Engineering Laboratory Design, Inc.

PO Box 278, 2021 South Highway 61, Lake City, Minnesota 55041 USA
Voice: 651-345-4515 • 800-795-8536 • FAX: 651-345-5095
www.eldinc.com • eldinfo@eldinc.com

16’-0” SEDIMENT DEMONSTRATION CHANNEL

Minnesota State University - Mankato
Mankato, Minnesota

Serial No.: 31400
Purchase Order No.: 18976
Delivered: October 2000

16’-0” SEDIMENT DEMONSTRATION CHANNEL

OPERATION AND
MAINTENANCE INSTRUCTIONS

1. SITE SELECTION AND ELECTRIC SERVICE

The channel should be located so that convenient access is available to both sides of the working sections and each pump motor. Proximity to electric service and water source/drain should be considered.

This unit should be provided with a separate branch electric circuit. The motor amperage draw is denoted on the pump motor serial number label. The full load amperage of the system is denoted on the demonstration channel serial number label. Please note that all of the electrical components are powered from the main electrical location, therefore the current draw for the facility is greater than that for each pump. The National Electrical Code, Paragraph 430-22 specifies a branch circuit capacity of 140% of the motor nameplate "full load amperage" for a motor operating in this service.

2.0 DESCRIPTION

2.1 GENERAL

The Sediment Demonstration Channel is a self contained, recirculating channel, designed for use as a student laboratory flume and for smaller scale sediment transportation studies. All flow variables are controlled by the operator.

System components include: 16'-0" long working section fabricated of two (2), equal length plexiglass modules, a headtank with an adjustable undershot gate, an adjustable tailgate, a fiberglass reservoir, two circulating pumps, a sediment trap with removable cover, supply piping, supporting framework, and a flow metering system.

Overall dimensions of the unit are: length, 20'-6.25" (6.25m); height at 0% slope, 7'-1" (2.16m); height at 10% slope, 8'-8.75" (2.66m); width, 9'-10" (3.21m). The weight of the system, empty, is approximately 1,850lbs (840kg). The tunnel has a capacity of approximately 400 gallons (1,480 Liters) of water.

2.2 CONSTRUCTION

2.2.1 Channel Modules:

Two (2), 8'-0" (2.44m) long modules are assembled to form the working channel. The sidewalls and working floor of the modules are fabricated from 0.50" (12.70mm) thick acrylic sheet. The working cross section is 18.0" (45.72cm) high by 12.0" (30.48cm) wide. A double bottom box beam floor design is used. All plexiglass joints are mechanically fastened with stainless steel screws and solvent welded. An anodized aluminum bar is fitted at the top edge of the channel sidewall to serve as a stiffener.

2.2.2 Headworks:

A closed duct, fabricated of 0.50" (12.70mm) thick acrylic is furnished to convey the flow to the upstream end of the channel. The unit is flanged to the 4.0" (10.16cm) supply piping and includes a wide angle diffuser, an elbow assembly with turning vane cascades, and a precision, round cell, polycarbonate plastic, honeycomb.

2.2.3 Headtank:

A headtank, fabricated from 0.50" (12.70mm) thick acrylic, is positioned at the upstream end of the upstream channel section. The headtank has internal dimensions of 12.0" (30.48cm) width; 10.3" (26.16cm) length; and 24.0" (61.0cm) height). An undershot gate (headgate) is provided. The headgate is positioned by a 1/15HP, 12.8 RPM gearmotor *(Dayton Model2Z799D)*. All plexiglass joints are mechanically fastened with stainless steel screws and solvent welded.

2.2.4 Tailgate:

An anodized aluminum plate serves as a tailgate at the reservoir entrance. The tailgate serves to regulate the flow depth. The tailgate is positioned by a 1/15HP, 12.8 RPM gearmotor (*Dayton Model2Z799D)*.

2.2.5 Reservoir:

A 358 gallon (1,325L) capacity reservoir will be furnished at the downstream end of the channel. A sloped floor prevents build-up of sediment suspended in the supply line.

The reservoir is be fabricated of a composite lamination of fiberglass reinforced plastic and a rigid, PVC, foam core material. The incorporation of the foam core material produces a strong, relatively light weight, structure that easily withstands the static and dynamic loads imposed upon it. The foam is also an excellent thermal insulator and significantly reduces condensation on the exterior of the ducts during periods of high relative humidity. Interior surfaces are glass smooth, blue, vinyl ester gel-coat. Exterior surfaces are spray finished with a blue, polyester gel-coat enamel. PVC suction pipes are fitted for the pumps. The reservoir incorporates a drain valve.

2.2.6 Piping:

Commercial PVC pipe is used throughout. Mating flanges are fabricated of PVC.

2.2.7 Flow Metering:

Two venturi meters (high and low flow ranges) are installed in the piping system. Calibration data is provided in the operation portion of this manual.

2.2.8 Supporting Frames:

The plexiglass channel assembly is supported by a welded steel beam structure. The structure is secured mechanically to the reservoir support frame. The reservoir is supported by a frame which pivots on a series of pillow blocks. An ACME screw elevating mechanism, driven by a 0.5HP, 30 RPM gearmotor (*USMotors Model E438*), adjusts the slope of the channel bed. The channel is designed to be adjustable from +10% to -2% slope.

All supporting structures are etched, prime coated and spray finished with a water based, acrylic enamel.

2.3 PUMPS

Two commercially available, enclosed impeller, all bronze construction, centrifugal pumps are used *(Scot Pump Model No. 55B 3x3, 5 3/4)*. Each pump is designed to deliver approximately 170 GPM against 25'-0" total head.

2.4 MOTOR AND CONTROLLER

The pumps are direct driven by 1.5 HP, ODP, 1800RPM, 460 VAC/3ϕ/60Hz motors *(Baldor Model No. JMM315T)*.

A 2.0 HP transistor inverter type, variable speed motor control *(Toshiba Model No. VFS9-4015PL-WN)* regulates the pump shaft RPM of Pump No. 1. The controller is arranged for 460VAC/3ϕ/60Hz/4Amp electric service. A remote control station, located on the control console regulates pump operating RPM. The variable frequency inverter is protected by three (3) type FNQ 4Amp fuses.

Pump No. 2 operates with a non-reversing motor starter *(Telemecanique Model LC1D0910G6)* and is protected by a 4.0Amp Overload Relay *(Telemecanique Model LR2D1308)*. The pump motor always operates at the designated nameplate RPM. A lighted pushbutton start and stop is provided on the control console.

A NEMA rated fusible disconnect is furnished to protect all of the channel components. The disconnect is mounted in a NEMA Type 12 enclosure.

A 20'-0" length of SO cord is provided from the main electrical enclosure. The buyer is responsible for the connecting the SO cord to the building electric service.

2.5 FLOW RATES

Flow rate in the channel section is continuously variably from more than 340GPM (21.4 l/s) down to approximately 2.0GPM (0.13 l/s) at 0% slope. Note: Refer to the test data results sheet at the end of this manual for flow rates achieved.

3.0 OPERATING INSTRUCTIONS

3.1 GENERAL

Before attempting to operate the sediment channel, insure that tools and other loose objects have been removed from the test section and that the electrical branch circuit serving the channel is energized. It is recommended that new users be familiarized with the equipment prior to first operation.

3.2 FILLING/DRAINING PROCEDURE

Fill the channel reservoir and piping to an appropriate level to ensure sufficient volume of water for the specific test. Note that at elevations beyond +5% the water level may be below the venturi pressure taps and air may become entrained in the manometer metering lines.

3.2.1 TOOLS/MATERIAL REQUIRED

Channel Lock Pliers
Rags
Garden Hose

3.2.2 FILLING PROCEDURE

The channel can be filled through any of the two (2) drain fittings provided on the channel or through the open surface of the reservoir or channel sections.

1. To fill through the drain fitting provided at the bottom of the reservoir simply connect a garden hose to the fitting. Open the ball valve and open the water supply.

2. To fill through the drain fitting provided at the bottom of the 2" PVC piping simply connect a garden hose to the fitting. Open the ball valve and open the water supply.

3. Filling through the open surface of the channel section simply consists of securing the supply hose inside of the channel and starting the water source.

4. Fill the channel such that the water level in the reservoir is just below the floor of the channel.

3.2.3 DRAINING PROCEDURE:

Draining the channel consists of using the two (2) drain valves provided.

1. To drain the water through the 2" PVC line,

   a. Connect a garden hose to the drain fitting,

   b. Close the 4" and 2" PVC valves at the upstream end of the channel and the pump No.2 isolation valve

   c. Open the pump No.1 isolation valve and start pump#1 at a medium rate of flow.

   d. STOP pump No.1 prior to completely emptying the reservoir.

   e. Open all valves to drain piping.

2. To drain the water remaining in the reservoir, connect a garden hose to the drain fitting at the bottom of the reservoir.

3. To insure that all of the water has been drained from the system the slope of the channel can be increased, causing the water in the system to drain into the channel.

3.3 SPEED CONTROL

The channel flowrate is controlled by varying the RPM of the one pump and adding the second pump at the full output. The inverter will respond to control signals from either the remote keypad, mounted onto the control console, or an external 0-10 VDC or 4-20mA signal provided to the inverter control board.

Each pump has an isolation valve mounted immediately downstream of the pump outlet. Keep each pump's valve closed unless it is operating. This keeps water from flowing back through the pump into the reservoir. The valves are physically retarded from fully opening to keep a minimum amount of head on the pumps. Do not change the pump opening settings, damage to the motors may occur.

3.3.1 OPERATION OF PUMP No. 1 FROM INVERTER KEYPAD

1. Apply power to the inverter.

2. Enter the desired operating frequency by using the up and down arrows to scroll to a specific frequency.

3. Press the **ENT** button once the desired frequency is achieved. The display will flash between the frequency setting and "FC" indicating that the setting has been made.

4. Press the **RUN** button. The acceleration or deceleration to the new set speed designated by "FC" will be shown on the inverter's output. During operation , the **RUN** lamp will be lit.

5. Repeat steps 3-5 to change the frequency setting during operation.

6. To stop the drive, either enter an operating frequency of 0.0, or press the **STOP** button.

3.3.2 OPERATION OF PUMP No. 1 USING AN EXTERNAL VOLTAGE SIGNAL

NOTE: The inverter can be set to run from either an external input of 0-10 VDC or 4-20 mA. Refer to pages 10 and 20 of the Toshiba manual for a description of the different settings required to operate using these control signals.

1. Insure that the following connections are made to the inverter control board:

   0-10 VDC Input
   Jumper between **F** and **CC**
   (+) external signal to **VIA**
   (-) external signal to **CC** (Please note that the two **CC**'s referred to are **not** the same. Connections are made to the **CC** on the left side of the terminal board.)

   4-20mA Input
   Jumper between **F** and **CC**
   (+) external signal to **II**
   (-) external signal to **CC** (Please note that the two **CC**'s referred to are **not** the same. Connections are made to the **CC** on the left side of the terminal board.)

