TECHNICAL MEMORANDUM

MWH

To:	Jim Lennington	**Date:**	February 24, 2003
	Roger Hagen	**Reference:**	SA 24
From:	Silas Gilbert		
Subject:	BPS Predesign		

BOOSTER PUMP STATION/ PRETREATMENT FACILITY PREDESIGN

This pre-design memorandum provides a description of the Booster Pump Station/ Pretreatment Facility (BPS/PTF) predesign and presents the pre-design level criteria and drawings. The attached Figure 1 presents the design criteria and drawings C-1, M-1, M-2 and M-3 show the predesign level and site plan and facility layout. The BPS and PTF have been combined into one facility that meet the requirements of the NORTHWEST AREA WATER SUPPLY PROJECT BIOTA TRANSFER CONTROL FACILITIES AND CRITERIA December 1997 report. A brief description of the major BPS/PTF systems and operations considerations are also presented in the following paragraphs. A construction cost estimate is included at the end of the memorandum. The Pretreatment Facility (PTF) chemical systems are described in detail in the SA # 7 – Pretreatment Predesign Technical Memorandum. The BPS/PTF is sited immediately east of Highway 83, just south of the railroad tracks.

The BPS/PTF pre-design is based on an Ultimate capacity of 26 mgd, with a Phase 1 constructed capacity of 18 mgd. The facility consists of major systems that are as follows:

- Influent Valve Vault
- Wet-wells/ Chlorine Contactors
- Booster pumps
- Surge Control
- Detention pond
- 'Pig' receiving station
- Pretreatment Facility
- Building
- Control system
- Miscellaneous systems

Influent Valve Vault

The influent valve vault is a buried cast-in-place concrete structure that contains five (5) parallel pipe/ butterfly valve (BFV) systems that individually provide influent flow to the five (5) parallel wetwells as shown on Drawings M-2 and M-3. There are two (2) BFVs in series, identified as 'A' and 'B', on each parallel system that each have an electric open/close actuator. The 'B' valve open/closes with the start/stop sequence of the appropriate booster pump. The 'A' valve is the primary emergency and fail-safe valve (Note: the "A" value electric actuator is an option that would provide 100% redundancy for emergency/fail-safe operation). Both valves will be connected to an uninterruptible power supply (UPS) to provide one hundred percent redundancy for emergency and fail-safe operation (Note: the value of having 100% redundant electric actuators should be discussed). Operation and control of these valves will be discusses in the Control System description section of this technical memorandum. A manway hatch with ladder is planned to provide access into this vault. An access building with stairs can be provided if desired. Maintenance hatches are located directly over each BFV set. The ventilation system will consist of positive pressure fan and louver controlled by an on/off switch located inside adjacent to the manway access hatch. A contact for on/off control of the ventilation system may also be located on the manway access hatch jam. A thermostatically controlled electric unit heater will be sized to provide sufficient space heating to prevent freezing inside the vault.

Wetwells (Refer to M-1, M-2 and M-3)

The wetwell is a buried cast-in-place concrete structure that is divided into five (5) parallel wetwells (cells) with three cells 10'-10" wide and two cells 6'-0" wide. The three wide cells each serve as individual wetwells for the respective three 9-mgd constant speed pumps and the two narrow cells each serve as individual wetwells for the respective two 5-mgd constant speed pumps. The relationship of cell width to the pump capacity provides equal hydraulic detention time for all cells. Five (5) minutes is the theoretical detention time based on the length of the cells, a specific water depth, and the appropriate cell width. This configuration provides the method for utilizing the cells as the chlorine contactors. By maintaining a constant and equal water level in all cells, the required chlorine contact time is established. The method for controlling and maintaining the water level in the cells is discussed in the control section of this technical memorandum. The dimensional relationships and volume of each cell has been optimized to promote moderate settling of particles. The full height influent baffle wall is recommended to promote plug flow through a cell that improves settling and contact time control. The ratio of the baffle wall open area, total orifice area, will equal 2.5% to 3.5% of a cell cross-sectional area. This will be produce approximately ½-1 inch of headloss across the baffle. The 12-inch curb, just prior to the pumps, is to provide a quiescent zone along the cell floor for settled solids.

