0.003	2.97
(3")	(3.12")	(3.66")	35 psi	(4.40 lbs)	(0.074 in^2/in)	(0.0002 in^4/in)	(0.117 in)
100 mm	102 mm	120 mm	240 kN/m^2	2.61 kg	2.06	0.011	4.29
(4")	(4.03")	(4.71")	35 psi	(6.30 lbs)	(0.081 in^2/in)	(0.0007 in^4/in)	(0.169 in)
125 mm	127 mm	148 mm	240 kN/m^2	4.43 kg	2.34	0.016	4.78
(5")	(4.99")	(5.81")	35 psi	(9.90 lbs)	(0.092 in^2/in)	(0.0010 in^4/in)	(0.188 in)
150 mm	151 mm	176 mm	240 kN/m^2	6.39 kg	3.15	0.033	6.22
(6")	(5.95")	(6.92")	35 psi	(14.30 lbs)	(0.124 in^2/in)	(0.0020 in^4/in)	(0.245 in)
200 mm	207 mm	240 mm	240 kN/m^2	11.02 kg	3.25	0.118	8.08
(8")	(8.14")	(9.45")	35 psi	(24.60 lbs)	(0.128 in^2/in)	(0.0072 in^4/in)	(0.318 in)
250 mm	255 mm	300 mm	240 kN/m^2	16.23 kg	3.48	0.261	11.20
(10")	(10.05")	(11.83")	35 psi	(36.30 lbs)	(0.137 in^2/in)	(0.0159 in^4/in)	(0.441 in)
300 mm	306 mm	366 mm	345 kN/m^2	26.56 kg	5.23	0.879	15.88
(12")	(12.04")	(14.41")	50 psi	(59.40 lbs)	(0.206 in^2/in)	(0.0536 in^4/in)	(0.625 in)
375 mm	378 mm	444 mm	290 kN/m^2	36.39 kg	4.67	1.537	14.86
(15")	(14.87")	(17.49")	42 psi	(81.40 lbs)	(0.184 in^2/in)	(0.0938 in^4/in)	(0.585 in)
450 mm	454 mm	524 mm	275 kN/m^2	53.51 kg	6.22	2.755	20.02
(18")	(17.86")	(21.04")	40 psi	(119.70 lbs)	(0.245 in^2/in)	(0.1681 in^4/in)	(0.788 in)
600 mm	600 mm	699 mm	235 kN/m^2	100.33 kg	8.99	7.436	25.38
(24")	(23.61")	(27.50")	34 psi	(224.40 lbs)	(0.354 in^2/in)	(0.4537 in^4/in)	(0.999 in)

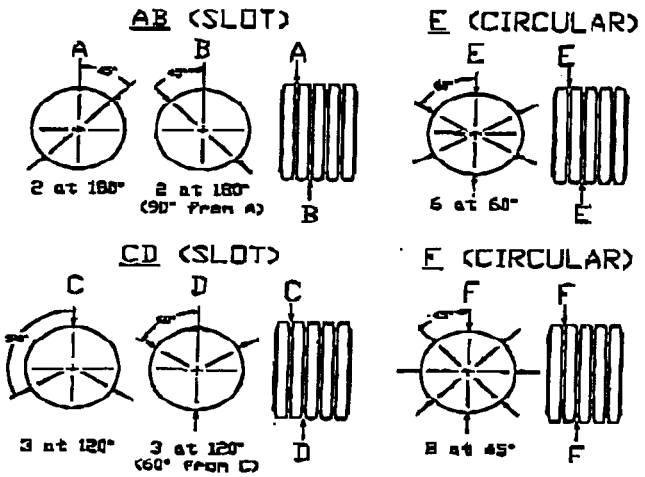
Date: February 2000

Product Notes

Product Note 3.109
Re: Standard Pipe Perforations
3-24" I.D. Single Wall Pipe
Date: October 1, 1996