2. Apply power to the inverter.

3. Change the frequency setting mode parameter (F∩od):

   Press MON

   Press ▲ ▼ until **Basic Parameter Group** is reached.
   Press ENT

   Press ▲ ▼ until **Frequency Selection Mode (F∩od)** is reached.
   Press ENT
   Set the parameter value to **0** to accept inputs via the terminal block. (A parameter value of 1 indicates that control input is accepted through the up/down arrows.)
   Press ENT
   Press MON twice to return to the frequency display.

4 Apply an external voltage/amperage signal within the chosen operating range. The inverter will proceed to run at a level which corresponds to the input control signal level.

5 The system can be stopped by discontinuing the input signal.

For a complete description of the inverter operating and programming characteristics, please refer to the TOSHIBA Industrial Inverter VF-S7 Series Instruction Manual and the TOSHIBA S7-OIS Quick Start Manual.

3.3.3 OPERATION OF PUMP No. 2

Pump No. 2 is provided with an START/STOP pushbutton for operation of the motor starter. This is used to enhance the low speed performance of the channel by operating with only one pump. If the desired testing is below approximately 200 GPM (12.6 l/s) disengage Pump No. 2. Pump No. 2 can be engaged at any point during the operation of the system.

3.4 SLOPE ADJUSTMENT

The operating slope of the channel is designed to be adjustable between +10% and -2%. The slope is adjusted by the gearmotor attached to the ACME screws of the jacking station. The jacking station is located at the upstream end of the channel.

3.4.1 ADJUSTMENT

The 3 position, momentary, rotary switch labeled **SLOPE** on the control console is used to control the gearmotor. The slope of the channel can be determined using the spirit level attached to the beam assembly to the left of the control console. Inclination of the channel bed can be determined by adjusting the indicator until the bubble depicts that the needle is level. The corresponding percent slope can be read from the scale. Alternatively, a desired channel slope can be obtained by adjusting the needle to the desired percent slope, and operating the slope mechanism until the bubble depicts that the needle is level.

3.4.2 LIMITS

The slope mechanism is protected from dangerous over-travel by limit switches mounted underneath the reservoir frame. These limits have been pre-set at the factory. Changing these settings is strongly discouraged, as damage may result to the system.

3.5 HEAD ADJUSTMENT

The amount of head against the channel flow can be adjusted by controlling the position of the undershot type headgate located at the upstream end of the channel.

3.5.1 ADJUSTMENT

The momentary toggle switch labeled **HEADGATE** on the control console controls the direction which the headgate moves. To increase the head applied to the channel flow lower the headgate until the channel flow is restricted.

CAUTION: When the headgate is lowered into the flow, the water volume backs up into the headtank. At high flow rates the headtank will fill quickly which could cause it to overflow. When lowering the headgate, constantly monitor the water level in the headgate and be prepared to decrease the volume flow rate of the channel.

3.5.2 LIMITS

The headgate is protected from dangerous over-travel by limit switches mounted in the electrical box near the gear motor. These limits have been pre-set at the factory. Changing these settings is strongly discouraged, as damage may result to the system.

3.6 FLOW DEPTH ADJUSTMENT

The operating depth of the channel is controlled by adjusting the position of the tailgate mounted at the reservoir entrance.

3.6.1 ADJUSTMENT

The momentary toggle switch labeled **TAILGATE** on the control console controls the direction which the tailgate moves. To increase the operating depth of the flow in the channel, raise the tailgate to obstruct the flow.

3.6.2 LIMITS

The tailgate is protected from dangerous over-travel by limit switches mounted in the electrical box near the gear motor. These limits have been pre-set at the factory. Changing these settings is strongly discouraged, as damage may result to the system.

3.7 FLOW METERING

Monitoring the volumetric flowrate which the pumps are outputting is accomplished using the two venturi meters, the 4" and 2" ball valves located near the upstream end of the channel, the two (2) 3" ball valves located near the pump outlets, and the manometers mounted mid way along the channel side.

3.7.1 2" VENTURI

The 2" venturi is intended for very low flow rates below 40GPM (2.5 l/s). In this situation only PUMP NO. 1 should be used. The 3" ball valve at the exit of PUMP NO. 2 should be closed to prevent flow from circulating back through the pump. The ball valve in the 4" line should also be closed. The differential head measurement are made on the 4'-0" air/water manometer (closest to the channel)[1].

The following is the flow equation for this venturi:

$$Q = K \cdot \frac{\pi d^2}{4} \cdot \sqrt{2g\Delta h}$$

where:

	Q:	volume flow rate (ft^3/s)
	K:	flow coefficient calculated from the included chart ≈ 1.032
	D:	entrance diameter of the venturi, 2.045" (0.17041667ft)
	d:	throat diameter of the venturi, 1.052" (0.08766667ft)
	g:	gravitational acceleration, $32.16 ft/s^2$
	Δh:	measurement from a differential manometer (ft)

substituting results in the equation becoming:

$$Q = 0.04998 \cdot \sqrt{\Delta h}$$

3.7.1 4" VENTURI

The 4" venturi is intended for the majority of flow measurements performed with the system. When measuring at rates between 40GPM (2.5 l/s) and 200GPM 12.6 l/s) the venturi is used in combination with the middle 4'-0" air/water manometer. Above 200GPM (12.6 l/s) the 2'-0" water/mercury manometer should be used[1]. Below 200 GPM (12.6 l/s) only PUMP NO. 1 needs to be used and the 3" ball valve at the exit of PUMP NO. 2 should be closed to prevent flow from circulating back through the pump. Above 200GPM (21.6 l/s), open the valve at the exit of PUMP NO. 2 and engage PUMP NO. 2. The ball valve in the 2" line should be closed.

The following is the flow equation for this venturi:

$$Q = K \cdot \frac{\pi d^2}{4} \cdot \sqrt{2g\Delta h}$$

[1] To ensure accurate measurements all manometer lines must be properly bled.

where:

- Q: volume flow rate (ft^3/s)
- K: flow coefficient calculated from the included chart ≈ 1.0665
- D: entrance diameter of the venturi, 3.998" (0.333167ft)
- d: throat diameter of the venturi, 2.400" (0.2000ft)
- g: gravitational acceleration, $32.16 ft/s^2$
- Δh: measurement from a differential manometer (ft)

substituting results in the equation becoming:

$$Q = 0.2688.\sqrt{\Delta h} \text{ (air/water manometer)}$$

$$Q = 0.2755.\sqrt{\Delta h} \text{ (water/mercury manometer)}$$

3.8 CHANNEL SECTION

3.8.1 GENERAL

The channel sections interior may be accessed through the upper open surface.

The plexiglas floor has eighty-one (81) brass threaded inserts (internal thread #10-24UNC-2B) installed at 6" spacing for the mounting of test models. The plexiglas walls of the channel sections may be drilled and tapped to facilitate mounting of models, instruments and test fixtures as required.

3.8.2 MODEL/TEST FIXTURE CHANGES

Included at the end of this manual are the individual procedures for the installation, operation and testing of the supplied models. Additional standard models can be obtained from ELD Inc. at an additional cost.

4.0 CAUTIONS

1. Insure that all persons using this equipment have been familiarized with its operation.

2. Confirm that all drain valves are closed before operating the system.

3. Verify that models and test fixtures are securely fastened in the channel sections before starting the pumps.

4. Monitor the water level in the headtank when lowering the headgate to prevent overflows.

5. **DO NOT** change any of the limit settings for the slope motor, headgate or tailgate. This could result in damage to the system.

6. **Do not** operate the system with any of the safety guards removed.

5.0 MAINTENANCE

5.1 GENERAL

Users and maintenance personnel are urged to read the manufacturer's instructions which are applicable to the system components. Adherence to the pump lubrication schedules is particularly important. Consult the frequency control manufacturer's documentation for troubleshooting advice on the speed control device.

5.2 PUMP AND MOTOR ASSEMBLIES

The motors are furnished with double sealed or shielded ball bearings, pre-lubricated prior to installation. Grease fittings are not supplied and bearings are designed for an average of 100,000 hours (7 years) of operation under standard conditions (8 hours of operation per day, normal loading, relatively dust free). Consult with a Baldor, Inc. representative for motor maintenance.

For detailed instructions related to pump and motor maintenance and service see respective manufacturer's documentation.

5.2 HEADGATE AND TAILGATE MOTOR ASSEMBLIES

The gearmotors are furnished pre-lubricated prior to installation. Grease fittings are not supplied and bearings are designed for an average of 100,000 hours (7 years) of operation under standard conditions (8 hours of operation per day, normal loading, relatively dust free). Consult with a Dayton, Inc. representative for motor maintenance.

Should the gears require lubrication, use 4 oz. of SynTech Grease #NS-3091-G.

For detailed instructions related to pump and motor maintenance and service see respective manufacturer's documentation.

5.3 SLOPE MOTOR ASSEMBLIES

5.3.1 LUBRICATION

The slope gearmotor is furnished pre-lubricated prior to installation. Grease fittings are not supplied and bearings are designed for an average of 100,000 hours (7 years) of operation under standard conditions (8 hours of operation per day, normal loading, relatively dust free). Consult with a Dayton, Inc. representative for motor maintenance.

Check the gearcase oil level periodically, keep the oil level at the centerline of the horizontal plug.. If it requires replacement, use ¾ qt. of worm gear oil with AGMA oil number 8EP.

For detailed instructions related to motor and gearcase maintenance and service see respective manufacturer's documentation.

Lubricate the ACME screws every six (6) months.

5.3.1.1 TOOLS/MATERIAL REQUIRED

Grease gun
Rags
Canister #2 grease

5.3.1.2 PROCEDURE

1. Raise the channel to +10% slope.
2. Apply #2 grease to the ACME screw threads just below the brass nut (inside the support frame).
3. Lower the channel to introduce the grease.

5.3.2 CHAIN TENSION

The slope mechanism chain drive will stretch over time. Adjust the tension of the chain drive every six (6) months or when a noticeable slack response in the system occurs.

5.3.2.1 TOOLS/MATERIAL REQUIRED

Phillips #2 Screwdriver — 9/16" Open End Wrench (2)

5.3.2.2 CHAIN TENSION PROCEDURE

1. Remove the chain drive guard by removing the four (4) #10 Round Head Machine Screws (RHMS), located at the ends of the guard. Slide the guard off.
2. Loosen the four (4) 3/8-16UNC-2A Hex Head Machine Screws (HHMS), located at the gearmotor mount plate.
3. Pull the gearmotor to increase the tension on the chain drive. The correct amount of tension is when the chain can be moved back and forth about 3/8".
4. Tighten the four (4) 3/8" HHMS and recheck the chain tension.
5. Attach the chain guard.

5.4 FIBERGLASS/SUPPORTING FRAMEWORK

5.4.1 GENERAL

Dirt and grease marks may be removed from the laminate and painted surfaces using a detergent/water solution applied with a soft cloth and a sponge. Abrasive cleaners should not be used.