An access hatch and sump is located in the center of each cell to facilitate cleaning. The cleaning plan includes closing of a cell influent valve while continuing to pump that cell down to at least the 2-foot level, then turn off the cell booster pump. A temporary sump pump for dewatering and solids removal may then be lowered into the sump through the access hatch located above it, with the discharge hose run out to the detention basin. A 2-foot depth of water is approximately 6,100 gallons and 11,000 gallons in the 6"-0" and 10'-10" width cells respectively. During this operation, squeegees and washdown water may be used to move the retained sludge toward the sump. The washdown water is supplied from a 2-inch flanged connection on the booster pump discharge header inside the BPS building. A pressure regulating valve, isolation valve and a fire hose connection coupling is attached to this connection. A 2-inch fire hose may then be attached to this connection and run into the cell through the cell access hatch located inside the building adjacent to the respective cell booster pump discharge header.

Booster Pumps (Refer to M-1)

Constant speed vertical turbine pumps are planned for the Booster Pump Station. Phase 1 pumps consist of four (4) pumps of two capacity ranges that provide a total capacity of 18 mgd. These pumps are identified as P-110, P-120, P-130 and P-140. Pump P-150 is planned to be installed as part of the Phase 2 expansion to provide an ultimate Booster Pump Station capacity of 26 mgd. The capacity of these pumps is listed on Figure 1 – Booster Pump Station Design Criteria. Figures 2 and 3 are the respective pump curves for P-110, P-120 and P-130, P-140 and P-150.

This figure shows that the booster pumps and all combinations of them have finite discharge capacities of approximately 3,600 gpm (5.2 mgd), 7.100 gpm (10.2 mgd), 8,200 gpm (11.8 mgd), 11,200 gpm (16.1 mgd), 13,500 gpm (19.4 mgd), 14,500 gpm (20.0 mgd), 16,400 gpm (23.6 mgd) and 18,700 gpm (26 mgd). The largest difference between any tow consecutive flow rates is 3,500 gpm (5 mgd). This difference is created by P-110 or P-120 on and both P-110 and P-120 on. The affect of this difference in pump selection has on Pretreated Water Storage Reservoir volume directly corresponds to MWTP influent flow rate. The greatest difference between booster pump station discharge and MWTP influent flow rate that can occur is 2.5 mgd if the proper pump combination is selected. The Pre-treated Water Storage Reservoir (PWSR) has been designed to provide 2–million gallons of operational storage volume. If the PWSR contains 1 million gallons of stored supply, leaving 1 million gallon of empty storage volume, and there is a 2.5 mgd BPS/PTF supply and MWTP demand differential, over 9 hours of lag time are available before a change in booster pump on/off combination is required.

Variable frequency drives (VFD) on pumps P-110 and P-129, or a single VFD, may be used to reduce the incremental flow differences between the different pump combinations. This could significantly increase the lag time between having to change booster pump combinations. However, the worst case condition just described may be significantly diminished, or 9 hours of lag time increased, by modifying MWTP influent flow rate and how the empty storage volume is coordinated with pump selection. The cost of adding a VFD to this system may be in the range of $100,000, depending on numerous variables. At this time, VFDs are not planned for any of these pumps.

Surge Control

The surge control system consists of a surge tank, an air/vacuum valve, a pressure relief valve on the pumping system discharge header, and a pump control valve (PCV) on each pump. A surge tank provides the most positive method of minimizing system negative and positive surge pressures created when main power is lost to the pump station. The air/vacuum and pressure relief valves function to assure that positive or negative surge pressures never exceed system design pressures. Each pump has a pump control valve (PCV) to control surges to the system during any normal pump start or stop sequence by controlling the rate at which flow is added or subtracted from the system. The PCV configuration for this system is a non-typical design as compared to the other components. The following paragraphs describe the typical PCV design verses this non-typical PCV design.

