CUYAHOGA RIVER-CANAL DIVERSION DAM ALTERNATIVE FLOW OPTIONS

Prepared for:

Friends of the Crooked River
Carter Store
2179 Everett Road
Peninsula, OH 44264

Prepared by:

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August 31, 2006

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Introduction and Background

Within the Cuyahoga Valley National Park system, the Cuyahoga River supplies water to the Ohio and Erie Canal via a canal diversion dam. The dam is located just south of the Brecksville-Northfield High Level Bridge, where the Cuyahoga River and the Canal both meander north in a parallel fashion. First constructed in 1951, the main purpose of the dam was to provide a constant feed of water to the Canal by the Brecksville Feeder Gates. No pumps or mechanical devices were used in the dam, rather gravity maintained the varying water supply required. Recently the diversion dam has been recognized by the Ohio Environmental Protection Agency as a cause for deficient water quality downstream in the Cuyahoga River. It has been shown in a Total Maximum Daily Load report provided by the Ohio EPA that an evaluation for removal of the dam should be conducted. Following the initial evaluation, a study team acknowledged additional solutions worthy of careful consideration such as, no removal or modification, partial removal/modification of existing components, or complete removal of the dam.

In light of the various alternatives under investigation, a supply of water from the Cuyahoga River to the Ohio and Erie Canal must be provided. If the Canal does not receive the proper amount of water, there could be small, but important, environmental or agricultural impacts. Therefore the National Park Service, who maintains the Cuyahoga Valley National Park, has issued a report called the *Hydrologic Study and Design Alternatives: Watered Section of the Ohio and Erie Canal Brecksville Feeder Dam to Rockside Road.* Within the report, a flow estimate of 20 ft^3/sec or 12.9 million gallons per day (mgd) from the Cuyahoga River is required for proper function of the Canal. This report addresses identification and evaluation of pump alternatives to meet the required flow.

Project Scope

The scope of this project was to provide a minimum of four options to provide the needed flow to the Ohio and Erie Canal. The evaluation will include assessment of centrifugal and screw pump alternatives. The evaluation included pump sizing, estimated equipment costs, estimated annual operation and maintenance costs, estimated pipe costs, and area needed for installation. The objective is to identify and rank the selected pump alternatives based on their ability to meet the required flow in a cost effective manner.

Approach

The primary sequence for this project was as follows:

1. Create a physical model of the site (Cuyahoga River and Ohio and Erie Canal).
2. Select pipe material and size.
3. Identify potential pump candidates that can deliver the required flow under the physical model conditions developed in Step 1.
4. Compare selected pump option costs and rank the options accordingly.

Physical Model

Based on a pictures taken during a site visit (see Figure 1 and 2), a physical model of the site and proposed pump location for centrifugal pumps was created and is shown in Figure 3. This system included an estimated water level elevation difference of 5 feet. The pipe inlet should be placed sufficiently under the water surface and a strainer provided to prevent debris and wildlife from entering the pipe. The pump house (estimate 20 ft x 20 ft floor plan) is

Figure 1. Ohio and Erie Canal Adjacent to Brecksville Feeder Dam.

Figure 2. Ohio and Erie Canal Running Under S.R. 82.

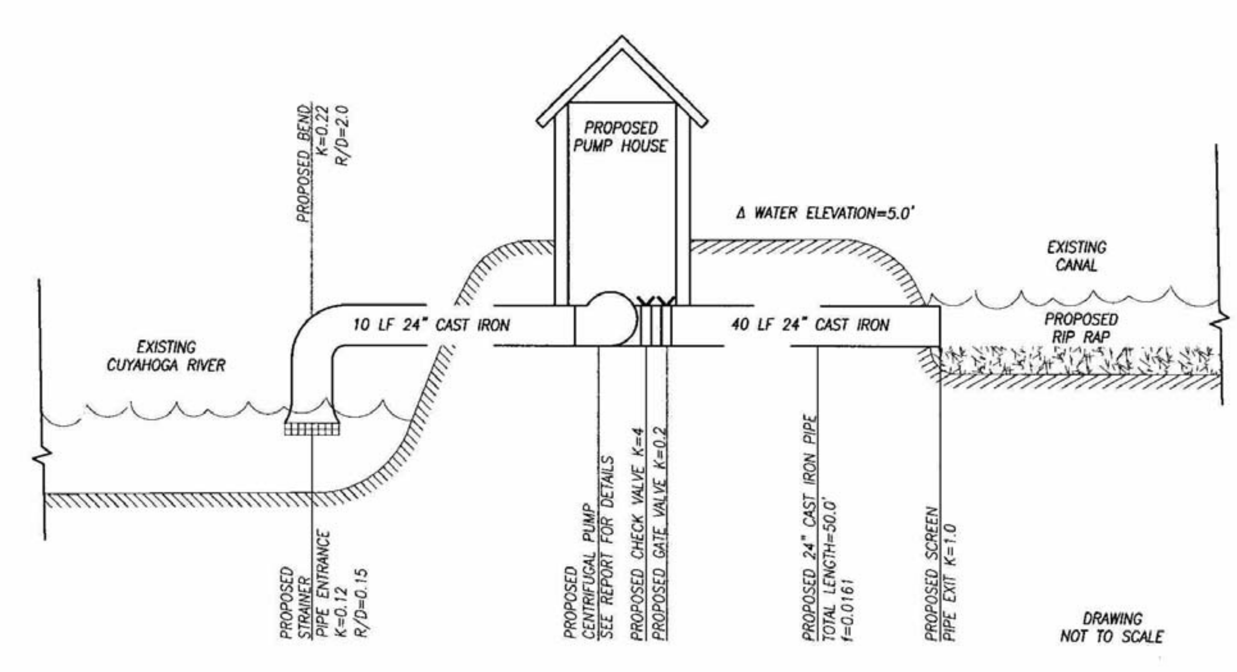


Figure 3. Physical System Layout.

proposed to provide cover as well as sheltered operation and maintenance of the pump. Additionally, the pump house will aid in sound control and pump security. A gate valve is to be installed downstream from the pump for circumstances requiring pump or system maintenance. Lastly, the pipe outlet is horizontally directed into the Canal with an affixed screen to prevent debris or wildlife entering the pipe, as well as riprap installed to prevent erosion. Screw pump installation and layouts were provided by the pump manufacturer.

<u>Pipe Material and Sizing</u>

Reinforced concrete pipe (RCP) and ductile iron were evaluated for this project. Price quotes were obtained (get-a-quote.net) and showed ductile iron to be almost four times as expensive as RCP. The final pump type (centrifugal or screw pump) selection will likely determine the more appropriate choice. The pipe size, however, is a significant factor in the hydraulic system performance. Analysis was performed on 18" and 24" diameter pipes and showed the benefit of reduced friction losses in a 24" diameter pipe outweigh the additional material cost. This was not unexpected because the total pipe length is not a significant cost factor for this project.

Pump Selection and Hydraulic Analysis

For centrifugal pumps, Goulds Pumps data was obtained via their web site and the pumps were evaluated based on their ability to provide the required flow (20 cfs). Hydraulic analysis was performed using WaterCAD® software. Screw pumps, however, operate on different principles than centrifugal pumps and do not require the same type of analysis. They can simply be selected based on the required flow. Two companies were contacted for screw pump quotes: Lakeside Equipment Corporation (Bartlett, Illinois) and Hayward Gordon (Mississauga, Ontario).