Nominal I.D. In. (mm)	Perforation Type	Slot Length or Diameter Max. In. (mm)	Slot Width Max. In. (mm)	Perforation Configuration
3 (75)	Slot	0.875 (22.2)	0.125 (3.18)	AB
4 (100)	Slot	0.875 (22.2)	0.125 (3.18)	CD
5 (125)	Slot	0.875 (22.2)	0.125 (3.18)	CD
6 (150)	Slot	0.875 (22.2)	0.125 (3.18)	CD
8 (200)	Slot	1.250 (31.8)	0.125 (3.18)	CD
10 (250)	Slot	1.250 (31.8)	0.125 (3.18)	CD
12 (300)	Slot	2.50 (63.5)	0.125 (3.18)	CD
12 (300)	Circular	0.375 (9.52)	—	E
15 (375)	Circular	0.375 (9.52)	—	E
18 (450)	Circular	0.375 (9.52)	—	E
24 (600)	Circular	0.375 (9.52)	—	F

Perforation Configurations



NOTE 1
ADS pipe is perforated for water entry with slots or circular perforations. The perforations are uniformly spaced along the length and circumference of the pipe.

NOTE 2
Unless otherwise specified, ADS pipe is manufactured to comply with the perforation requirements specified in the following industry standards: ASTM F405, ASTM F667, AASHTO M252, AASHTO M294, and SCS Code 606.

NOTE 3
A **SPECIAL PRODUCT REQUEST FORM** is required for non-standard perforations.

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TECHNICAL NOTE FROM PIPE MANUFACTURER
FOR
PX FACILITY

Technical Notes

Technical Note 2.105

Re: Outflow From Perforated Pipe
Date: September 1, 1995

Introduction

In order to provide guidance to engineers in designing drainage or recharge systems, ADS conducted a series of exfiltration tests on pipe with standard perforations. It should be emphasized that these values are based on a free outlet (no backfill) through the perforations. Infiltration is assumed to equal the measured exfiltration rates.

Tests were conducted in accordance with AASHTO standard specification M176 for porous concrete pipe. Although intended for use with porous concrete pipe, the test method is applicable to perforated pipes of all types.

Test Procedure

A 2-foot-long section was used for each size tested. The level of water in the pipe was measured by means of a floating staff scale accurate to 1/16th of an inch.

For small diameter pipes, the flow rate was determined by the time to fill a 21.25 liter bucket. For larger sizes, a V-notch weir was used.

Results

The results of the tests showed a consistency in the manner in which flow rate increased with increasing height of water in the pipe and were in line with the theory of flow through orifices. Variation in the inlet area of the perforations impacted the flow rates in a linear manner with flow increasing uniformly with increased open area for equal head.

A quadratic equation is used to represent the data. The best fit curves by the method of least squares using a logarithmic transformation are shown for each size. The equation constants are included in the graphs and tables.

The equation is: $Q = A_0 + A_1H + A_2H^2$

Where:
Q = Quantity of water in GPM/ft.
H = Head of water above pipe invert in inches
A_0, A_1, & A_2 are equation coefficients