A PCV is typically located directly on the pump discharge pipe downstream of an air/vacuum valve and prior to a check valve. Either diaphragm or butterfly valves (BFV) are used as PCVs and they are sized according to the pump discharge head size. With this configuration, when the pump is off, the PCV is closed. When the pump is signaled to start, the PCV remains closed for a short time delay, usually 3 to 6 seconds, providing sufficient time for the pump to start speeding up and evacuate air through the air/vacuum valve that is in the piping between the pump impellers and PCV. The PCV is then signaled to open. When a pump is signaled to stop, the PCV is signaled to close first. When the PCV close contact is actuated, the pump is permitted to stop. PCV open/close speed, normally 30 to 60 seconds depending on valve size, is set by the gears of an electric actuated BFV or needle valves on a hydraulically actuated diaphragm valve. With this design, the pump discharge pressure begins at shut-off head once the pump reaches full speed and the pressure declines to system pressure as the PCV opens.

The non-typical PCV design shown on the drawings places the PCV valve on the side outlet of a tee which is located between the pump discharge head and the check valve. The air/vacuum valve is not required with this design. Discharge through the PCV flows directly back into the wetwell. A diaphragm valve must be used with this design due to a cavitation index that BFVs will not handle effectively. The diaphragm valve size is smaller, approximately 2/3, than that used for the typical design. The size however must be based on specific pump characteristics. With this configuration, when the pump is off, the PCV is open. When the pump is signaled to start, the PCV closes over a brief time period, usually 30 to 60 seconds, to provide sufficient time for the pump to reach full speed and air evacuated through the PCV that is retained in the piping between the pump impellers and check valve. As the PCV closes, the pump discharge pressure increases until it starts to exceed the system pressure downstream of the check valve. As this occurs, pump discharge flow is diverted from the PCV to the system. When a pump is signaled to stop, the PCV is signaled to open first and pump discharge flow into the system decreases as it increases through the PCV. When the PCV open contact is actuated, the pump is permitted to stop. PCV open/close speed is normally set by needle valves on a hydraulically actuated diaphragm valve. With this non-typical design, pump discharge starts at a low pressure high flow through the PCV system, then climbs to system pressure and decreasing flow as the PCV closes and flow is contributed to the system flow. Individual air/vacuum valves on each pump discharge header are not necessarily required.

The main advantages of the non-typical PCV design with higher pressure and larger flow pumps include smaller PCVs, less stress and strain on pumps and lower surge influence on system during normal pump start/stop sequences.

Detention Pond

A non-lined detention pond is necessary on the site to contain emergency wetwell overflow, waste water generated during cleaning the wetwell cells, containment of non-contaminated facility reject water such as emergency eyewash or showers, and 'pigging' of the pipeline. The detention pond size is approximately 3 feet deep covering an area of 6000 square feet. These pond dimensions provide detention space for containing approximately 90,000 gallons of water in a 1-foot depth, 1-foot depth for stormwater and sludge, and 1-foot of freeboard depth. The 90,000-gallon volume in a 1-foot depth is the summation of contributory volumes as follows:

- Anticipated waste water and wash water generated during two cleaning cycles per year of all wetwell cells - 42,000 gallons;
- Emergency overflow volume – 8,500 gallons;
- 'Pigging' operational volume - 35,000 gallons;
- Miscellaneous storage – 4,500 gallons.

The historic evaporation rate in North Dakota is 12 inches per year.

'Pig' Receiving System

'Pigging' of the transmission pipeline from the Intake Pump Station to the BPS/PTF will rarely if ever be a necessary operation. However, the 'pig' receiving system is incorporated into this facility design to minimize 'downtime' when facility if the 'pigging' operation becomes necessary in the future. Incorporating the necessary components of a 'pig' receiving system is a relative minor cost to the overall facility cost if constructed as part of the BPS/PTF. The 'pig' receiving system is an extension of the 36-inch BPS/PTF influent pipeline that discharges to the detention pond. It consists of a 36-inch gate valve with a 4-inch by-pass plug valve, both with manual operators, and a flap-gate valve. The gate and plug valves are anticipated to be buried valves with manual operator valve boxes. The flap gate valve will be mounted on the headwall at the detention pond influent box.