Results and Discussion

Hydraulic analysis results for the centrifugal pumps are presented first and then compared to equipment and operation costs of the screw pumps (as provided by the screw pump manufacturers). We have analyzed three centrifugal pumps which are capable of providing the required flow rate to the Canal and are capable of pumping river water. Appendix A has the specific centrifugal pump performance curves and details for three pumps that met the required flow. Using the Energy Cost Analysis module in WaterCAD® and using an energy cost of $0.075/kWh, Table 1 presents the energy costs associated with operating these pumps. There was not much difference between the 20x20 WSB-14.25" and 18x18-22H-L-16.5" Models, however, the 20x18S-19.375 Model was prohibitively expensive.

Table 1. Energy Costs Associated with Selected Centrifugal Pumps.

Goulds Pump Model	Daily Cost ($)	Annual Cost ($)
20x20 WSB-14.25"	$78	$28,470
18x18-22H-L-16.5"	$84	$30,660
20x18S-19.375	$124	$45,260

The next step in the project was to obtain daily power costs for two screw pumps that could deliver the required flow. Several manufacturers (Lakeside Equipment Corporation and Hayward Gordon) were contacted and their calculated energy costs are summarized in Table 2. All quotes and information are also provided in Appendix B for Lakeside Equipment and in Appendix C for Hayward Gordon.

Table 2. Energy Costs Associated with Selected Screw Pumps.

Pump Manufacturer	Pump Model	Daily Cost ($)	Annual Cost ($)
Lakeside Equipment	60”-3 Flight	$51	$18,615
Hayward Gordon	XCS16C	$73	$26,645

As shown in Table 2, the screw pumps have much lower energy costs than the centrifugal pumps. The low power draw and high efficiency of the screw pump make it considerably more appealing than the traditional centrifugal pumps. Furthermore, the Cuyahoga River is likely to have solids in the water and screw pumps by design are better equipped to handle this situation. Table 3 summarizes the energy cost information for the five pump options assessed for this project. As ongoing energy costs are the major cost factor for this project, Table 3 clearly shows the screw pumps are the pump of choice.

Table 3. Rank of Pump Options for Providing Alternative Flow.

Option Rank	Pump Manufacturer	Pump Type	Pump Model	Energy Daily Cost ($)
1	Lakeside Equipment	Screw	60”-3 Flight	$51
2	Hayward Gordon	Screw	XCS16C	$73
3	Goulds	Centrifugal	20x20 WSB-14.25"	$78
4	Goulds	Centrifugal	18x18-22H-L-16.5"	$84
5	Goulds	Centrifugal	20x18S-19.375	$124

Note: Rank of 1 indicates the most favorable option.

Since the Lakeside equipment screw pump was far more superior (from an energy cost perspective) than the rest of the pumps, a pump equipment cost quote was only obtained for this pump. Lakeside Equipment quoted a unit price of $65,900 per pump and recommends two pumps for service and maintenance issues, for a total equipment cost of $131,800. The pricing includes a motor and other items required for the operation of the pumps (details are included in Appendix B). A summary of costs and items associated with the Lakeside Equipment pump are summarized in Table 4.

Table 4. Cost Breakdown and Requirements for Recommended Pump Alternative from Lakeside Equipment.

Item	Unit Cost	Cost	Note
Two Pumps	$65,900 per pump	$131,800 (one time)	--
50 ft Iron Pipe	$65 per LF	$3,900 (one time	--
Energy	$0.075 kWh	$18,615 per year	--
Maintenance	$1,500 per month	$18,000 per year	Low Maintenance
Pump Area	--	--	30 ft x 50 ft

Conclusions and Recommendations

Five pump alternatives were assessed and a screw pump from Lakeside Equipment proved to be the most economical choice. According to Lakeside Equipment, the exact type should be "a 60-inch diameter, 3-flight open pump with a 30-inch diameter by [0.375]-inch thick wall for a lift (H) of 10.0 feet (assumed) while operating at 30 degrees inclination. Each pump would operate at 34 rev/min […]" (Eckstein 2006). This recommendation is based on several major assumptions described earlier in the report and this information needs to be verified before a final design or decision is made. There are also some operational concerns which are beyond the scope of this study, but should be noted for future reference. One challenge will be to try and maintain some type of pump control as it relates to the quantity of water in the Ohio and Erie Canal. This may addressed by investigating some type of intermediate reservoir-retention system between the two bodies of water and could result in lower energy costs.

References

1. National Park Service. Cuyahoga Valley National Park: Ohio and Erie Canal Towpath Trail. "Hydrologic Study and Design Alternatives: Watered Section of the Ohio Canal-Brecksville Feeder Dam to Rockside Road." Bergmann Associates. August 2005.

2. Eckstein, Steve. "Letter Suggesting Lakeside Open Screw Pumps." Regional Sales Manager. Lakeside Equipment Corporation. Bartlett, IL. July 31, 2006.

3. Chin, David A. Water-Resources Engineering. Sections 3.4, 3.5. Pages 101-132. Prentice Hall. 2000.

4. Goulds Pumps. Pump Selection Service on the Web. Pump Data. 2006. http://www.gouldspumps.com.

5. Get-A-Quote.net. Ohio Online Construction Costs for Contractors. 2006 Ohio Heavy Construction Costs. Page 203, 242. 2006. http://www.get-a-quote.net/

6. Wong, Kevin. Electronic Mail. "Screw Pump for 9000 GPM @ 10 ft." Hayward Gordon Ltd. Mississauga, ON. August 22, 2006.

7. Haestad Methods, Walski, T. M.; Chase, D. V.; Savic, D. A.; Grayman, W.; Beckwith, S.; Koelle, E. (2003). *Advanced Water Distribution Modeling and Management*, Haestad Methods, Inc., Waterbury.

Appendix A

Pump Performance Curves for Centrifugal Pumps (Goulds Pumps)

[redacted]	[redacted]	60Hz	RPM: 890	Stages: 1

Job/Inq.No. :
Purchaser :
End User :
Item/Equip.No. : ITEM 001
Service :
Order No. :