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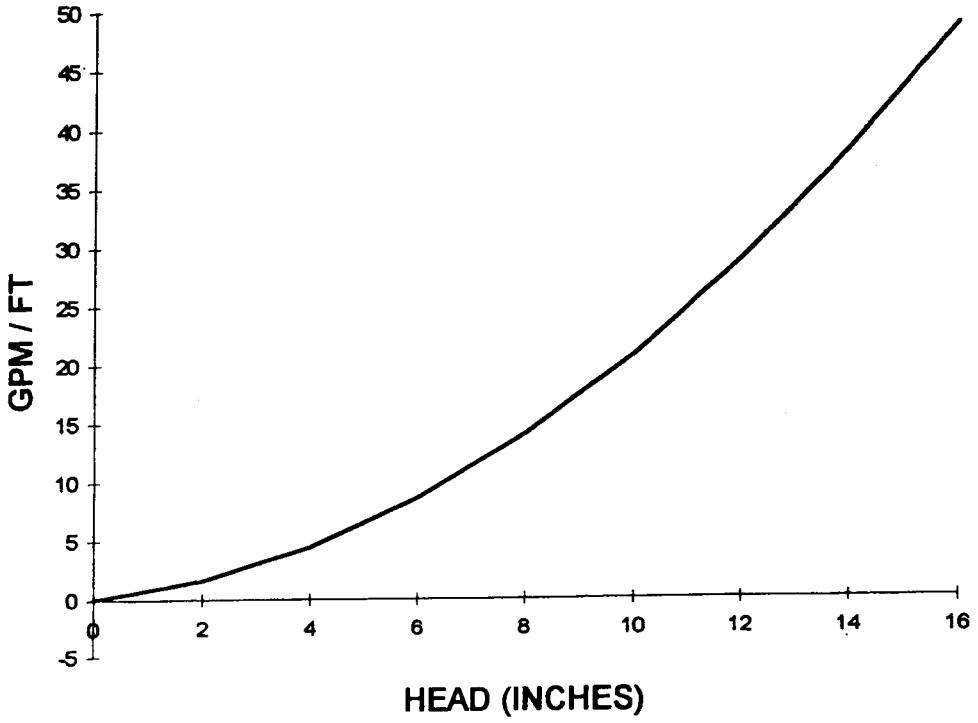
Discussion

In design of perforated pipe systems, the pipe is seldom used in a situation where it has a free discharge through its perforations but is more typically surrounded by gravel or soil. In virtually every case, the surrounding material will determine the inflow or outflow of a perforated pipe if the perforation opening area is in the range represented by the tested pipe. Thus, particular attention should be paid to the permeability of the surrounding soil in designing these systems. An excellent reference for this work is the book, *Seepage, Drainage, and Flow Nets,* by Harry R. Cedergren, published by John Wiley & Sons.

It should also be noted that the inlet capacity, utilized to the fullest, will quickly exceed the flow capacity of the pipe. This is particularly true of AdvanEDGE and the smaller pipe diameters. For guidance on flow capacity of these pipes refer to ADS Technical Note No. 2.109, Flow Capacity.

OUTFLOWS - ADS PIPE
4" SINGLE WALL PIPE TYPE C



FACTORS FOR OUTFLOW CALCULATIONS
ADS 4" SINGLE WALL PIPE TYPE C

OPEN AREA	AO	A1	A2	H2	H	Q=GPM/FT
2	-0.02616	0.47014	0.1608	0	0	-0.03
2	-0.02616	0.47014	0.1608	4	2	1.56
2	-0.02616	0.47014	0.1608	16	4	4.43
2	-0.02616	0.47014	0.1608	36	6	8.58
2	-0.02616	0.47014	0.1608	64	8	14.03
2	-0.02616	0.47014	0.1608	100	10	20.76
2	-0.02616	0.47014	0.1608	144	12	28.77
2	-0.02616	0.47014	0.1608	196	14	38.07
2	-0.02616	0.47014	0.1608	256	16	48.66

NOTE: Q = AO + (A1*H) + (A2*H2)

INFILTRATION GALLERY DESIGN CALCULATIONS
AND MANUFACTURER INFORMATION
FOR
LOADING RACK AREA

CATLIN ENGINEERS and SCIENTISTS
WILMINGTON, NORTH CAROLINA

SKETCH/COMPUTATION SHEET

CATLIN PROJECT:
FHR North Terminal
CATLIN # : ~~210~~ 201-125

Drawn/Calculated by: Jeff Becker
Date: 1/7/03
Reviewed by: NASH

Design Infiltration Gallery

Assumptions

- Based on Summary of Pilot Test activities an infiltration gallery of 1,060 square feet (assumed 10'x 107') will be required to handle an anticipated 40 gal./min flow rate. See attached summary of calculation and data sheets used for determining the size of the infiltration gallery.