5.4.2 FIBERGLASS SCRATCH REPAIR

5.4.2.1 Tools/Material Required

Touch-up Kit (Provided) — Rags

5.4.2.2 Procedure

1. Fill a Dixie cup roughly 1/3 full of gelcoat.
2. Mix 3-4 drops of hardener into the cup.
3. Brush the gelcoat onto any scratched areas.

4. Let the gelcoat patch harden.

5.5 FLOW CONDITIONING COMPONENTS

The honeycomb, which comprises the flow conditioning component, should be cleaned periodically. The frequency of this servicing will depend upon the number of operating hours and the cleanliness of the operating environment. Under typical installation conditions, servicing on a yearly basis is satisfactory. If a decrease is observed in the performance of the channel (reduced maximum velocity, increased turbulence level, etc.) then the honeycomb should be serviced.

5.5.1 CLEANING

Simply raise the headgate as far as possible. Increase the slope of the system to a moderately positive inclination and back rinse the honeycomb with a water hose. Continue this until all of the blockages are removed.

5.6 CHANNNEL SECTIONS

The plexiglass channel sections should be washed periodically with a mild detergent and clean water using a soft cloth. Remove residual water with fresh paper toweling. Care should be exercised to avoid scratching the channel surfaces. Fine abrasions and cloudiness may be removed by fine sanding and polishing. A scratch removal kit available from

Micro-Surface Finishing Products, Inc.
Box 456
Wilton, Iowa 52788

is recommended. Attempts to remove deep scratches are generally futile.

6.0 LIMITED WARRANTY

Engineering Laboratory Design, Inc. (ELD) warrants its new products to be free of defects in material and workmanship under normal use and service for a period of one (1) year from the date of acceptance of the product by the original purchaser. Engineering Laboratory Design's obligation under this warranty shall be limited to replacing at its factory, any products, or parts thereof which are returned to ELD with transportation charges prepaid, and which upon ELD's examination are determined to be in fact defective. In the event of warranty service, ELD reserves the right to substitute new or improved equipment as replacement components.

This warranty shall not apply to any product which has been repaired or altered, outside of ELD's factory, in any way deemed to affect the product's stability or reliability, nor to any product having been subjected to improper installation by others, improper operation or storage, negligence, accident, abrasion, corrosion, electrolysis, improper electrical supply, careless handling, nor to any product subjected to other than normal use or service.

Engineering Laboratory Design will not grant any allowance for repairs or alterations made without written consent of authorized personnel. ELD shall in no way be liable or responsible for injuries or damages to persons or property, arising from or out of the use or operation of the product.

Engineering Laboratory Design reserves the right to make changes in design, or to make additions to, or improvements in, its products without imposing any obligation upon itself to install them on products previously manufactured.

Maintenance and service, at the purchaser's location, or maintenance and repair service for equipment for which the warranty has expired, can be contracted for by contacting Engineering Laboratory Design, Inc., PO Box 278, 2021 South Highway 61, Lake City, MN USA 55041, (651) 345-4515. Alternatively you may contact ELD Inc. via fax at: (651) 345-5095, or e-mail to: eldinfo@eldinc.com or visit our website at: www.eldinc.com.

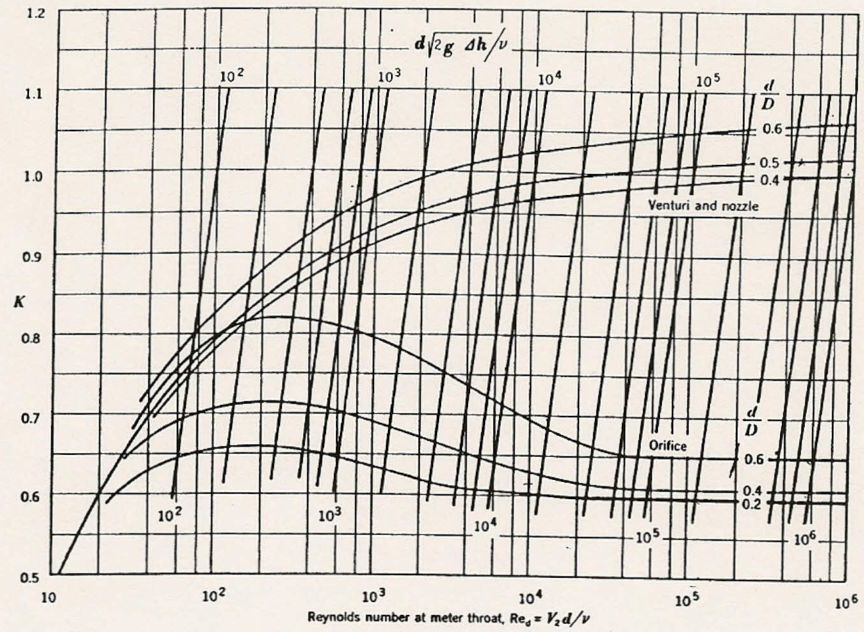
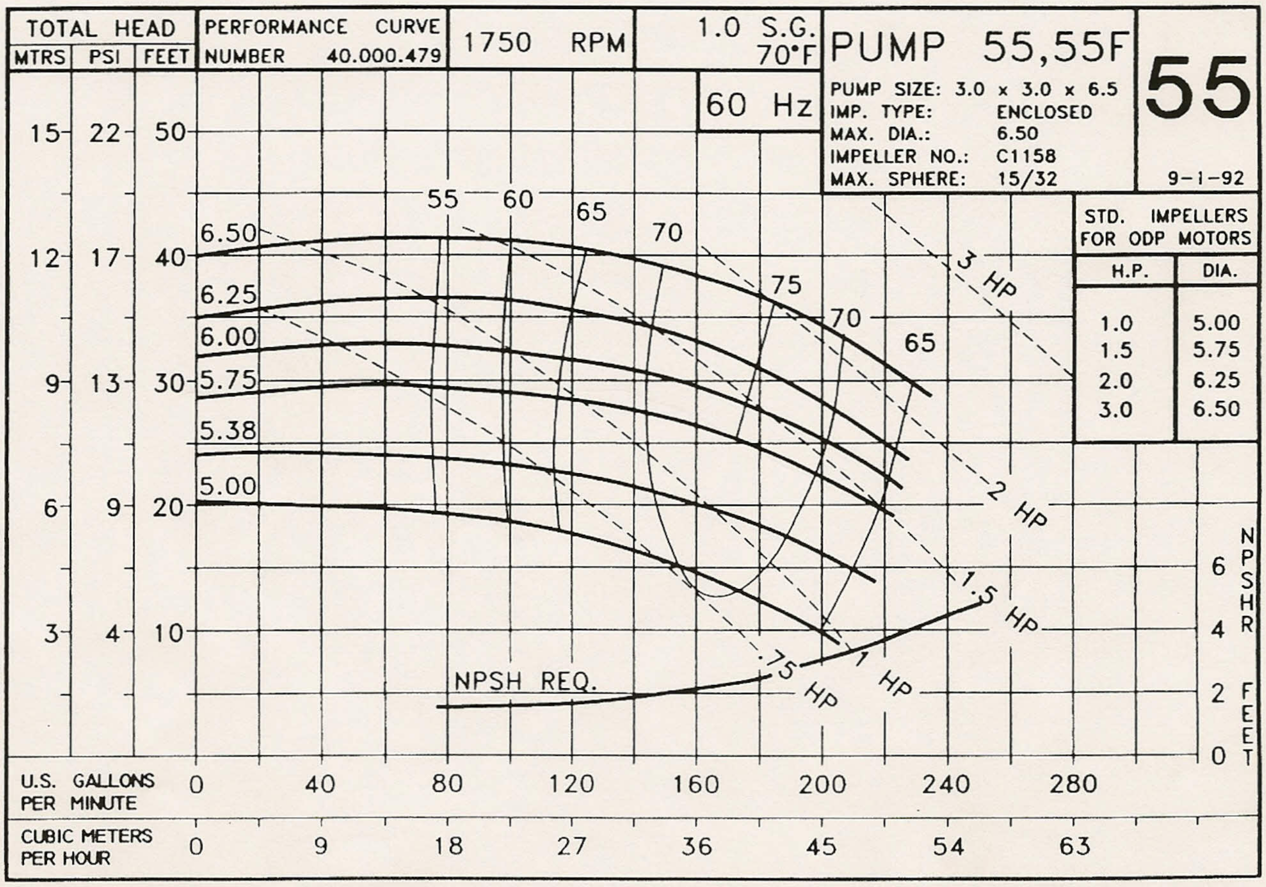


FIG. 13–12. Approximate flow coefficients for pipe meters.

Olson, R. Essentials of Engineering Fluid Mechanics. International Textbook Company, 1966. pg. 356.



Pump Curve Courtesy of Scot Pump

ENGINEERING LABORATORY DESIGN, INC.
Designers and Manufacturers of Quality
Engineering Laboratory Equipment since 1962.

SERVICE CENTERS

Company:	Component(s):	Local Representative:	Telephone No.:	Fax No.:
Baldor Electric Company PO Box 2400 Fort Smith, AK 72902 www.baldor.com	1.5HP ODP Pump Motors	Ron's Electric 1005 N. Main Blue Earth, MN 56013	(507) 526-3060	(507) 526-4070
Dayton Electric Mfg Co. 1250 Busch Parkway Buffalo Grove, Il 60089	Gear Motors Headgate & Tailgate		(800) 323-0620	
Scot Pump 6437 Pioneer Road Cedarburg, WI 53012	3x3 5 3/4" 55B Centrifugal Pumps		(262) 377-7000	(262) 377-7330
Square D Co. 1415 S. Roselle Rd Palatine, IL 60067	Power Transformer		(847)-397-2600	(847)-397-8814
Toshiba, International Industrial Division 13131 West Little York Road Houston, TX 77041	Variable Frequency Inverter		(800) 231-1412	(713) 466-8773
US Motors	Slope Gear Motor	Dayton Electric Mfg Co. 1250 Busch Parkway Buffalo Grove, Il 60089	(800) 323-0620	
W. W. Grainger, Inc. www.grainger.com	Fuses	W. W. Grainger, Inc. 201 E. 78th St. Bloomington, MN 55420	(612) 531-0300	(612) 531-7660

Post Office Box 278 2021 South Highway 61 Lake City, Minnesota 55041 USA
651-345-4515 FAX: 651-345-5095 800-795-8536
www.eldinc.com eldinfo@eldinc.com

ENGINEERING LABORATORY DESIGN, INC.

Designers and Manufacturers of Quality
Engineering Laboratory Equipment since 1962.