Issued by : DAN VAN BOXEL
Quotation No. : DV06-07-26 01
Date : 07/30/2006

Operating Conditions

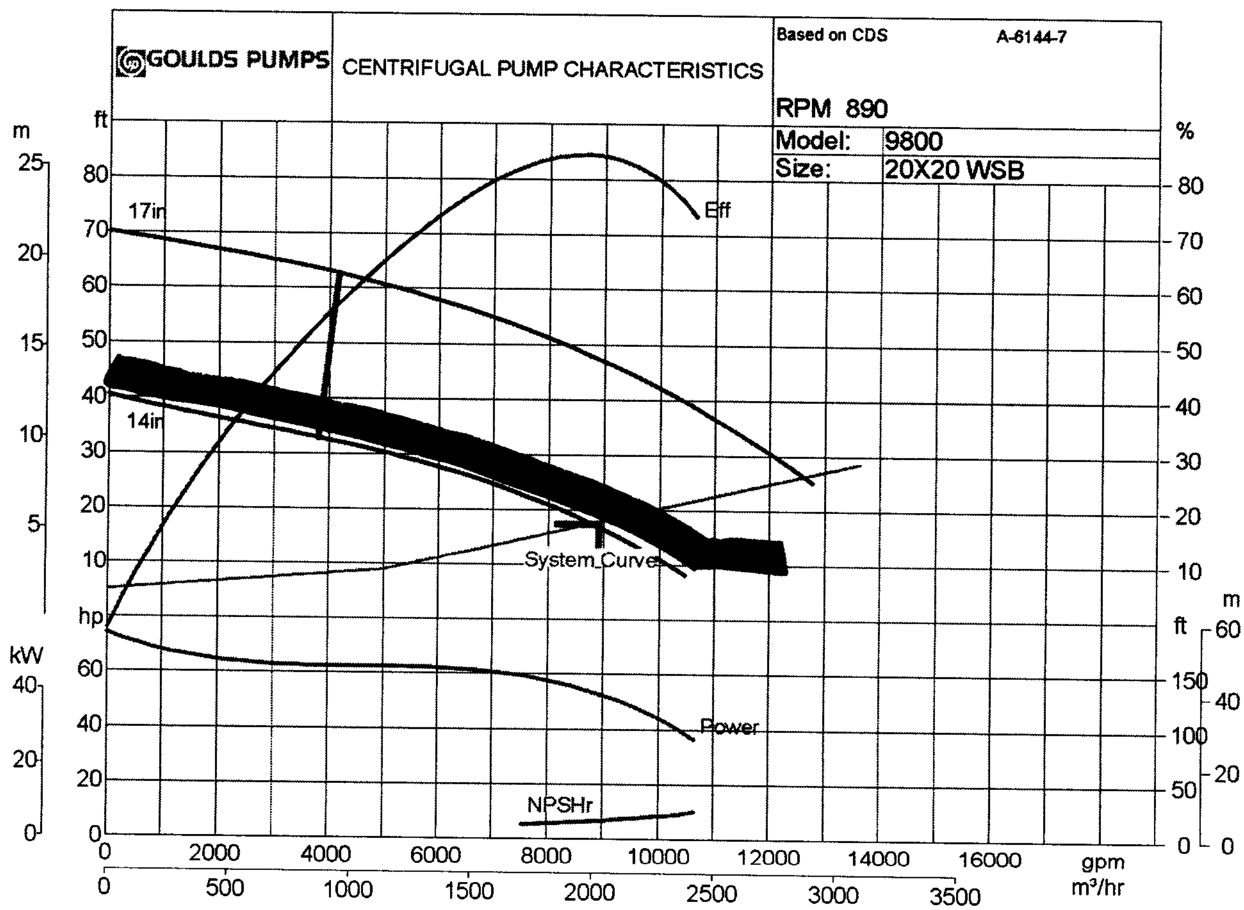
Liquid:	River Water
Temp.:	68.0 deg F
S.G./Visc.:	1.000/1.050 cp
Flow:	8,960.0 gpm
TDH:	18.0 ft
NPSHa:	
Solid size:	
% Solids:	
Max. Solids Size:	1.2500 in

Pump Performance

Actual Pump Eff.:	83.5 %
Actual Pump Power:	51.8 hp
Total Power Loss:	0.00 hp
Rated Total Power:	51.8 hp
Imp. Dia. First 1 Stg(s):	14.2500 in
NPSHr:	19.1 ft
Shut off Head:	43.7 ft
Vapor Press:	

Suction Specific Speed:	
Min. Hydraulic Flow:	3,829.2 gpm
Min. Thermal Flow:	N/A
Non-Overloading Power:	74.1 hp

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



ITT

[redacted]	60Hz	RPM: 590	Stages: 1

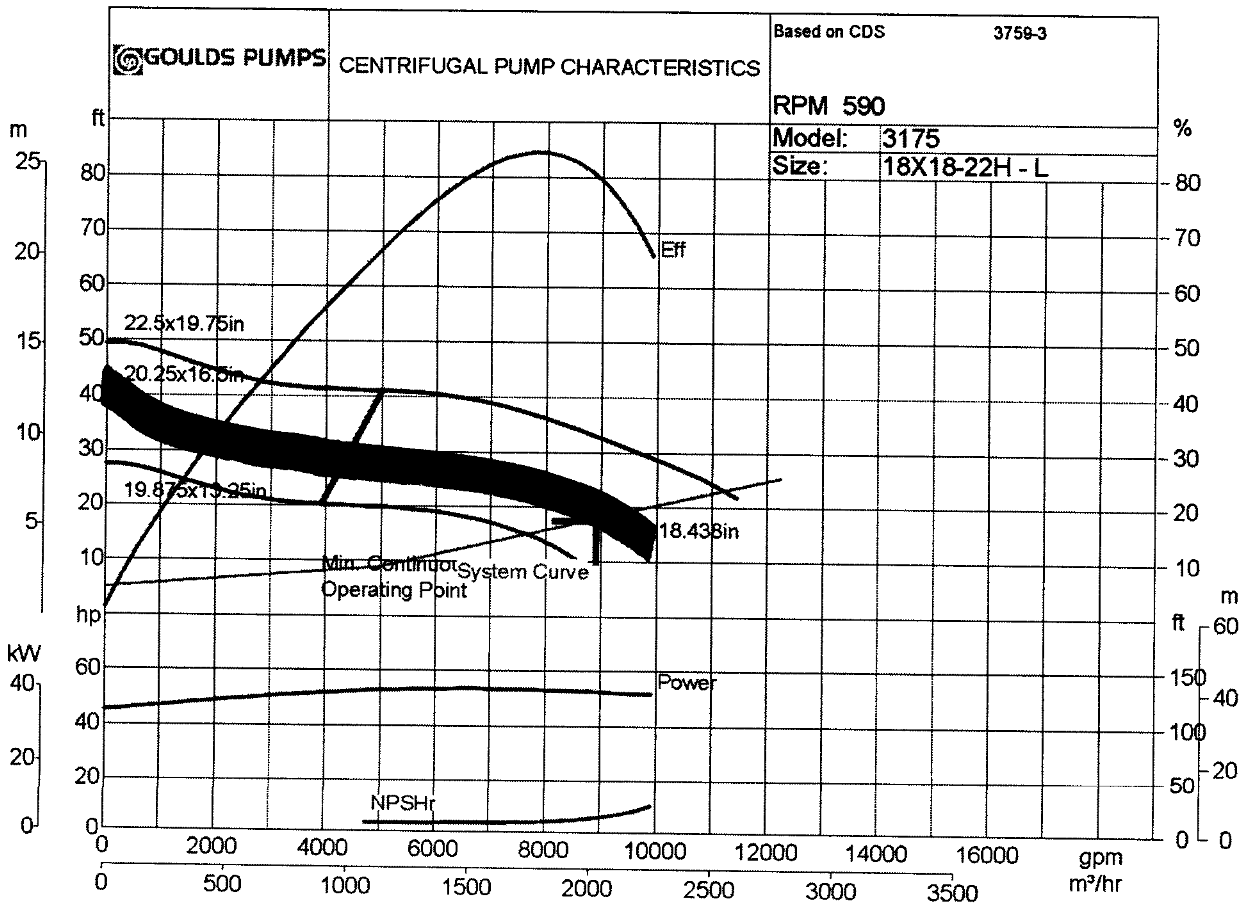
Job/Inq.No. :
Purchaser :
End User :
Item/Equip.No. : ITEM 001
Service :
Order No. :