- The head of water above invert of pipe in the infiltration gallery is assumed to be greater than 1 foot. However, for conservative design, assume only 1 foot of head will be present.

Determine if Length of Pipe in Infiltration Gallery is Sufficient For Design Flow

- Pipe Length = 107 feet
- Design Flow = 40 gpm
- Pipe 4" Single Wall Perforated Pipe (see attached specifications)
- Use attached Technical Note 2.105 provided by ADS for tests conducted to determine Outflow From Perforated Pipe (ADS is manufacturer of proposed pipe)
  - Equation determined by ADS to determine flow is:

$$Q = A_0 + A_1 H + A_2 H^2$$

Where:
Q = Flow (gpm/ft)
H = Head of water above pipe invert (inches) = 12"
A_0, A_1, A_2 are equation coefficients → See ADS Technical Note

Using table provided in Technical Note From Tests

$Q = 28.77 \text{ GPM/FT} \times 107 \text{ Ft}$

$Q = 3,078 \text{ GPM} > 40 \text{ GPM}$ ← Sufficient Length of Pipe

SUMMARY OF PILOT TEST ACTIVITIES FOR INFILTRATION GALLERY FOR LOADING RACK AREA

(SEE ATTACHMENT A3 OF THE NON-DISCHARGE PERMIT APPLICATION FOR A COPY)

SPECIFICATIONS PROVIDED BY MANUFACTURER OF PROPOSED INFILTRATION GALLERY PIPE FOR LOADING RACK AREA

Product Notes

ADS

Product Note 3.120
Re: Specification for Single Wall Corrugated Polyethylene Pipe
Date: February 2000

This specification applies to high density corrugated polyethylene pipe, Type C. Nominal sizes for which this specification is acceptable are 75 – 600 mm (3 – 24 inch) diameters. Requirements for test methods, dimensions and markings are found in AASHTO designation M-252 and M-294.

Pipe and fittings shall be made of virgin PE compounds that conform with the requirements of cell classification 335420C as defined and described in ASTM D-3350. Compounds that have higher cell classifications in one or more properties are acceptable provided product requirements are met.

The minimum parallel plate stiffness values when tested in accordance with D-2412 shall be as follows:

Diameter (nominal)	Pipe Stiffness (minimum)	Diameter (nominal)	Pipe Stiffness (minimum)
75 mm (3")	240 kN/m² (35 pli)	250 mm (10")	240 kN/m² (35 pli)
100 mm (4")	240 kN/m² (35 pli) ←	300 mm (12")	345 kN/m² (50 pli)
125 mm (5")	240 kN/m² (35 pli)	375 mm (15")	290 kN/m² (42 pli)
150 mm (6")	240 kN/m² (35 pli)	450 mm (18")	275 kN/m² (40 pli)
200 mm (8")	240 kN/m² (35 pli)	600 mm (24")	235 kN/m² (34 pli)

The pipe and fittings shall be free of foreign inclusions and visible defects. For pipe sizes 300 mm (12 inch) diameter and greater, designed drainage perforations shall be permitted in corrugation valleys only. All holes of any kind in the corrugation crests or sidewalls shall be considered unacceptable. Standard perforations for 75 - 250 mm (3 - 10 inch) shall be AASHTO M-252 Class 2 and for 300 - 600 mm (12 - 24 inch) shall be AASHTO M-294 Class 2. The ends of the pipe shall be cut squarely and cleanly so as not to adversely affect joining.

The nominal size for the pipe and fittings is based on the nominal inside diameter of the pipe. Corrugated fittings may be either molded or fabricated by the manufacturer. Fittings supplied by manufacturers other than the supplier of the pipe shall not be permitted without approval of the Project Engineer.