The 'pigging' operational volume of 35,000 gallons in the detention pond is equal to the quantity of water contained in 1/8 mile of 36-inch pipeline. At a pumping rate of 5 mgd (3,475 gpm) the 'pig' will travel at 1.1 fps which equates to stopping the 'pig' 10 minutes or 1/8 mile prior to the 'pig' receiving station. A transponder is attached to the 'pig' for tracking progress and location of the 'pig'.

Pretreatment Systems

The Pretreatment systems include chlorine injection vault, wetwell cell contactors, chlorine gas storage and feed systems, aqueous ammonia gas storage and feed systems, chlorine gas scrubber and chlorine residual analyzers. The chlorine injection vault is a pre-cast vault located over the 36-inch influent pipeline. There will be two chlorine injection quills, one of which is a spare. It is located a sufficient distance upstream of the influent valve vault to allow sufficient diffusion of the chlorine solution into the raw water. SA No. 7 – Pretreatment Facility Technical Memorandum contains a complete description of the chlorine and ammonia feed systems and components, operation and control. Separate rooms for the chlorine cylinder storage, chlorinators, and ammonia storage tanks and feeders are required by code. Code also requires each of the chlorine rooms have exterior entrance doors only. Chlorine will be normally dosed at 4.5 mg/l. This dosage will be primarily be controlled by adjusting the chlorine solution feed rate based on pump station effluent flow rate. Ammonia will be injected into the pump station discharge header. The feed rate will be flow paced controlled by pump station effluent flow rate at a dosage set to provide a chlorine to ammonia ratio of approximately 4:1.

Building

A single building is anticipated to house the booster pumps, pre-treatment chemical feeds, electrical and control equipment. The materials of construction for the building will be addressed in future SA # 24 – Booster Pump Station and Pretreatment Facility Final Design, however concrete masonry or pre-fabricated metal building are anticipated at this time. Separate interior rooms are required for the chlorine gas storage, chlorinators, and ammonia storage and feeders. These rooms are required by specific codes due to the hazardous material and quantity classifications. The chlorine scrubber may also require a separate room depending on type of scrubber and code requirements. An electrical room for the motor control centers (MCCs) is planned due to anticipated code requirements and special HVAC demands for them. The heat generated by MCCs in hot climatic conditions may exceed the maximum recommended operating conditions for this equipment. A separate room for the MCCs with special ventilation and air conditioning requirements is sometimes more cost effective than to incorporate it with the overall building heating and ventilation system. A unisex restroom with a toilet and sink is planned due to the remoteness of this facility. A potable water supply and wastewater handling systems will be required to serve this restroom.

Control System

A PLC based control system is planned for control and monitoring the booster pump system, chemical feed systems, pre-treatment contactor, and miscellaneous devices at the BPS/PTF. Human Machine Interface(s) (HMI) will be used for local control and input setpoints of equipment and systems through the PLC. The addition of a PC workstation is also an option for this interfacing and also to remotely monitor and/or control other remote systems and facilities. The PLC will communicate with the SCADA system via a data highway for remote operations, control and alarming of the facility. The SA No. 10 – P&ID/ Control Strategy Technical Memorandum and drawings fully describes the pretreated raw water supply system and this facility.