Issued by : DAN VAN BOXEL
Quotation No. : DV06-07-26 01
Date : 07/30/2006

Operating Conditions		**Pump Performance**			
Liquid:	River Water	Actual Pump Eff.:	78.0 %	Suction Specific Speed:	11,217 gpm(US) ft
Temp.:	68.0 deg F	Actual Pump Power:	52.5 hp	Min. Hydraulic Flow:	4,363.9 gpm
S.G./Visc.:	1.000/1.050 cp	Total Power Loss:	0.00 hp	Min. Thermal Flow:	N/A
Flow:	8,960.0 gpm	Rated Total Power:	52.5 hp		
TDH:	18.0 ft	Imp. Dia. First 1 Stg(s):	20.2500x16.5000 in		
NPSHa:		NPSHr:	14.1 ft	Non-Overloading Power:	53.5 hp
Solid size:		Shut off Head:	39.2 ft		
% Solids:		Vapor Press:			
Max. Solids Size:	2.7500 in				

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.

- Some impeller diameters of this selection will require a taper cut trim. They are indicated in the performance curve below as MAJOR DIAMETER x MINOR DIAMETER.



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[redacted] [redacted] **60Hz** **RPM: 505** **Stages: 1**

Job/Inq.No. :
Purchaser :
End User :
Item/Equip.No. : ITEM 001
Service :
Order No. :

Issued by : DAN VAN BOXEL
Quotation No. : DV06-07-26 01
Date : 07/30/2006

Operating Conditions

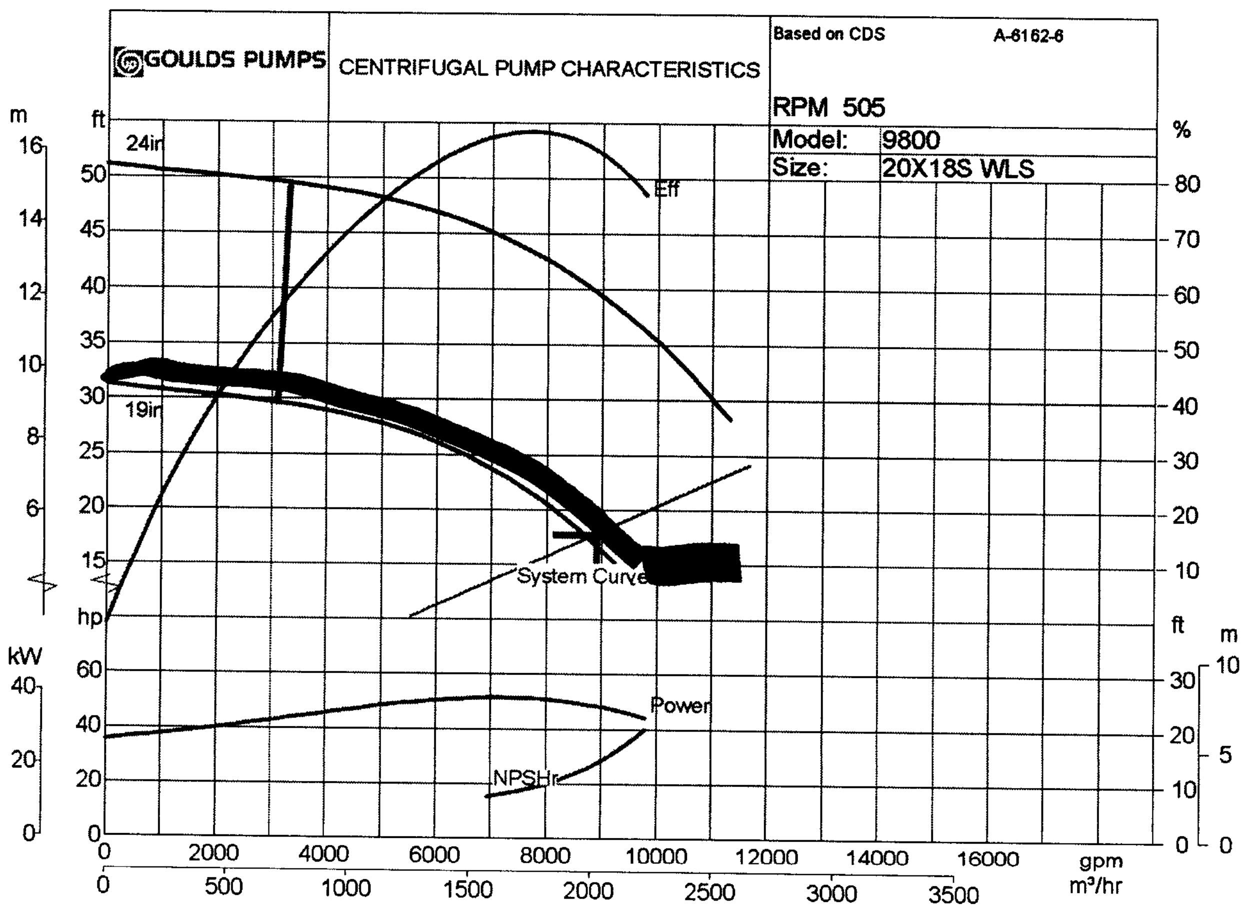
Liquid:	River Water
Temp.:	68.0 deg F
S.G./Visc.:	1.000/1.050 cp
Flow:	8,960.0 gpm
TDH:	18.0 ft
NPSHa:	
Solid size:	
% Solids:	
Max. Solids Size:	1.7500 in

Pump Performance

Actual Pump Eff.:	85.0 %
Actual Pump Power:	47.6 hp
Total Power Loss:	0.00 hp
Rated Total Power:	47.6 hp
Imp. Dia. First 1 Stg(s):	19.3750 in
NPSHr:	14.2 ft
Shut off Head:	32.7 ft
Vapor Press:	

Suction Specific Speed:	
Min. Hydraulic Flow:	3,118.2 gpm
Min. Thermal Flow:	N/A
Non-Overloading Power:	51.1 hp

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



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Appendix B

Lakeside Equipment Corporation Screw Pump Quote and Details

LAKESIDE
Water Purification Since 1928

Lakeside Equipment Corporation
1022 E. Devon Avenue ● Bartlett, IL 60103 ● 630-837-5640 ● FAX: 630-837-5647 ● E-mail: sales @lakeside-equipment.com

July 31, 2006

TO: The University of Akron

ATTENTION: Mr. Dan Van Boxel
Research Assistant

SUBJECT: The University of Akron, Ohio
Ohio EPA Project
Lakeside Open Screw Pumps

Dear Mr. Van Boxel:

In accordance with your request, we are pleased to provide our Open Screw Pump recommendations for the referenced project. Enclosed is the following information:

- Bulletin 217 - Screw Pumps
- D-44855-S - Open Screw Pump Layout Drawing
- PPR-115 - Cape Girardeau, MO Plant Performance Report
- PPR-132 - Highspire, PA Plant Performance Report
- PPR-135 - Pleasant Hills, PA Plant Performance Report
- SPD-114 - The Rebirth of Archimedes' Ancient Pump

INTRODUCTION

Refer to our Bulletin 217 for design information regarding Lakeside's Open Screw Pumps. Lakeside Open Screw Pumps offer the following advantages over conventional pumps:

- **Variable Pumping Capacity** - The open screw pump has built-in variable capacity that automatically adjusts the pumping rate and power consumption to the depth of the liquid in the inlet chamber while operating at a constant speed.