16'-0" Sediment Demonstration Channel

List of Components

Component	Manufacturer	Model/Part No.	Serial No.
1. Chain, Jacking	Martin	No 35 (ISO No. 06C-1)	
2. Fuse, Headgate 2.5A (1)	Bussman Cooper Industries	FNM 2 1/2	
3. Fuse, Main Input 8A (3)	Bussman Cooper Industries	LPJ 8SP	
4. Fuse, Pump Motor 4A (3)	Bussman Cooper Industries	FNQ 4	
5. Fuse, Tailgate 2.5A (1)	Bussman Cooper Industries	FNM 2 1/2	
6. Fuse, Transformer 1A (2)	Bussman Cooper Industries	FNQ 1	
7. Fusible Disconnect 30A	ABB	OESA F30J6P	
8. Gearmotor, Head/Tail Gate	Dayton	2Z799	
9. Gearmotor, Slope, 1/2HP	US Motor	E438	
10. Limit Switch, Lever	Omron	Z15GW-B7-K	
11. Limit Switch, Plunger	Omron	ZE-N-2S	
12. Motor Starter, Non-Reversing	Telemecanique	LC1D0910G6	
13. Motor Starter, Reversing	Telemecanique	LC2K0601F7	
14. Motor, Pumps, 1.5HP	Baldor	JMM3154T	
15. Overload Relay, 1.2Amp	Telemecanique	LR2K0306	
16. Overload Relay, 4Amp	Telemecanique	LR2D1308	
17. Pumps, (2)	Scot Pump	3089K413	
18. Sprocket, Drive	Martin	35BS18-1	
19. Sprocket, Idler	Martin	35BS18-1	
20. Sprocket, Jacking Screw	Martin	35BS18-5/8	
21. Transformer	Square D	9070 T300D1	
22. Variable Frequency Inverter	Toshiba	VFS9-4015PL-WN	801615020030

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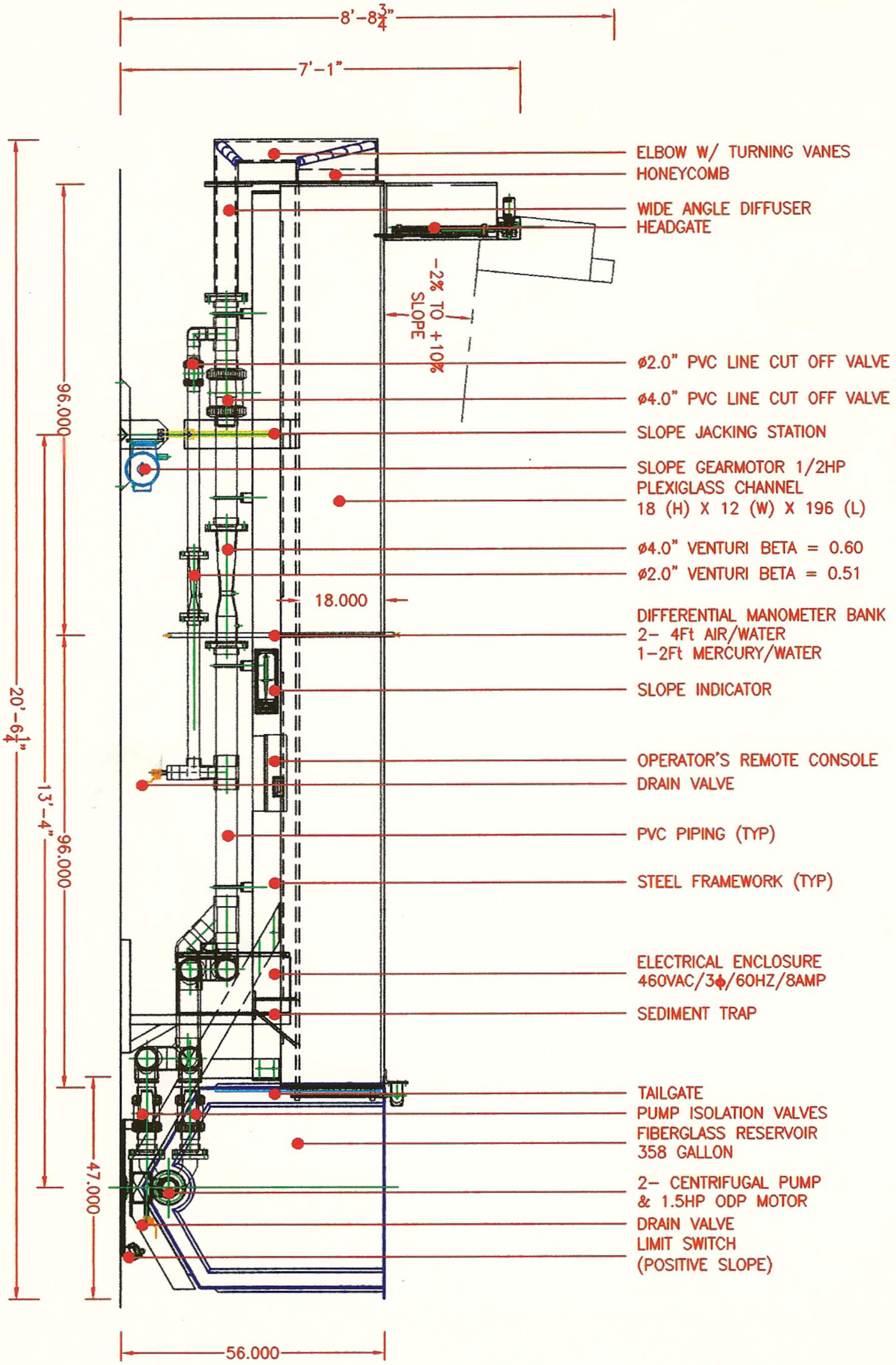
www.eldinc.com eldinfo@eldinc.com



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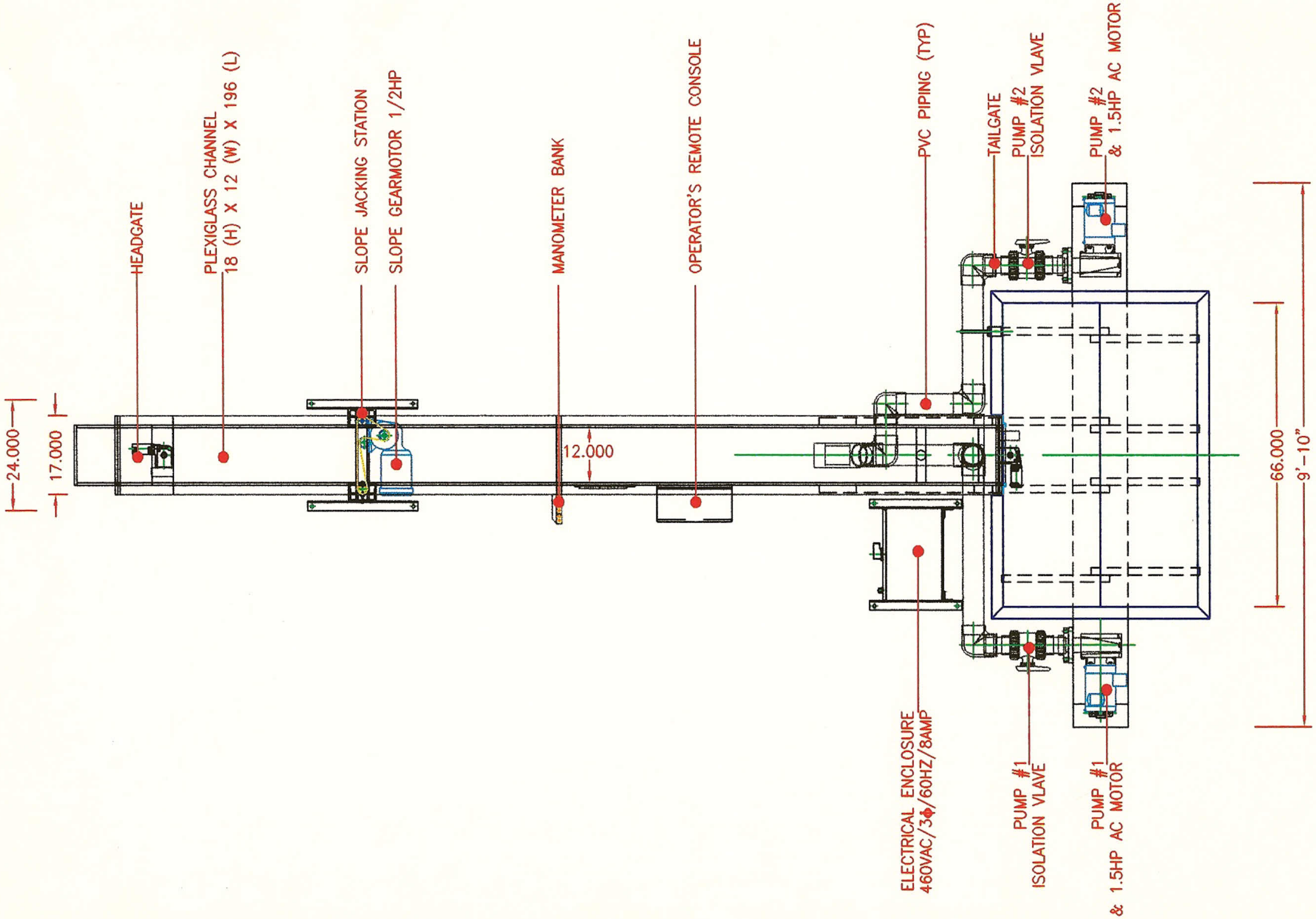
PROJECT: 16'-0" SEDIMENT DEMONSTRATION CHANNEL
OVERALL ELEVATION

ORGANIZATION: MINNESOTA STATE UNIVERSITY - MANKATO

REFERENCE: P.O.# 18976

DATE: 10/19/00

SCALE: 3/8" = 1'-0"