Normal Operation: Normal operation of the BPS/PTF starts with a Systems Operator selecting which pumps are to be operating. A flow meter on the pump station discharge header will be used to control (flow pace) the chlorine and aqueous ammonia feed rates. The flow meter does not have any control function relative to on/off control. The selection of a pump, on or off, directly controls the open/close position of the appropriate cell influent control valve. Therefore all cells with operating pumps are hydraulically connected through the influent header and associated influent control valves. The water level in a cell does not control the pump operation during normal operation. The water level in the cells, wetwell as a whole, is used for control of the Intake Pump Station (IPS) pumping rate and this level is an input value into the IPS control logic. This control will maintain a very stable water level because the booster pump system will operate at a constant discharge flow rate. With a constant speed booster pump, pumping at a constant rate, the detention time of flow through the associated cell will remain constant. The detention time is a function of the flow rate divided by the cell volume multiplied by the ratio of a T10/T factor. The T10/T factor relates the effectiveness of the cell to perform as a plug flow vessel. It is anticipated that a T10/T factor for all of these cells will be between 0.7 and 1.0 based on MWH experience. A tracer test is the only method to specifically determine the factor value. However, this variance will be accounted for by selection of the appropriate wetwell water level setpoint. An operating depth of 6.0' to 8.4' relatively corresponds to 1.0 to 0.7 T10/T values by adjusting effective contact time.

Emergency Operation: Emergency operation consists of loss of SCADA/telemetry, loss of facility power, loss of facility PLC, and high wetwell level. All of these conditions will automatically force shutdown of all equipment at the facility except the PLC and wetwell cells influent valves. The 'A' and 'B' influent valves for each cell may each have an open/close actuators for emergency valve closure due to high wetwell water level, loss of SCADA/telemetry, and loss of facility PLC. Valve 'B' is the primary emergency valve and valve 'A' if provided with an electric actuator would provide emergency backup to valve 'B'. The need and value of valve 'A' having an electric actuator to provide 100% redundancy for emergency operation should be discussed. Operator local or remote closure is for emergency operation only. Closure speed of these valves will be 90 seconds maximum. If the IPS is pumping 26 mgd, this equates to 8,700 gallons of flow into the wetwell during this time. Emergency closure of these valves will be initiated if the wetwell level is within 18 inches below the overflow weir. A 18-inch wetwell depth allowance for overflow between initiating emergency valve closure and the invert of the overflow weir provides a volume of approximately 4,575 gallons and 8,140 gallons in the 6'-0" and 10'10" wide cells respectively. Therefore, there may be minor overflow into the detention pond if there is a failure of the level control system of the IPS. However, loss of level control signal will also initiate emergency closure of valve 'B'. If the wetwell was operating at a normal water level of 7 feet when the signal was lost, or any of the other emergency conditions, there is an additional 1.5 feet of storage depth prior to overflow.

Fail-Safe Operation

Fail-safe operation of the Booster Pump Station is incorporated into the design of this facility to meet the failure scenarios and contingency plan actions described in the NAWS PROJECT BIOTA TRANSFER CONTROL FACILITIES and CRITERIA – December 1997 Report. Table 4-1 Failure Scenarios and Contingency Plan Actions of this report list the failure scenarios and corresponding actions for the entire raw water and pretreated raw water delivery system. Specific fail-safe Booster Pump Station features function as part of the hydraulic cascading shutdown sequence. Shutdown of the booster pumps is initiated when the Pretreated Water Storage Reservoir influent valves are forced closed as part of the facility fail-safe operation. This creates a zero booster pump discharge flow. Individual flow switches on each pump will electronically disconnect which will shutdown each pump under a zero flow condition. Shutdown of the booster pumps will cause the water level in the wetwell cells to rise. A common wetwell level transmitter is the primary device to signal high-high wetwell level and subsequently close the cell(s) influent valve(s). Individual level switches are designed for each cell which provides redundant high-high level signal to close the respective cell influent valve.

Heating and Ventilation System

The heating and ventilation system(s) for this facility will most likely require independent systems for each space/room. This is due to the different heat loads generated by the pumps and MCCs verses the other spaces, and the special air changes per hour requirement in the chemical rooms. The chemical rooms also require special ventilation system control if a leak is detected within a space. Heating system options for each space/room that appear to be appropriate are gas-fired or electric unit heaters.