Joints for 75 – 150 mm (3 – 6 inch) shall be made with snap couplings. Joints for 200 – 600 mm (8 – 24 inch) shall be made with split couplings to engage the pipe corrugations.

Installation shall be in accordance with ASTM Recommended Practice D-2321 or as specified by the Project Engineer or local approval agency.

A manufacturer's certification that the product was manufactured, tested and supplied in accordance with this specification shall be furnished to the Project Engineer upon request.

3300 RIVERSIDE DRIVE COLUMBUS, OH 43221 (614) 457-3051 http://www.ADS-pipe.com

ADS SINGLE WALL PRODUCT INFORMATION SHEET

Nominal Diameter	Inside Diameter, Average	Outside Diameter, Average	Minimum Pipe Stiffness @ 5% Deflection	Weight kg./6m (lbs./20 ft.)	Area mm^2/mm	"I" cm^4/cm	"C" mm
75 mm	79 mm	93 mm	240 kN/m^2	1.97 kg	1.88	0.003	2.97
(3")	(3.12")	(3.66")	35 psi	(4.40 lbs)	(0.074 in^2/in)	(0.0002 in^4/in)	(0.117 in)
100 mm	102 mm	120 mm	240 kN/m^2	2.61 kg	2.06	0.011	4.29
(4")	(4.03")	(4.71")	35 psi	(6.30 lbs)	(0.081 in^2/in)	(0.0007 in^4/in)	(0.169 in)
125 mm	127 mm	148 mm	240 kN/m^2	4.43 kg	2.34	0.016	4.78
(5")	(4.99")	(5.81")	35 psi	(9.90 lbs)	(0.092 in^2/in)	(0.0010 in^4/in)	(0.188 in)
150 mm	151 mm	176 mm	240 kN/m^2	6.39 kg	3.15	0.033	6.22
(6")	(5.95")	(6.92")	35 psi	(14.30 lbs)	(0.124 in^2/in)	(0.0020 in^4/in)	(0.245 in)
200 mm	207 mm	240 mm	240 kN/m^2	11.02 kg	3.25	0.118	8.08
(8")	(8.14")	(9.45")	35 psi	(24.60 lbs)	(0.128 in^2/in)	(0.0072 in^4/in)	(0.318 in)
250 mm	255 mm	300 mm	240 kN/m^2	16.23 kg	3.48	0.261	11.20
(10")	(10.05")	(11.83")	35 psi	(36.30 lbs)	(0.137 in^2/in)	(0.0159 in^4/in)	(0.441 in)
300 mm	306 mm	366 mm	345 kN/m^2	26.56 kg	5.23	0.879	15.88
(12")	(12.04")	(14.41")	50 psi	(59.40 lbs)	(0.206 in^2/in)	(0.0536 in^4/in)	(0.625 in)
375 mm	378 mm	444 mm	290 kN/m^2	38.38 kg	4.67	1.537	14.86
(15")	(14.87")	(17.49")	42 psi	(81.40 lbs)	(0.184 in^2/in)	(0.0938 in^4/in)	(0.585 in)
450 mm	454 mm	524 mm	275 kN/m^2	53.51 kg	6.22	2.755	20.02
(18")	(17.86")	(21.04")	40 psi	(119.70 lbs)	(0.245 in^2/in)	(0.1681 in^4/in)	(0.788 in)
600 mm	600 mm	699 mm	235 kN/m^2	100.33 kg	8.99	7.436	25.38
(24")	(23.61")	(27.50")	34 psi	(224.40 lbs)	(0.354 in^2/in)	(0.4537 in^4/in)	(0.999 in)