- **High-Efficiency** - Screw pumps provide efficient pumping over a wide range and operate economically down to 30% of maximum design pumping capacity. The high-efficiency pumping results in lower electrical costs over the entire life of the equipment.

- **Non-Clogging** - Open screw pumps require no screening and pass debris as large as the gap between the screw flights or the wall and torque tube.

- **<u>Minimum Maintenance</u>** - Open screw pumps operate at slow speed to reduce friction that causes parts damage and heat generation. Only periodic maintenance is required for oil changes, greasing the upper bearing and adding grease to the lower bearing automatic lubrication system.

- **<u>No Wetwell</u>** - Open screw pumps do not require a wet well, pump house or housing.

Attached are several of our Open Screw Pump installations. These Plant Performance Reports demonstrate the superior performance of screw pumps and the quality of equipment that is furnished by Lakeside.

OPEN SCREW PUMPS

To handle the peak flow of 8,976 gpm, we recommend a 60-inch diameter, 3-flight open pump with a 30-inch diameter by 375-inch thick wall for a lift (H) of 10.0 feet (assumed) while operating at 30 degrees inclination. Each pump would operate at 34 rev/min while delivering 9,146 gpm and would draw 32.4 brake horsepower at the motor. We recommend a 40 hp motor with the speed reducer rated at a minimum of 85,550 in.-lb torque for the maximum pumping condition. The second pump would serve as a "standby" unit.

Budget pricing is as follows:

Unit Price:	- $65,900
Total Price:	- $131,800
Approximate Shipping Weight/Unit:	- 10,550 lb
Estimated Installation Time/Unit:	- 80 hours (excluding grouting)

Budget pricing includes:

- 40 hp premium-efficiency drive motor
- Double-reduction shaft-mounted reducer
- V-belt and sheave drive with hinged belt guard
- 4-1/2-inch upper bearing assembly and drive stub shaft
- 60-inch diameter screw body with three (3) flights and 30-inch diameter by 0.375-inch thick torque tube
- 6-inch lower bearing assembly, lower stub shaft and shield
- Lower bearing grease pump with grease recovery system
- Stainless steel anchorage materials
- Shop prime painting of all other ferrous metals
- Two (2) days of start-up service and operator training in two (2) trips to the project site
- Freight allowed FOB our factory in Chariton, Iowa to the project site

DRAWINGS

Refer to drawing D-44855-S for our suggested layout of the screw pumps that have been selected for this project.

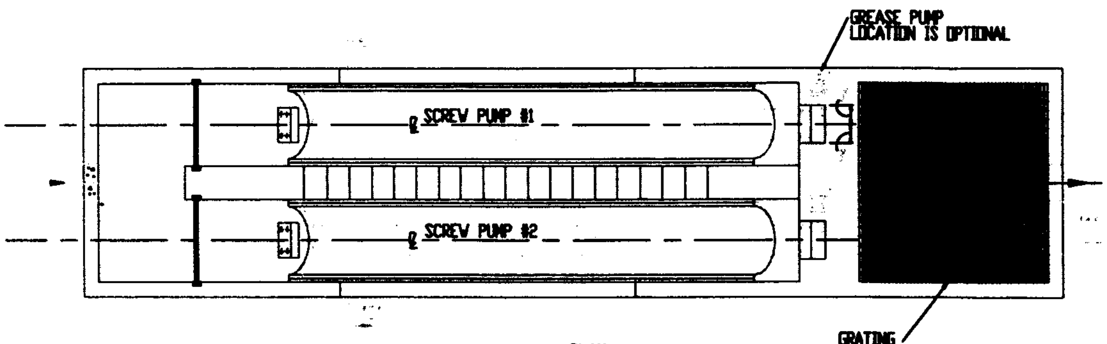
Should you have any questions or desire additional information, please do not hesitate to contact me.

Best personal regards,

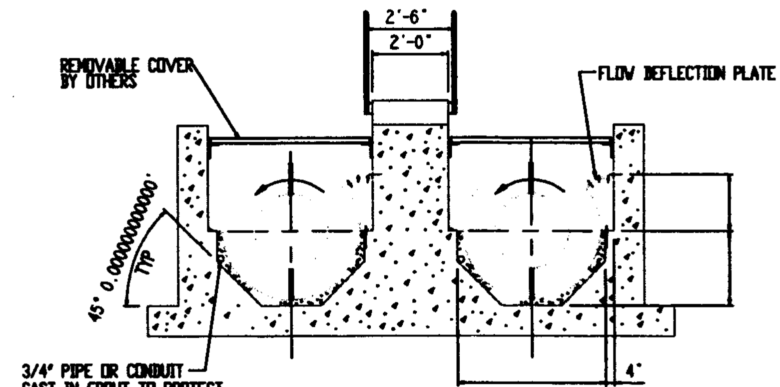
LAKESIDE EQUIPMENT CORPORATION

Steve Eckstein
Regional Sales Manager

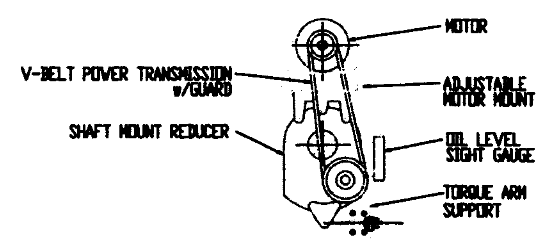
cc: Smith Environmental, Inc.



PLAN



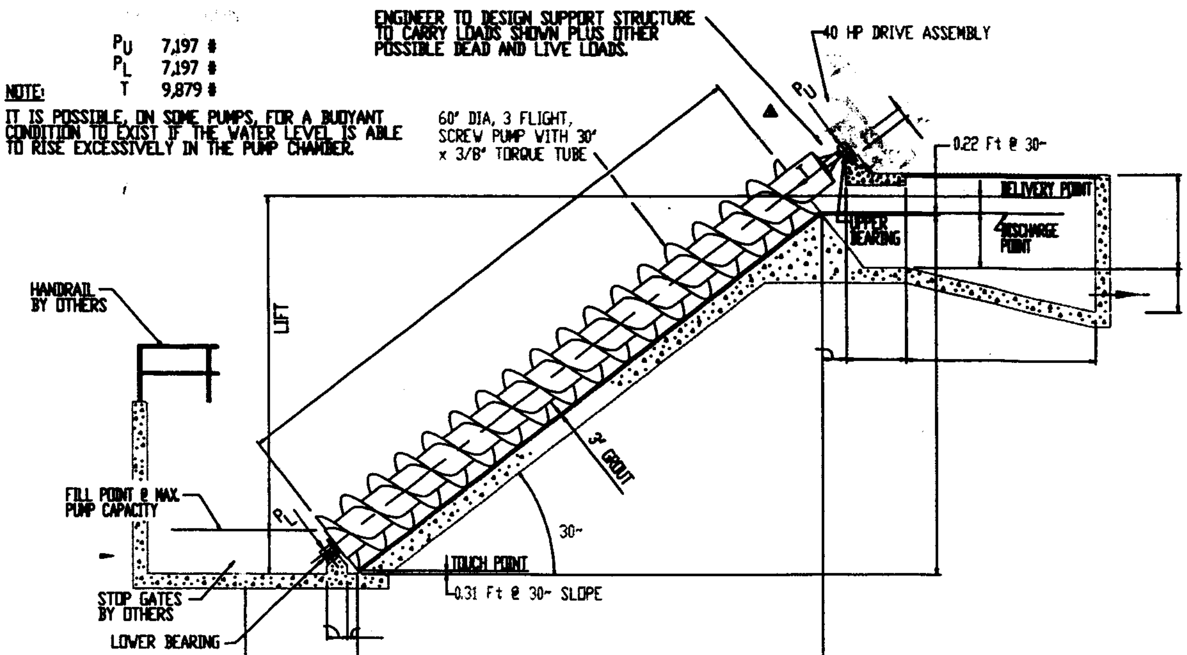
SECTION 'B-B'