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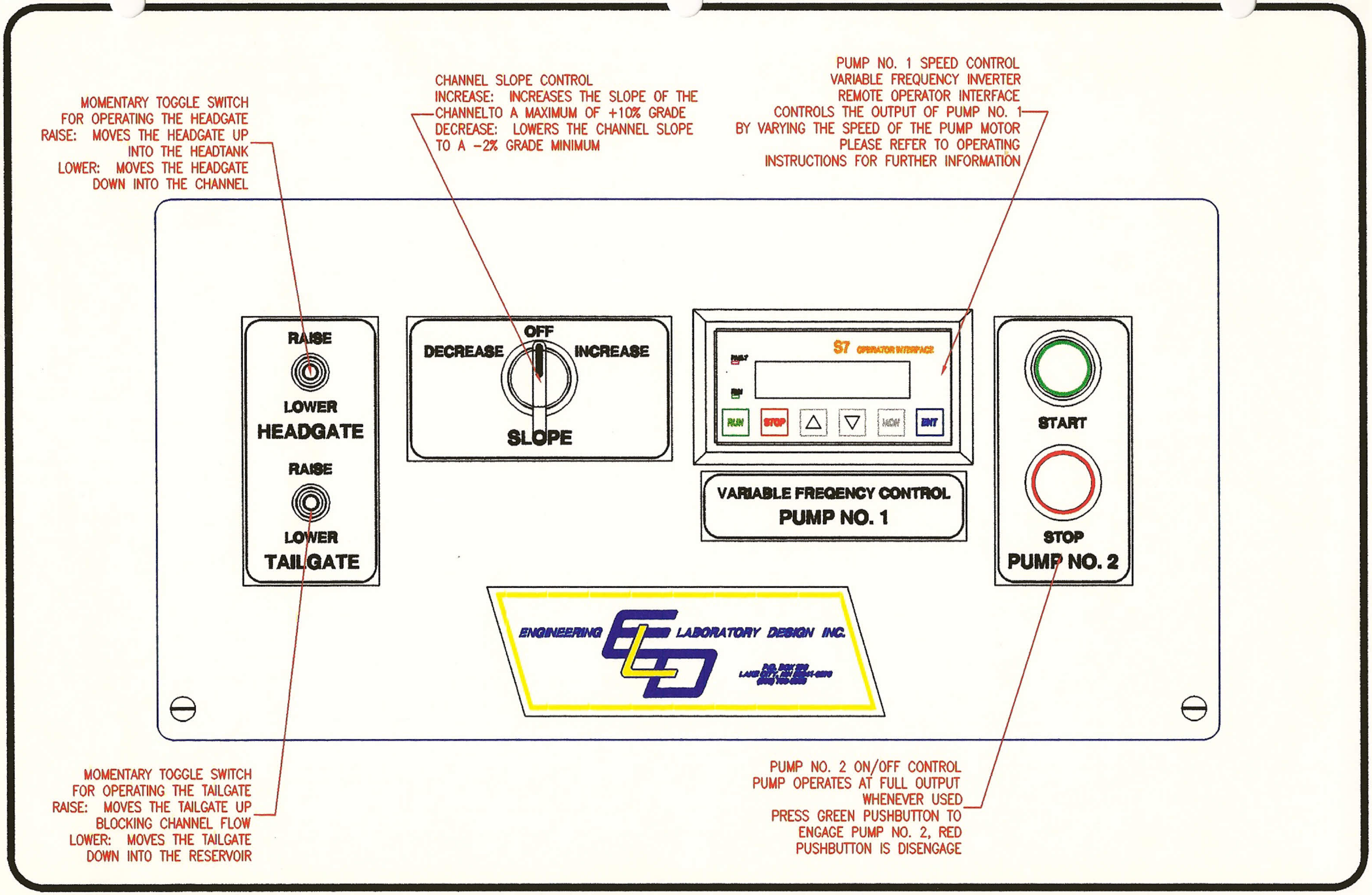
PROJECT: 16'-0" SEDIMENT DEMONSTRATION CHANNEL
OVERALL PLANVIEW

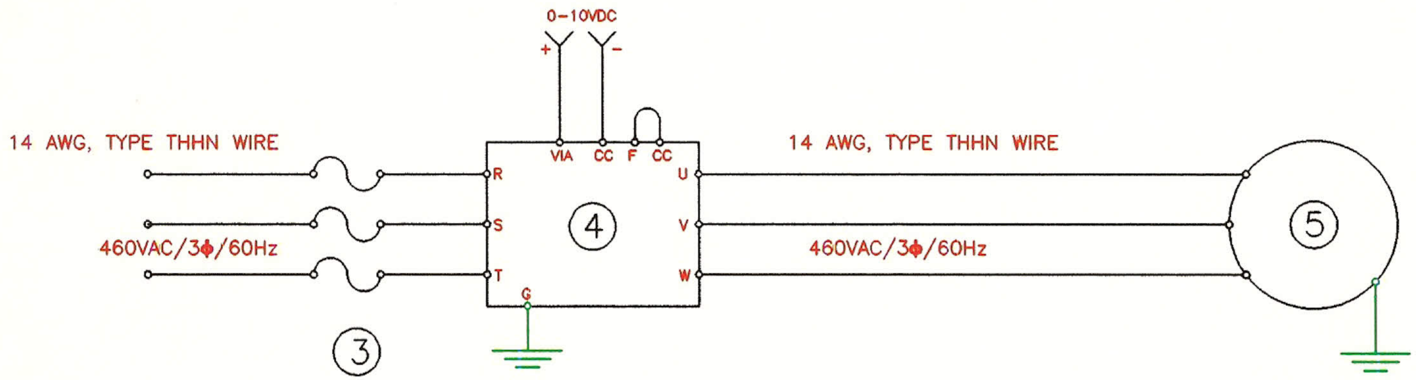
ORGANIZATION: MINNESOTA STATE UNIVERSITY – MANKATO

REFERENCE:	DATE:	SCALE:
P.O.# 18976	10/19/00	3/8" = 1'-0"



ENGINEERING LABORATORY DESIGN, INC. P.O. Box 278 Lake City, Minnesota 55041 USA 651-345-4515 FAX 651-345-5095	THIS DRAWING AND THE INFORMATION THAT IT CONTAINS ARE THE PROPERTY OF ENGINEERING LABORATORY DESIGN, INC. REPRODUCTION AND/OR TRANSMISSION WITHOUT EXPRESS WRITTEN AUTHORIZATION IS PROHIBITED.	PROJECT: 16'-0" SEDIMENT DEMONSTRATION CHANNEL OPERATING CONSOLE		
		ORGANIZATION: MINNESOTA STATE UNIVERSITY - MANKATO		
		REFERENCE: P.O.# 18976	DATE: 10/20/00	SCALE: 0.5" = 1.0"

No.	Component	Manufacturer	Part No.
3	Pump No. 1, Motor Fuses, 4A type FNQ	Bussman	FNQ 4
4	Variable Frequency Inverter	Toshiba International	VFS9-4015PL-WN
5	1.5HP, ODP AC Pump No. 1 Motor	Baldor Industrial	JMM3154T



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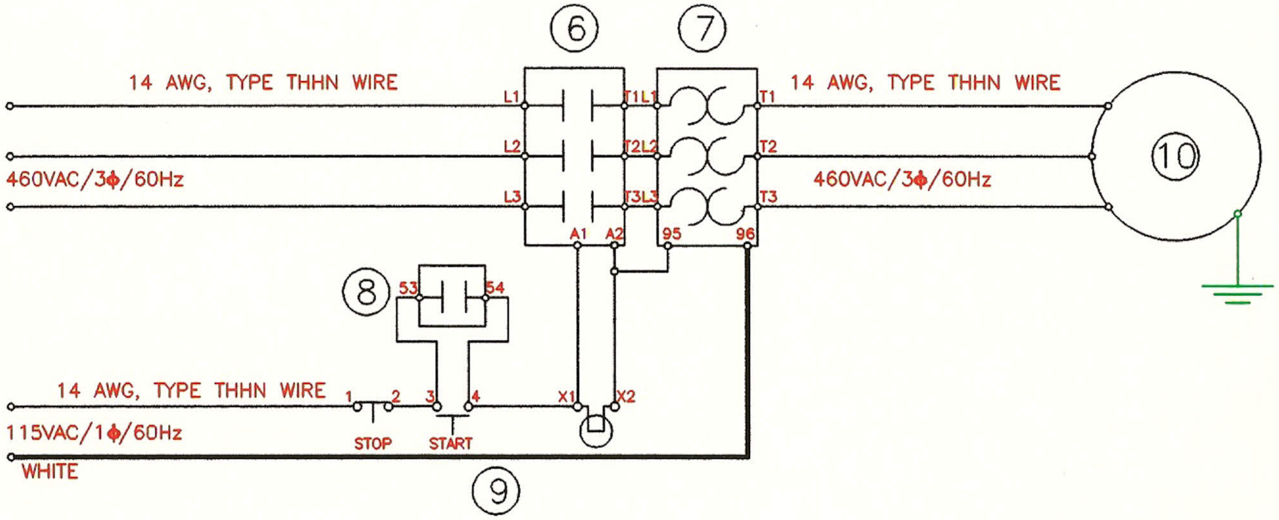
PROJECT: 16'-0" SEDIMENT DEMONSTRATION CHANNEL
PUMP NO. 1 WIRING DIAGRAM

ORGANIZATION: MINNESOTA STATE UNIVERSITY - MANKATO

REFERENCE:	DATE:	SCALE:
P.O. NO. 18976	10/20/00	NTS

No.	Component	Manufacturer	Part No.
6	Non-Reversing, Magnetic Motor Starter	Telemecanique	LC1D0910G6
7	Overload Relay, 10Amp	Telemecanique	LR2D1308
8	NO Auxiliary Contactor	Telemecanique	LA1DN11
9	Stop Push Button	Telemecanique	STOP: ZA BL4
	Start Push Button	Telemecanique	START: ZA2 BW33
10	1.5HP, ODP AC Pump No. 2 Motor	Baldor Industrial	JMM3154T



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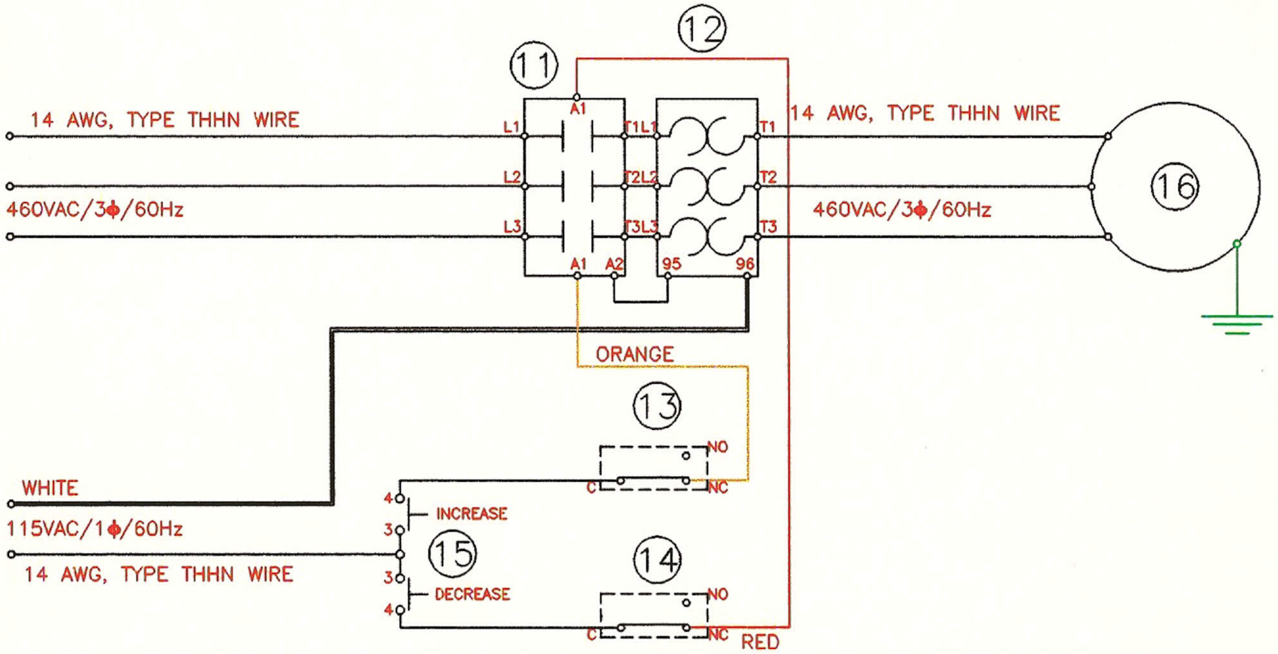
PROJECT: 16'-0" SEDIMENT DEMONSTRATION CHANNEL
PUMP NO. 2 WIRING DIAGRAM