Miscellaneous Systems

Miscellaneous systems include emergency eyewash/ shower and tempered heating system, potable water supply system, and wastewater handling system. Emergency eyewash and shower stations are required at strategic locations inside and outside of the BPS/PTF because of the chemical storage and feed systems. This requirement necessitates having a potable water supply at the facility. It is highly recommended to provide tempered water to the emergency eyewash and shower stations to mitigate shock if the water supply temperature is below 60 degrees F. A restroom also requires a potable water supply with a short duration of demand in the 2-gpm range. The emergency stations and restroom may be connected in common to a facility potable water supply. A metered connection to the Max community water supply is the only reasonable supply source. The potable water demand for any one of the emergency devices is normally limited to 30 gpm for 15 minutes with a pressure range of 40-60 psig . A hydro-pneumatic tank(s) system will most likely be required to provide sufficient storage volume for these devices.

A wastewater handling system will be required if a restroom is provided at the BPS/PTF. All other wastewater flows including floor drains, washdown water, analyzer waste stream, and emergency wash fixtures, could be sent to the detention pond. A wastewater handling system could be a septic tank and drain field if the soil conditions in the area of the facility provide acceptable perculation rates. Otherwise the wastewater will have to be pumped to the Max wastewater treatment facility.

Cost Estimate

Table 1 is a predesign level estimate of probable constructed cost for the Booster Pump Station. The cost does not include that portion of the building that houses the pretreatment equipment and 50 percent of the wet well/contactor.

TABLE 1

BOOSTER PUMP STATION CONSTRUCTION COST ESTIMATE

Item	Quantity	Units	Unit Cost	Cost
Excavation	1,050	CY	$ 3.50	$3,675.00
Structural Fill	2,050	CY	$ 15.00	$30,750.00
Concrete				
Footings	55	CY	$ 300.00	$16,500.00
Stem Walls	180	CY	$ 400.00	$72,000.00
Floor Slab	258	CY	$ 300.00	$77,400.00
Stairs	10	CY	$ 350.00	$3,500.00
Building				
General Area	4,270	SF	$ 83.00	$354,410.00
Room Areas	660	SF	$ 91.00	$60,060.00
Mechanical				
9 MGD Pumps	3	Ea	$ 108,000.00	$324,000.00
5 MGD Pumps	2	Ea	$ 83,000.00	$166,000.00
Pump Control Valves (16")	3	Ea	$ 15,000.00	$45,000.00
Pump Control Valves (12")	2	Ea	$ 9,000.00	$18,000.00
Pipe, Fittings, Misc.	1	LS	$ 93,000.00	$93,000.00
Valves & meters	1	LS	$ 101,000.00	$101,000.00
Surge Tank/Compressor	1	LS	$ 60,000.00	$60,000.00
Misc. Metals, Hatches & Ladders	1	LS	$ 20,000.00	$20,000.00
Electrical/ Instrumentation	1	LS	$ 815,000.00	$815,000.00
Wet Well/Contactor at 50%	1	LS	$ 241,900.00	$241,900.00
Yard Piping / Site Work	1	LS	$ 50,000.00	$50,000.00
Overflow Basin	1	LS	$ 25,000.00	$25,000.00
			Subtotal	**$2,577,195**
Construction Contingency At 20%				$515,439
			Subtotal	**$3,092,634**
Mobilization/Demobilization At 10%				$309,263
Total Construction Cost				**$3,401,897**