VIEW 'C-C'

P_U 7,197 #
P_L 7,197 #
T 9,879 #

NOTE:
IT IS POSSIBLE, ON SOME PUMPS, FOR A BUOYANT CONDITION TO EXIST IF THE WATER LEVEL IS ABLE TO RISE EXCESSIVELY IN THE PUMP CHAMBER.



SECTION 'A-A'

8,976 GPM @ 34 RPM
DAN VAN BOXEL
GS 07-28-06

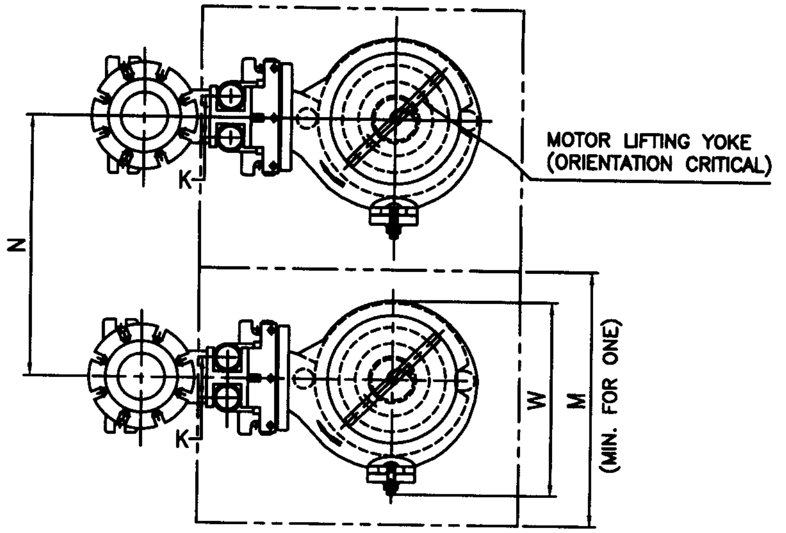
ADDED TABLE/LOADS
RAISED STEPS HGT
LAKESIDE
SNYDER
SHAFT MOUNTED DRIVE
U. of AKRON, OH
D-44855-S B

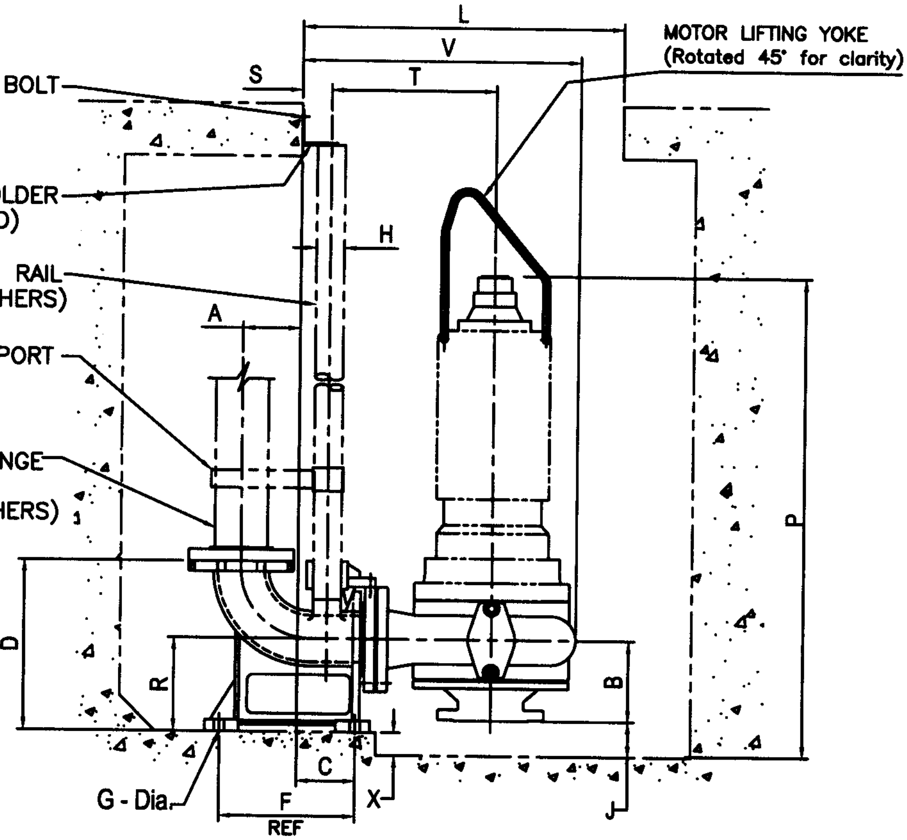
Appendix C

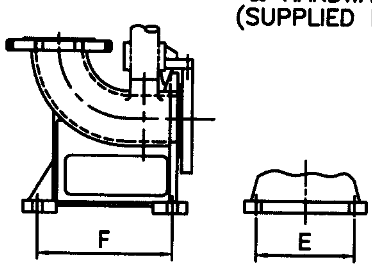
Hayward Gordon Screw Pump Details

NOTE:

1. ALL DIMENSIONS IN INCHES.
2. INTERMEDIATE SUPPORT ASSEMBLY REQUIRED IF GUIDE PIPE LENGTHS EXCEEDS 20 FEET.
3. CASTING DIMENSIONS MAY VARY ± 1/8".
4. MOUNT MOTOR ON CASING IN AN ORIENTATION SUCH THAT THE LIFTING YOKE LINES UP IN A PLANE STRADDLING THE DISCHARGE C/L AND THE CASING INSPECTION PORT C/L.