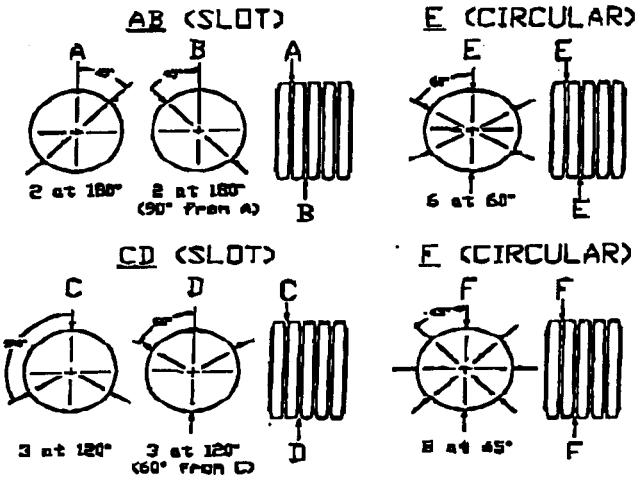
Date: February 2000

Product Notes

Product Note 3.109
Re: Standard Pipe Perforations 3-24" I.D. Single Wall Pipe
Date: October 1, 1996

Nominal I.D. In. (mm)	Perforation Type	Slot Length or Diameter Max. In. (mm)	Slot Width Max. In. (mm)	Perforation Configuration
3 (75)	Slot	0.875 (22.2)	0.125 (3.18)	AB
4 (100)	Slot	0.875 (22.2)	0.125 (3.18)	CD
5 (125)	Slot	0.875 (22.2)	0.125 (3.18)	CD
6 (150)	Slot	0.875 (22.2)	0.125 (3.18)	CD
8 (200)	Slot	1.250 (31.8)	0.125 (3.18)	CD
10 (250)	Slot	1.250 (31.8)	0.125 (3.18)	CD
12 (300)	Slot	2.50 (63.5)	0.125 (3.18)	CD
12 (300)	Circular	0.375 (9.52)	—	E
15 (375)	Circular	0.375 (9.52)	—	E
18 (450)	Circular	0.375 (9.52)	—	E
24 (600)	Circular	0.375 (9.52)	—	F

Perforation Configurations



NOTE 1
ADS pipe is perforated for water entry with slots or circular perforations. The perforations are uniformly spaced along the length and circumference of the pipe.

NOTE 2
Unless otherwise specified, ADS pipe is manufactured to comply with the perforation requirements specified in the following industry standards: ASTM F405, ASTM F667, AASHTO M252, AASHTO M294, and SCS Code 606.

NOTE 3
A **SPECIAL PRODUCT REQUEST FORM** is required for non-standard perforations.

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TECHNICAL NOTE FROM PIPE MANUFACTURER
FOR
LOADING RACK AREA

Technical Notes

Technical Note 2.105
Re: Outflow From Perforated Pipe
Date: September 1, 1995

Introduction

In order to provide guidance to engineers in designing drainage or recharge systems, ADS conducted a series of exfiltration tests on pipe with standard perforations. It should be emphasized that these values are based on a free outlet (no backfill) through the perforations. Infiltration is assumed to equal the measured exfiltration rates.

Tests were conducted in accordance with AASHTO standard specification M176 for porous concrete pipe. Although intended for use with porous concrete pipe, the test method is applicable to perforated pipes of all types.

Test Procedure

A 2-foot-long section was used for each size tested. The level of water in the pipe was measured by means of a floating staff scale accurate to 1/16th of an inch.

For small diameter pipes, the flow rate was determined by the time to fill a 21.25 liter bucket. For larger sizes, a V-notch weir was used.

Results

The results of the tests showed a consistency in the manner in which flow rate increased with increasing height of water in the pipe and were in line with the theory of flow through orifices. Variation in the inlet area of the perforations impacted the flow rates in a linear manner with flow increasing uniformly with increased open area for equal head.

A quadratic equation is used to represent the data. The best fit curves by the method of least squares using a logarithmic transformation are shown for each size. The equation constants are included in the graphs and tables.