FIGURE 1

BOOSTER PUMP STATION DESIGN CRITERIA

Description	Units	Criteria
Pump Station Capacity		
Phase 1	mgd	18
Phase 2	mgd	26
Chlorine Injection Vault		
Type: Buried Precast Concrete	-	-
Dimensions	ft (L x W x H)	6 x 8 x 9.5
Chemical Injectors	No.	2
Chemical Injector Size	Dia.	?
Influent Valve Vault		
Type: Buried Concrete	-	-
Dimensions	ft (L x W x D)	48.5 x 12 x 8.5
Influent Valves – Butterfly Valves		
Actuators – Electric w/UPS		
Cell 1, 2 BFV Dia (2 ea.)	in.	18
Cell 3, 4 BFV Dia (2 ea.)	in.	24
Cell 5 BFV Dia (Future)	in.	24
Wet Well/Contactor Cells		
Type: Buried Concrete, 5 cells	-	-
Dimensions (overall)	ft x ft	68 x 48.5
Dimensions cell 1, 2	ft x ft	68 x 6
Dimensions cell 3, 4, 5	ft x ft	68 x 10.8
Contact Time per Cell (theoretical $T_{10}/T = 1.0$)	min.	5
Depth (max at overflow)	ft.	11
Depth (HWL)	ft.	9.5
Depth (theoretical contact time)	ft.	7.0
Volume/ft Depth Cell 1, 2	gal	3,052
Volume/ft Depth Cell 3, 4, 5	gal	5,493
Max Overflow Rate	mgd	26
Surface Loading Rate	gpm/sf	8.5
Booster Pumps		
Type: Vertical Turbine	-	-
P-110, P-120	mgd (gpm)	2.66-5.47 (1,850-3,800)
P-130, P-140, P-150	mgd (gpm)	8.34-12.51 (5,800-8,700)
Max Capacity Phase 1	mgd	18
Max Capacity Phase 2	mgd	26
Operating Head TDH	ft	160-360

FIGURE 1 (Continued)

BOOSTER PUMP STATION/PRETRATMENT FACILITY
DESIGN CRITERIA

Description	Units	Criteria
Detention Pond		
Type: Unlined Earthen		
Dimensions	ft (L x W x D)	200 x 60 x 3
Total Volume (2 ft depth)	gal	180,000
Max Water Depth	ft.	2
Freeboard	ft.	1

1770 RPM ENCLOSED TYPE IMPELLER 16MKL

NO. OF STAGES	EFF. CHANGE (NO. OF POINTS)
1	−2
2	−1
3	−0

HORSEPOWER WILL BE EFFECTED BY CHANGE IN EFFICIENCY

PERFORMANCE FOR:
Bowl Pattern No.: 547419-A-R1
Imp. Pattern No.: 547415-A-R0

PUMP DATA

Shaft Dia. (IN.)	2¼
Maximum Sphere (IN.)	1¼
Maximum Head (FT.)*	718
Min. Submergence (IN.)**	32
Impeller Wt. (LBS.)	35.8
Thrust Constant (K)	20.0
Bowl O.D. (IN.)	15⅝

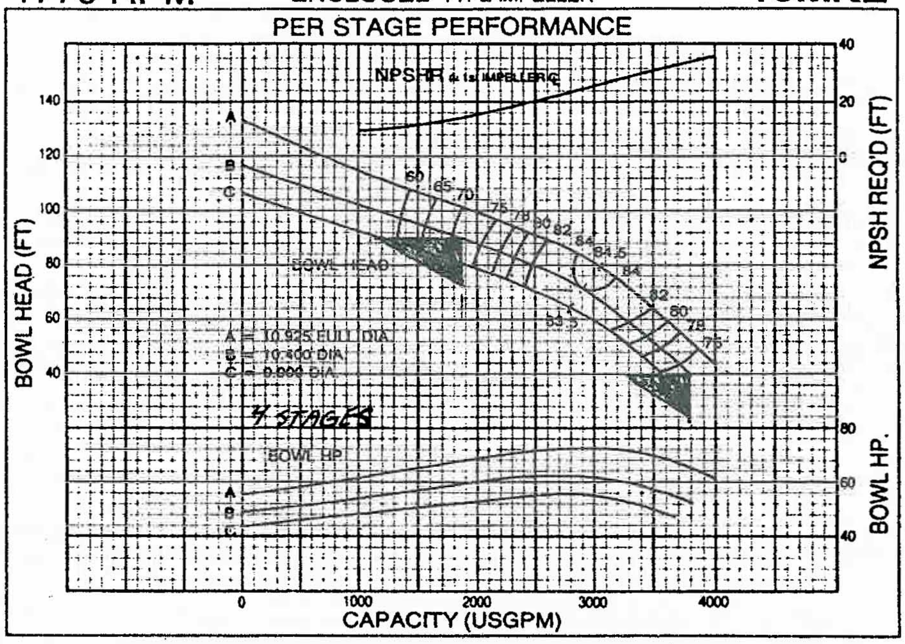
NOTES

Performance indicated based on cold water with a specific gravity of 1.0.