ANCHOR BOLTS PATTERN
(4-ANCHOR BOLTS, BY OTHERS)

PUMP MODEL	SUCT./ DISCH.	A	B	C	D	E	F	G	SCH 40 PIPE H	J	K	L	M	N	MAX P	R	S	T	V	W	X MIN
XCS4-A/B	4/4	4.88	6.87	5.00	14.63	8.38	11.63	7/8	2	3.63	3.50	26.50	22.00	22.00	44.50	8.00	2.50	14.00	24.00	18.25	2.50
XCS4-C	4/4	4.88	7.75	5.00	14.63	8.38	11.63	7/8	2	4.25	3.50	27.50	22.00	22.00	47.00	8.00	2.50	15.00	25.00	18.25	4.00
XCS4H	8/4	4.88	9.50	5.00	14.63	8.38	11.63	7/8	2	4.50	3.50	34.75	27.00	27.00	56.00	8.00	2.50	18.75	32.00	22.75	6.00
XCS5	6/5	4.88	9.81	4.00	21.56	9.75	10.50	7/8	1-1/2	5.13	9.00	30.25	26.00	26.00	54.50	13.94	2.63	15.63	27.88	22.50	1.00
XCS6	8/6	5.31	13.50	4.19	16.31	10.00	11.00	7/8	2	6.25	12.00	37.00	30.00	30.00	62.50	8.25	2.88	18.69	33.81	26.25	11.50
XCS8	8/8	9.18	10.90	5.57	17.75	8.00	11.00	7/8	2	5.38	4.00	38.75	30.00	30.00	58.00	8.75	3.38	21.38	37.25	26.50	7.50
XCS10	10/10	8.75	13.50	6.69	17.75	18.50	18.50	7/8	3	6.38	4.88	52.75	38.00	38.00	68.50	6.88	5.94	27.75	49.00	32.50	11.00
XCS12	12/12	11.31	18.00	12.5	31.50	20.75	19.69	7/8	3	8.19	4.88	64.00	47.00	47.00	75.00	19.69	5.94	34.50	60.00	40.25	6.50

PUMP MODEL: ____________

RATED FOR ________ GPM AT ________ Ft TDH

______ HP ________ RPM ________ VOLTS

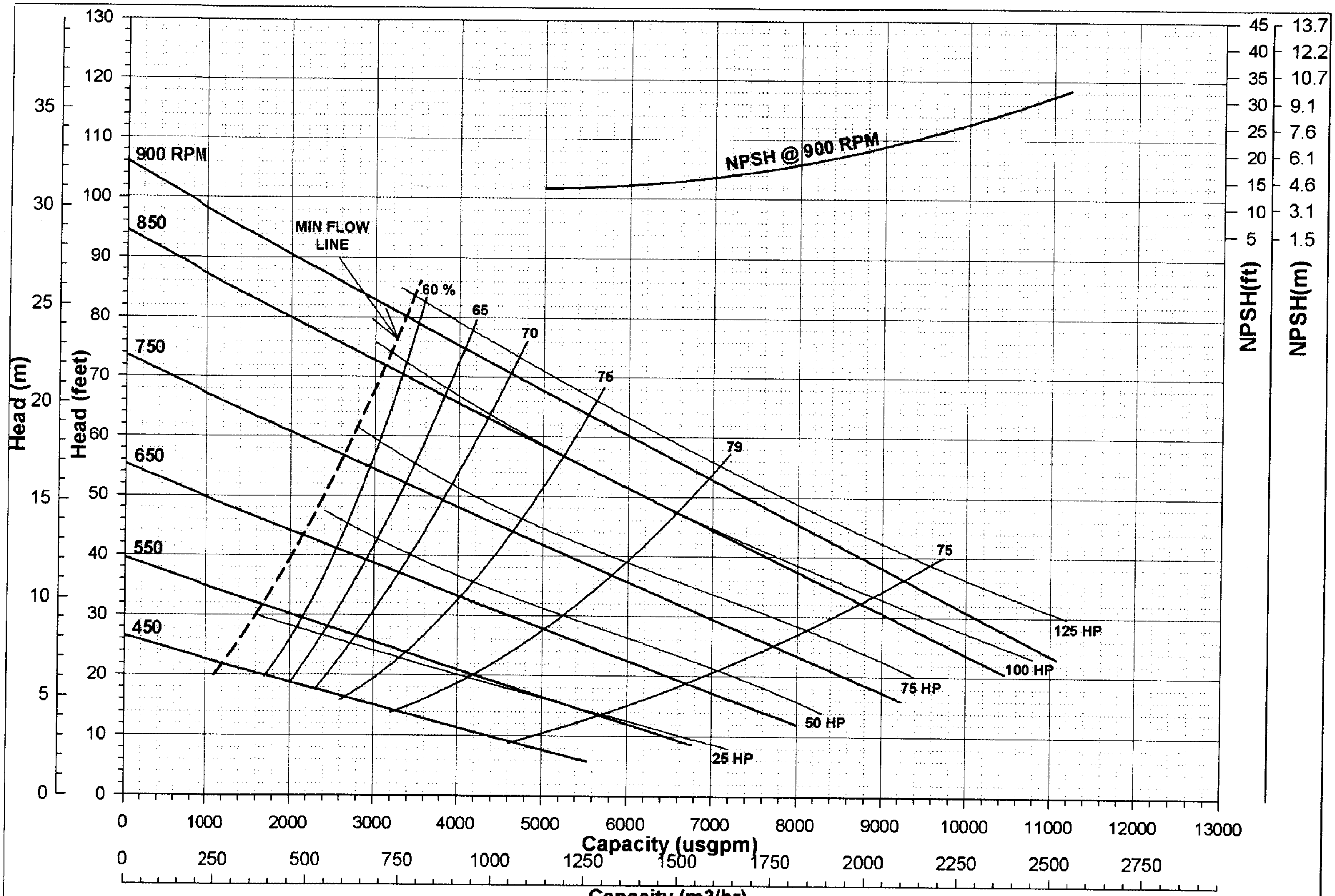
______ PHASE ________ Hz ________ MOTOR FRAME

TOTALLY ENCLOSED NON VENTILATED WITH THERMAL PROTECTION & MOISTURE DETECTION.

NO.	DATE	BY	REVISION
3			
2			
1	SEPT22.05	LF	GENERAL REVISION * ECR 05087

HAYWARD GORDON LTD.
TORONTO MONTREAL CALGARY VANCOUVER

SCALE	CUST. P.O. NO.	
NTS		GENERAL ARRANG'T
DATE: JUL 29,04	H.G. JOB NO.: STD	XCS SERIES SUBMERSIBLE /
DRN.: LF	DWG. NO.: 02330673	IMMERSIBLE PUMPS.



HAYWARD GORDON LTD. Performance Curves Screw Centrifugal Pumps	MODEL	XCS16C	SIZE	16 x 16 x 21	CURVE	005 - 10664	REVISION	4
	DRN. DATE / REV. DATE	SEPT 05,02 / DEC 31,03	DRN. / REV.	KW / LF	MAX SPHERE	7.4 "	SPEED	VARIABLE
					IMPELLER DIAMETER	21.5"		

HAYWARD GORDON
Solids Handling Pumps
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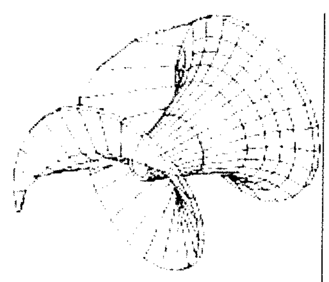
XCS Screw Centrifugal Pumps

GENERAL OVERVIEW

Introduction

The Hayward Gordon XCS Screw Centrifugal Pump line is a unique design that combines the advantages of a screw pump and a centrifugal pump. The result, is a pump that can efficiently handle thick sludges, large or stringy solids, shear sensitive fluids and delicate materials.