ORGANIZATION: MINNESOTA STATE UNIVERSITY - MANKATO

REFERENCE:	DATE:	SCALE:
P.O. NO. 18976	10/20/00	NTS

No.	Component	Manufacturer	Part No.
11	Reversing, Magnetic Motor Starter Overload	Telemecanique	LC2K0601F7
12	Relay, 1.2Amp	Telemecanique	LR2K0306
13	Limit Switch (Positive), Plunger Style	Omron	ZE-N-2S
14	Limit Switch (Negative), Plunger Style	Omron	ZE-N-2S
15	DPDT Switch (Mom.), 2, NO Contact Block	Telemecanique	ZA2 BJ5
16	Elevating Gear Motor, 30RPM, 1/2HP	USEM	E438



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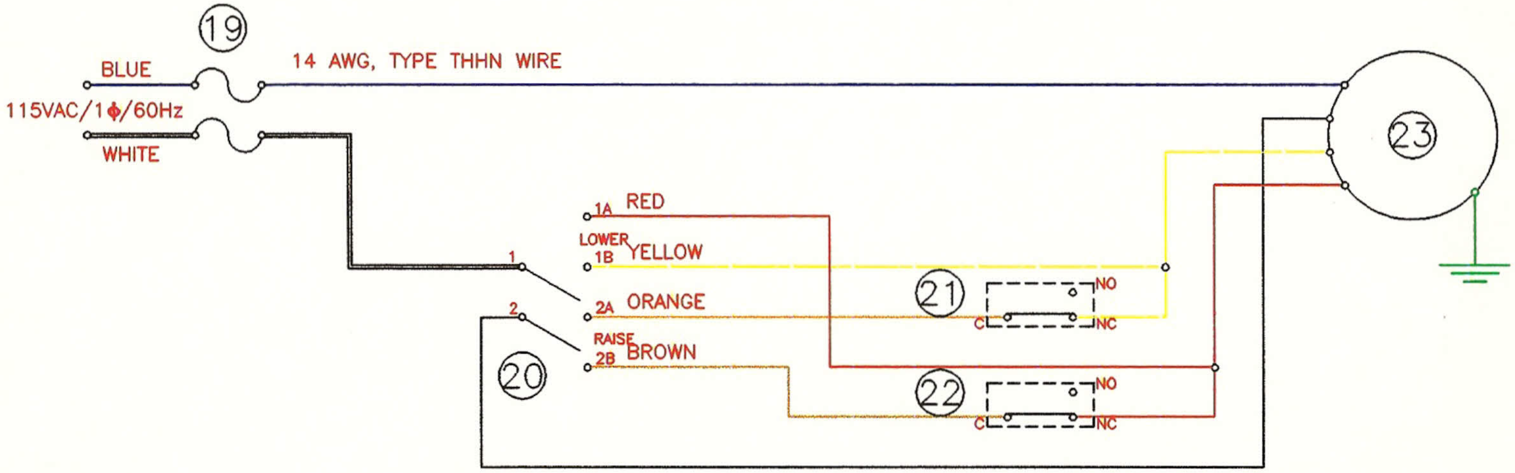
PROJECT: 16'-0" SEDIMENT DEMONSTRATION CHANNEL ELEVATING ASSEMBLY WIRING DIAGRAM

ORGANIZATION: MINNESOTA STATE UNIVERSITY - MANKATO

REFERENCE:	DATE:	SCALE:
P.O. NO. 18976	10/20/00	NTS

No.	Component	Manufacturer	Part No.
19	Fuses, Tailgate, 2.5Amp Type FNM	Bussman	FNM 2.5
20	DPDT, Momentary Toggle Switch	Eaton	7803K37
21	Limit Switch (Lower), Lever Type	Omron	Z15GW-B7-K
22	Limit Switch (Upper), Lever Type	Omron	Z15GW-B7-K
23	Tailgate Right Angle Gear Motor	Dayton	2Z799



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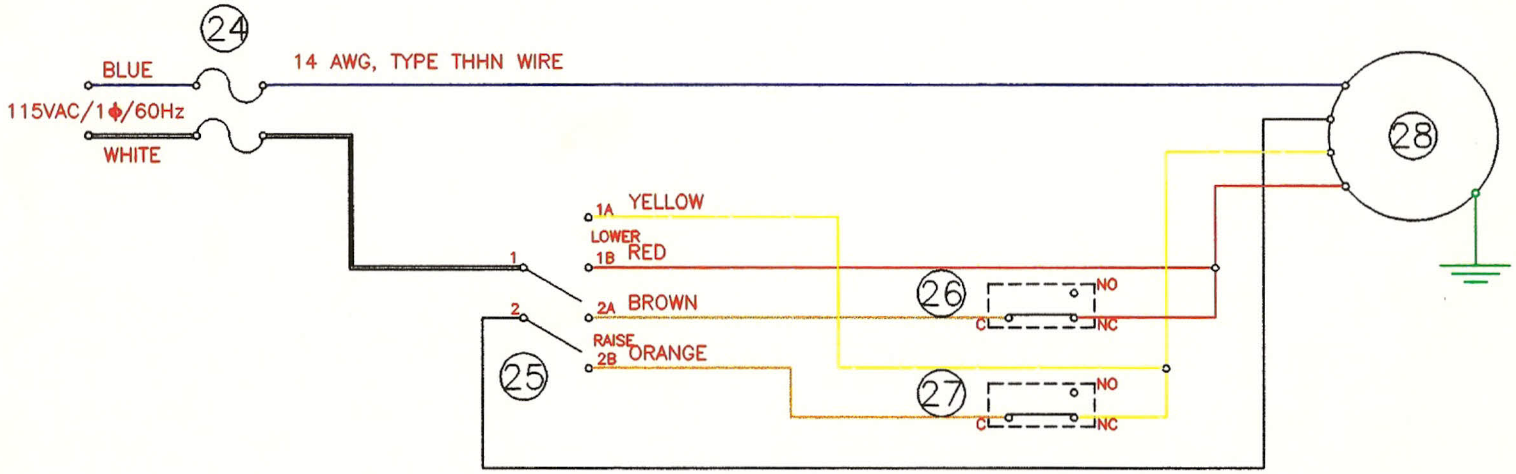
PROJECT: 16'-0" SEDIMENT DEMONSTRATION CHANNEL
TAILGATE WIRING DIAGRAM

ORGANIZATION: MINNESOTA STATE UNIVERSITY - MANKATO

REFERENCE:	DATE:	SCALE:
P.O. NO. 18976	10/20/00	NTS

No.	Component	Manufacturer	Part No.
24	Fuses, Headgate, 2.5Amp Type FNM	Bussman	FNM 2.5
25	DPDT, Momentary Toggle Switch	Eaton	7803K37
26	Limit Switch (Upper), Lever Type	Omron	Z15GW-B7-K
27	Limit Switch (Lower), Lever Type	Omron	Z15GW-B7-K
28	Headgate Right Angle Gear Motor	Dayton	2Z799



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PROJECT: 16'-0" SEDIMENT DEMONSTRATION CHANNEL
HEADGATE WIRING DIAGRAM

ORGANIZATION: MINNESOTA STATE UNIVERSITY - MANKATO

REFERENCE:	DATE:	SCALE:
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SLUICE GATE MODEL

A sluice gate is a vertical gate used to allow a controlled outlet of liquids. The model may be used to:

1. Illustrate the momentum theorem.
2. As a flow measuring device.

Momentum Theorem:

The force of water on the sluice gate may be computed from the momentum theorem, assuming one-dimensional flow and neglecting shear along the channel bed and the side walls. This may be compared with the force obtained from direct measurements of the pressure distribution on the sluice gate. Depths upstream and downstream of the sluice gate, the sluice gate opening, the channel width, and the heights of the various water columns in the piezometer tubes connected to the upstream face of the sluice gate are all the data required.

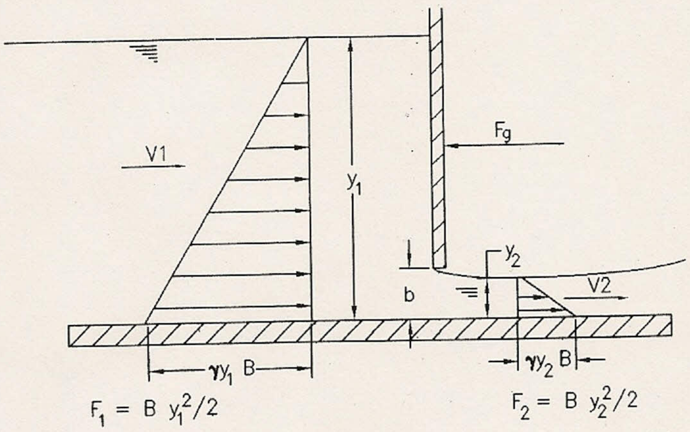

Figure 1 Momentum Theorem

Where: B = width of channel, $y_2 = bC_c$, C_c = Contraction Coefficient
γ = specific weight of fluid, ρ = density of fluid

From Figure 1 the continuity equation is

$$Q = V_1 y_1 B = V_2 y_2 B$$

For the assumptions mentioned above, the Bernoulli equation is valid. For a 0% slope bed:

$$(V_1^2 / 2g) + y_1 = (V_2^2 / 2g) + y_2$$

Combining these:

$$V_1 = 2g\,[\,(y_1 - y_2) / ((y_1/y_2)^2 - 1)]^{1/2} \text{ (ft/sec)}$$

and

$$V_2 = V_1\,(y_1/y_2) \text{ (ft/sec)}$$

The momentum theorem, based on the above assumptions is:

$$B\gamma y_1^2/2 - B\gamma y_2^2/2 - F_g = V_1 y_1 B \rho (V_2 - V_1)$$

Therefore:

$$F_g = \tfrac{1}{2}(\gamma y_1^2 B - \gamma y_2^2 B) - \rho Q (V_2 - V_1)$$

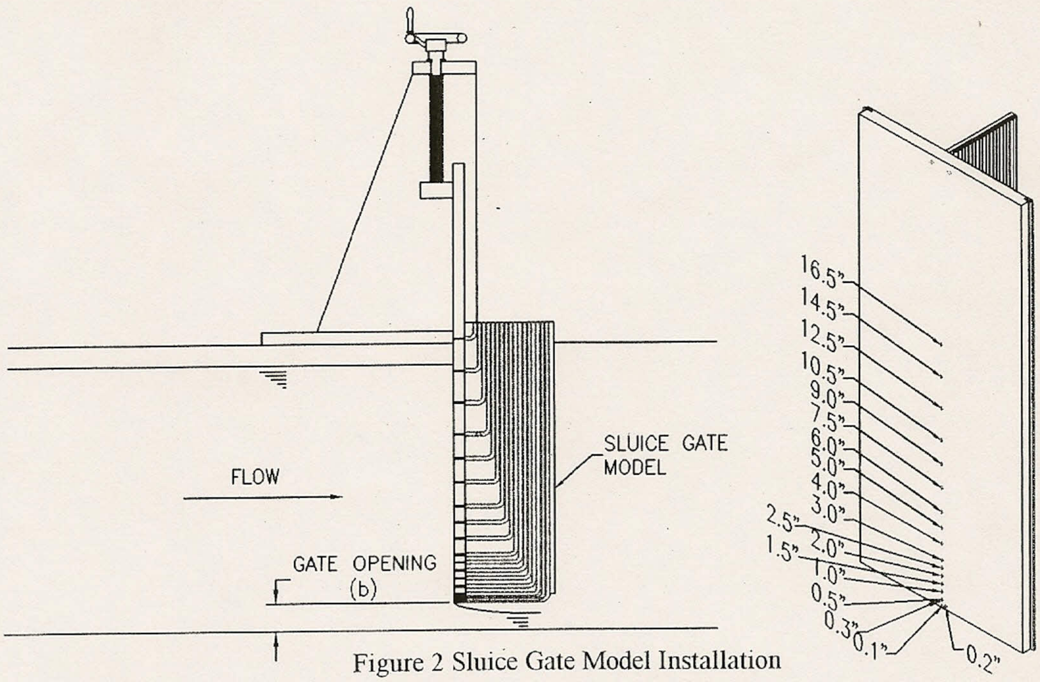

Figure 2 Sluice Gate Model Installation

Suggested Experiment Procedure

1. Initial settings:
   a, Adjust channel to 0% slope.
   b. Close off Pump No.2 valve.
   c. Close off low flow rate meter valve.
   d. Raise headgate to maximum height.
   e. Lower tailgate completely.
2. Install the sluice gate model mid way along channel section, at a position that the piezometer tubes are clearly visible from the side. Secure with C clamps along the channel top aluminum support rails (See Fig. 2)
3. Set the sluice model gate opening to a small height above the channel floor (b).
4. Turn on Pump No.1 and open valve for full discharge.
5. Measure the pressure on the gate face by measuring and recording the height of each water column in each piezometer tube (h) (See Fig 3).
6. Raise the gate to a larger opening (b).
7. Turn on Pump No.2 and open Pump No.2 valve for full discharge.
8. Repeat steps 5 and 6 for the increased gate opening.
9. Analytically determine the force on the gate by equating the hydrostatic and momentum forces on eachside of the sluice gate.

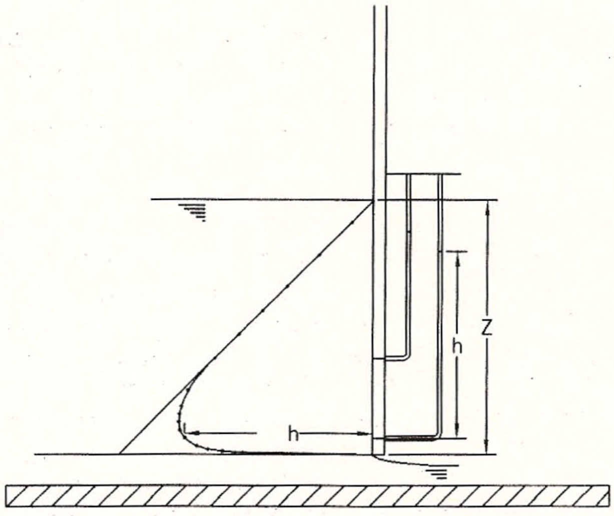

Figure 3 Sluice Gate Pressure Measurements

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INCLINED SLOPE MODEL

An inclined slope is used to illustrate types of flow in open channels. The inclined slope model is used to provide a point of control in the establishment of critical depth.

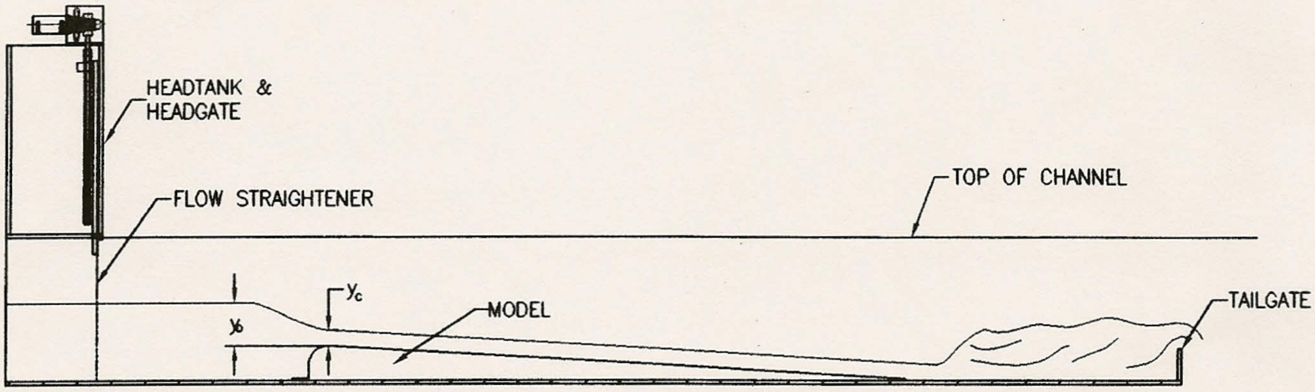


Figure 1 Installation

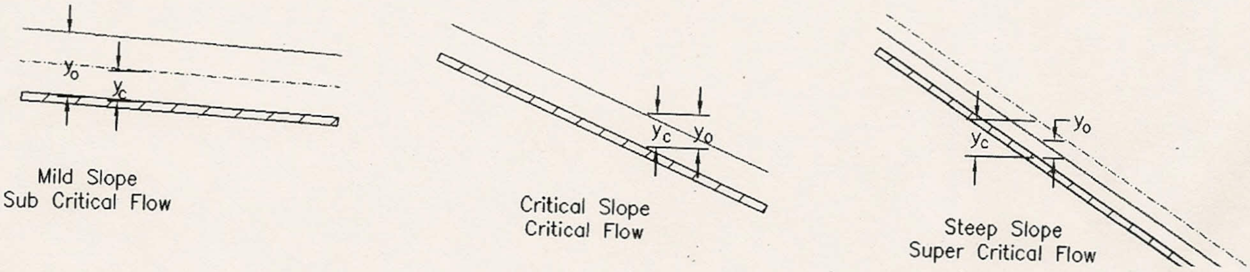
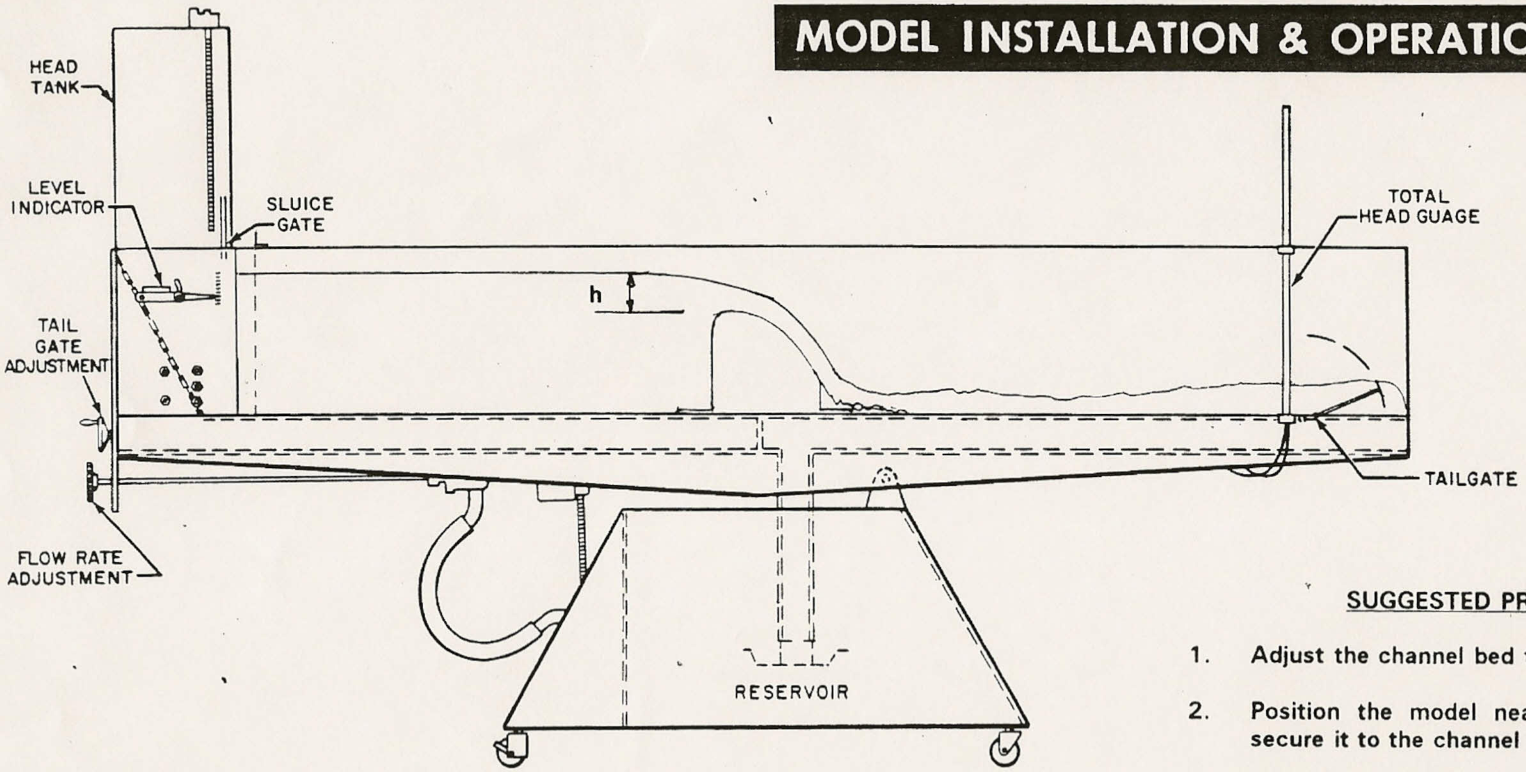


Figure 2 Various Types of Flow

Suggested Experiment Procedure

1. Initial settings:
   a. Raise headgate to maximum opening.
   b. Elevate channel to maximum negative slope.
   c. Open Pump No.1 & Pump No.2 valves for maximum discharge.
   d. Install flow straightener (if purchased) at exit of head tank.
   e. Lower Tailgate completely.
2. Mount the inclined slope model halfway up the upstream channel using two (2) #10-24UNC-2A x 0.75" long Round Head Machine Screws (RHMS) at the upstream flange and one (1) #10-24UNC_2A x 0.5" long Flat head Machine Screw (FHMS) at the downstream end.
3. Start Pumps No.1 & 2 at maximum discharge rates.
4. Adjust the tailgate to give a uniform tranquil (sub critical) flow down channel.
5. Slowly elevate the channel. until the critical depth is obtained over the entrance section of the model. Critical slope occurs when the velocity down the slope is uniform without acceleration or deceleration. Also. note that waves caused by surface disturbances do not travel upstream.
6. Mark the point of critical depth on the channel side wall for later reference.
7. Increase the slope to show accelerated (super critical) flow down the channel.
8. Adjust the tailgate height to form a hydraulic jump at the lower end of the slope.
9. Calculate the Froude Number for each condition.