The equation is: $Q = A_0 + A_1H + A_2H^2$

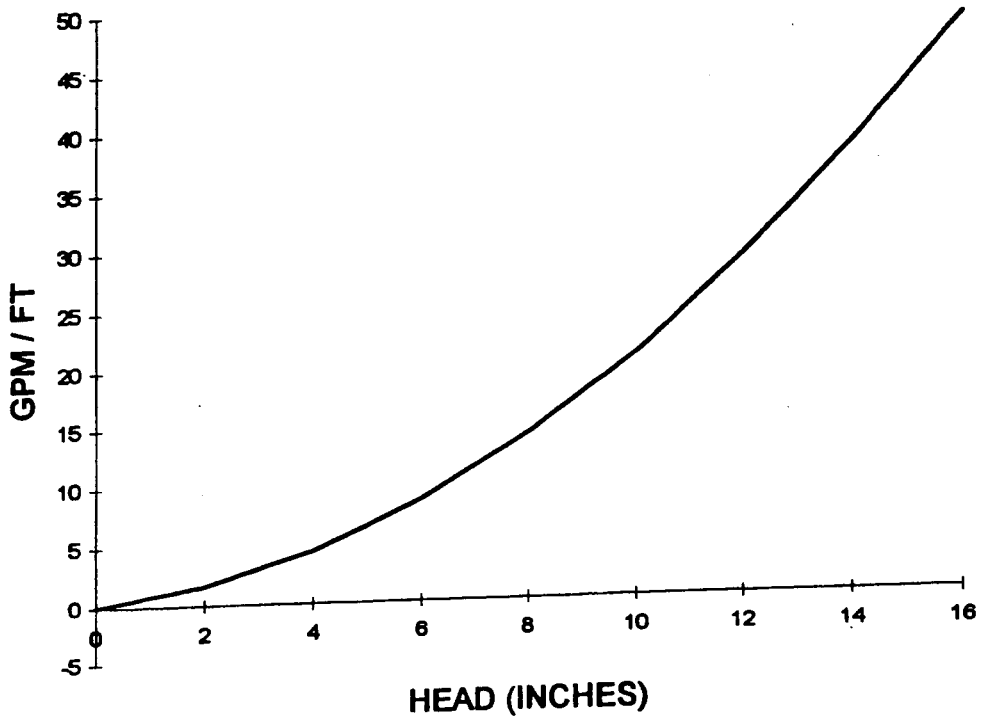
Where:
Q = Quantity of water in GPM/ft.
H = Head of water above pipe invert in inches
A_0, A_1, & A_2 are equation coefficients

Discussion

In design of perforated pipe systems, the pipe is seldom used in a situation where it has a free discharge through its perforations but is more typically surrounded by gravel or soil. In virtually every case, the surrounding material will determine the inflow or outflow of a perforated pipe if the perforation opening area is in the range represented by the tested pipe. Thus, particular attention should be paid to the permeability of the surrounding soil in designing these systems. An excellent reference for this work is the book, *Seepage, Drainage, and Flow Nets,* by Harry R. Cedergren, published by John Wiley & Sons.

It should also be noted that the inlet capacity, utilized to the fullest, will quickly exceed the flow capacity of the pipe. This is particularly true of AdvanEDGE and the smaller pipe diameters. For guidance on flow capacity of these pipes refer to ADS Technical Note No. 2.109, Flow Capacity.

OUTFLOWS - ADS PIPE
4" SINGLE WALL PIPE TYPE C



FACTORS FOR OUTFLOW CALCULATIONS
ADS 4" SINGLE WALL PIPE TYPE C

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2	-0.02616	0.47014	0.1608	36	6	8.58
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2	-0.02616	0.47014	0.1608	100	10	20.76
2	-0.02616	0.47014	0.1608	144	12	28.77
2	-0.02616	0.47014	0.1608	196	14	38.07
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NOTE: Q = AO + (A1*H) + (A2*H2)