Hydraulic Design Characteristics

The XCS impeller, is a single vane construction, with two hydraulic sections. The front section acts like a positive displacement screw, gently drawing fluid into the pump. The single vane slowly accelerates the fluid through the screw section into the centrifugal pump section, where the pressure head is developed. The long, single channel impeller produces high flow at relatively low total dynamic heads.

Services such as Return Activated Sludge (RAS), Waste Activated Sludge (WAS), and Digested Sludge Recirculation or Mixing often involve short pipe runs and relatively little static head, resulting in low overall total dynamic head (TDH). Required flows, however, can be high especially when large tanks are being recirculated or mixed. This high flow/low head hydraulic requirement is difficult to obtain with conventional centrifugal "non-clog" pumps but matches the performance characteristics of the screw centrifugal impeller very closely.

Gentle Pumping Action

Solids passing through the pump follow a parabolic path through the pump; changing trajectory gradually. Shear and turbulence is minimal, making the pump ideal for handling soft, shear sensitive or delicate materials such as flocculants, emulsions, and food products.

Low NPSH requirements

The inducer action of the screw section, allows the XCS pump to operate without cavitation on low NPSH available applications and on non-Newtonian fluids, where the shear thinning reduces the viscosity passing into the centrifugal section.

High Efficiency

The close clearance, low turbulence design, produces exceptional efficiencies for a solids handling pump – up to 80%.

Unlike a standard non-clog or process centrifugal pump, the XCS design maintains these high efficiencies at elevated apparent viscosities. In fact, performance can improve as the thicker fluid closes up the slip clearances in the screw section of the pump.

Steep Performance Curve

A steep head/capacity curve allows accurate control of a system, even under fluctuating head conditions. It also means, that extra pressure can be developed in the discharge to push through potential clogs due to rags or keep thick fluids moving during a process upset.

Non-overloading operation

The HP curve is relatively flat and often parallel to the pump performance curve. This means that power requirements are relatively constant across the range of a head/capacity curve so that the horsepower requirement will not increase significantly as the capacity increases and the pump motor will not overload.

Solids Handling

The single screw centrifugal vane allows passage of large spherical solids or long stringy material without clogging. For example a 4" pump will pass a 3" solid, a 10" pump would pass a 5" solid.

Abrasion Resistance

While designed primarily for soft and medium abrasive solids, the XCS pump has many features found on an abrasive slurry design. The very nature of the flow through the pump, tends to force the solids into the higher velocity zone at the center of the vane passage. The resulting wear would be seen on the impeller vane walls and on the suction cone internal surface. Actual impeller diameter typically does not change, until suction cone wear increases the running clearance and slip takes place.

Where wear is anticipated, steps can be taken to increase component life. Impellers, suction cones and volute casings can be produced in hard metals such as Ni-Hard or Hi-Chrome iron.

Impeller clearances are externally adjustable to maintain optimum performance and maximize component life.

Operating Range

At operating conditions close to best efficiency radial forces on the impeller are at a minimum. However, as the pump operates closer to shut-off, the forces increase, putting extra loading on the shaft and bearings. Also, the NPSH requirements dramatically increase close to shut-off, leading to potential cavitation and vibration of the pump. A minimum design flow of between 25 to 30% of best efficiency is recommended for continuous service.

Operation above the best efficiency flow rate can also create problems if insufficient NPSH is available. As in the low flow condition, excessive vibration due to cavitation can occur. Operation above 150% of best efficiency is not recommended.

Pump Construction

Volute Casing

Volutes are a centerline top discharge, self venting design as standard. XCS pumps are constructed similar to a slurry pump. All components are clamped together with through bolts, removing the necessity to drill and tap each component. This gives complete flexibility to produce volute sections in both machineable and non-machineable wear resistant metals.

In the unlikely event that clogging occurs, a clean-out port is provided on the side of the volute to provide access to the interior.

The XCS pump is a true back pull out design. Integrally cast feet support the volute, allowing the rotating element to be removed for service on bearings or mechanical seals, without disturbing the suction or discharge piping.

Impellers

Impellers consist of a single vane wrapped around a conical hub, to produce a spiral screw shape, with constant channel size.

Cast to the back shroud of the impeller is a series of pump out vanes or spiral grooves, designed to lower the pressure in the stuffing box area and eject any solids that may enter area between the rear of the impeller and the backplate.

The impeller is securely mounted to the shaft with a cap screw and lock washer. Torque is transmitted via a fitted impeller key.

Suction cones

XCS screw centrifugal suction cones can be produced as a one or two piece design.

The one piece construction, is a solid cast item, clamped to the volute section and fitted with a set of shims. When the clearance between impeller and internal cone surface increases due to wear, an adjustment can be made by removing shims.

To facilitate a simpler adjustment of these clearances, the two piece design offers a separate, replaceable and externally adjustable suction cone liner. The liner is held in place by a series of external bolts which allow the liner to be moved, with the pump in place; to reset the worn clearance. This is of particular advantage on larger, heavier pumps.

To assist in the transport of solids and rags through the cone section, a spiral groove is cast into the internal face of the suction cone or liner. This groove creates a cutting action and prevents any jamming that could occur if solids were caught between the impeller and suction cone.

Materials of Construction

The clamp type design allows a wide variety of material options to cover corrosion and abrasion resistant service.

The most common combination, used for municipal sludge applications, would see a combination of Hi-Chrome impeller and suction cone or liner, with a cast iron volute. The high chrome is hardened to 450 Brinell. When solids abrasion is a greater problem, the volute section can also be provided in 450 Brinell Hi-Chrome or for even longer life, 650 Brinell Ni-Hard 1 (this is the material used on our Torus vortex pump for grit service).

XCS pumps can also be provided in all machineable metals. i.e. cast iron, 316SS, CD4 MCu and other common metals and alloys.

Bearing Frame

High radial loading requires a greater load carrying capability for the bearings. Our combination of angular contact and roller bearings provides an L_{10} life of 100,000 hours.

Bearings can be provided with either grease or oil splash lubrication. A constant level oiler is provided on oil lube pumps. For special applications bearing housings can be fitted with heating or cooling coils.

On direct drive models, a removable slotted back foot is provided. This unique feature provides a locating point for pump alignment. Rotating elements can be removed for service and re-installed with only minor re-alignment necessary. V-belt driven pumps have a fixed back foot, required to accommodate the higher radial loading resulting from belt pull.

Shaft Seals

XCS stuffing boxes are designed to accept all common mechanical seals (single or double) or packing. Where required, special glands can be provided to allow flushing or quenching.

Shaft sleeves are available in various metallurgies as required by the application.

Configurations

The Hayward Gordon XCS pump is currently available in three standard configurations: horizontal direct or V-belt driven, submersible/immersible and vertical dry pit.

Summary

The XCS pump draws it's mechanical design from the best features available from both slurry pump and chemical pump technology. A review of the mechanical and hydraulic design features of the XCS pump, quickly establishes this design as the best choice for many solids and sludge handling applications.

For solids handling, the XCS is preferable to a non-clog design. Efficiencies are similar if not better and the XCS provides superior resistance to clogging and wear.

The Torus XR vortex pump would be recommended over the screw centrifugal where larger and more abrasive solids are to be handled. Otherwise the higher efficiency, XCS would be the pump of choice.