MODEL INSTALLATION & OPERATION



SPILLWAY MODEL

PURPOSE OF DEMONSTRATION

To develop a head/discharge curve and coefficient of discharge for a spillway model. The model represents a classical Waterways Experiment Station (WES) ogee type spillway.

SUGGESTED PROCEEDURE

1. Adjust the channel bed to a horizontal slope.

2. Position the model near mid-channel and secure it to the channel floor.

3. Fully raise the headgate and install the secondary screen near the upstream end of the channel. Lower the tailgate.

4. Measure "h", using a point gauge or similar device, and monitor the flow rate using the orifice meters throughout a broad flow range.

5. Develop a coefficient of discharge, C, using the relationship $Q = C\,h\,(2\,gh)^{1/2}$

Equation wrong

$Q = CLh^{3/2}$

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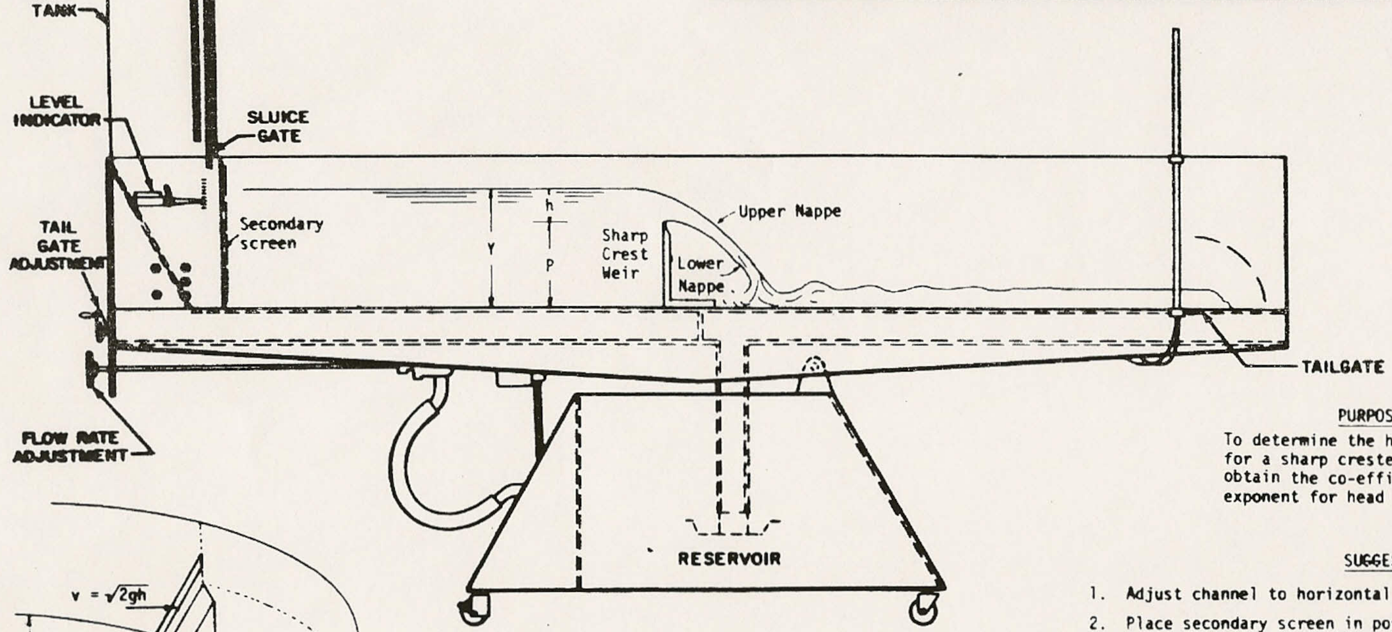
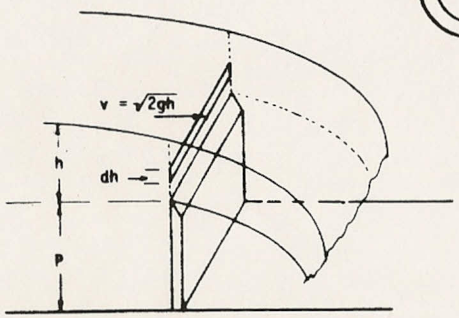
MODEL INSTALLATION & OPERATION





For discharge through orifice of height dh and length L

$$dQ = c_d \sqrt{2gh}\ L\ dh$$

Integrating from 0 to H

$$Q = 2/3\ C_d \sqrt{2g}\ L\ H^{3/2}$$

From previous experimenters Kindsvater and Carter summarized the data to suggest the basic equation

$$Q = C_d L_e H_e^{3/2}$$

where $C_d = 3.22 + 0.40\ H/P$ cfs

and $L_e = L - 0.003$

$H_e = H + 0.003$

PURPOSE OF CALIBRATION

To determine the head-discharge relationship for a sharp crested suppressed weir and obtain the co-efficient of discharge and the exponent for head factor.

SUGGESTED PROCEDURE

1. Adjust channel to horizontal position.
2. Place secondary screen in position and raise head gate to highest limit.
3. Insert weir and fasten to bottom at mid-point.
4. Determine elevation of weir crest by point gage or other measuring device.
5. Start pump and adjust discharge to obtain minimum discharge over weir consistent with full areation of the nappe.
6. Measure elevation of the water surface at such a distance upstream as to be out of the drawdown area.
7. Record head on the weir and manometer reading on the supply orifice meter.
8. Increase discharge and repeat Step 7 and repeat as necessary to define the head-discharge curve.
9. Plot results on semi-log paper and determine discharge co-efficients and head term exponent.

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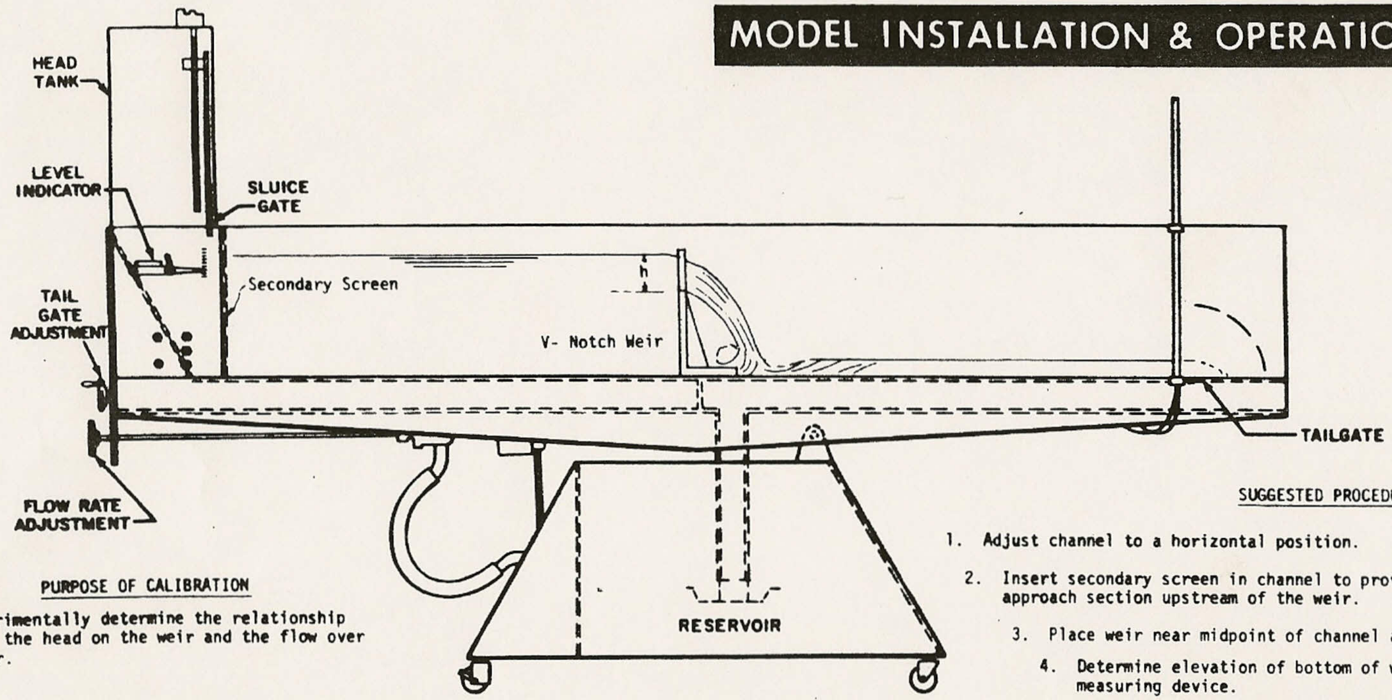
STRAIGHT WEIR

MODEL INSTALLATION & OPERATION

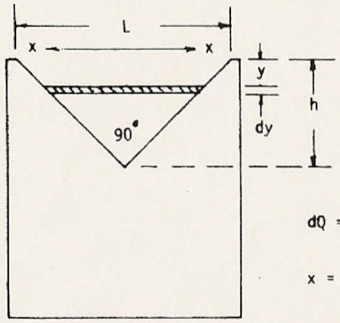


PURPOSE OF CALIBRATION

To experimentally determine the relationship between the head on the weir and the flow over the weir.

SUGGESTED PROCEDURE

1. Adjust channel to a horizontal position.
2. Insert secondary screen in channel to provide uniform velocities in the approach section upstream of the weir.
3. Place weir near midpoint of channel and fasten to bottom.
4. Determine elevation of bottom of weir notch by point gage or other measuring device.
5. Start pump and adjust discharge to obtain the minimum flow over the weir consistent with full areation of the nappe.
6. Measure elevation of the water surface at such a distance upstream as to be out of the drawdown area.
7. Record head on weir and manometer reading on channel supply orifice meter.
8. Increase discharge and repeat Step 7 to obtain as many points as desired to define the head discharge curve.
9. Plot results on semi-log paper to determine the exponent and discharge coefficient.



$$dQ = C_d \, x \sqrt{2gy} \;\; dy$$

$$x = L \left(\frac{h-y}{h} \right) = 2(h-y)\tan \theta/2$$

$$Q = 8/15 \; C_d \sqrt{2g} \; \tan \theta/2 \;\; h^{5/2}$$

$$Q = 2.5 \, h^{5/2} \;\; \text{cfs}$$

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V-NOTCH WEIR