* Standard construction.

** Minimum submergence over lip of bell to prevent vortexing.

Efficiency improvements are available in certain instances. Please contact the factory.



1770 RPM ENCLOSED TYPE IMPELLER 16MKM

NO. OF STAGES	EFF. CHANGE (NO. OF POINTS)
1	−2
2	−1
3	−0

HORSEPOWER WILL BE EFFECTED BY CHANGE IN EFFICIENCY

PERFORMANCE FOR:
Bowl Pattern No.: 547419-A-R1
Imp. Pattern No.: 547416-A-R0

PUMP DATA

Shaft Dia. (IN.)	2¼
Maximum Sphere (IN.)	1⅜
Maximum Head (FT.)*	718
Min. Submergence (IN.)**	32
Impeller Wt. (LBS.)	32.3
Thrust Constant (K)	20.0
Bowl O.D. (IN.)	15⅝

NOTES

Performance indicated based on cold water with a specific gravity of 1.0.

* Standard construction.

** Minimum submergence over lip of bell to prevent vortexing.

Efficiency improvements are available in certain instances. Please contact the factory.

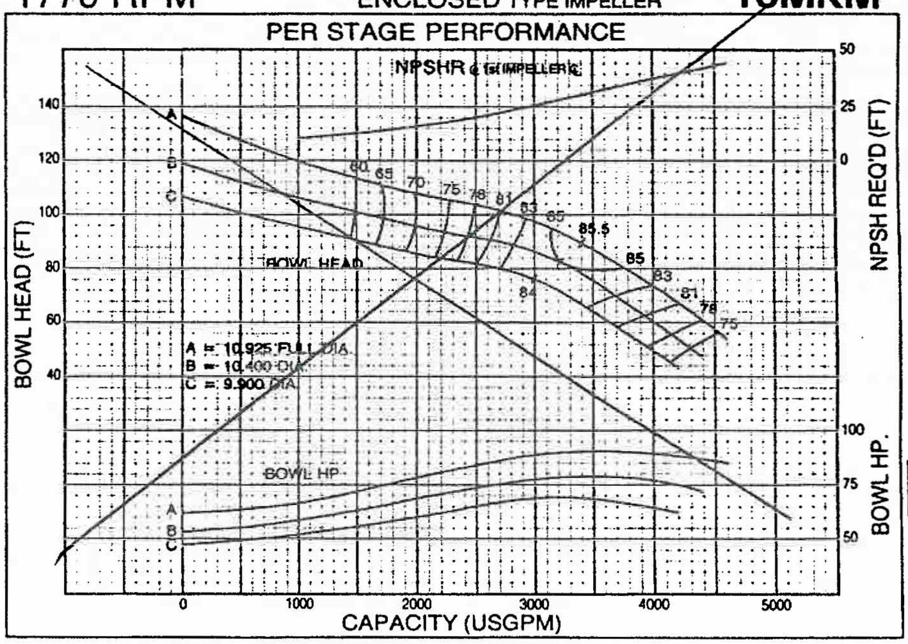


FIGURE 2

P-110, P-120

22BKL ENCLOSED TYPE IMPELLER 1770 RPM

NO. OF STAGES	EFF. CHANGE (NO. OF POINTS)
1	−0
2	−0
3	−0

HORSEPOWER WILL BE EFFECTED BY CHANGE IN EFFICIENCY

PERFORMANCE FOR:
Bowl Pattern No.: 547900-A-R0
Imp. Pattern No.: 547901-A-R1

PUMP DATA

Shaft Dia. (IN.)	2¹⁵⁄₁₆
Maximum Sphere (IN.)	1½
Maximum Head (FT.)*	601
Min. Submergence (IN.)**	48
Impeller Wt. (LBS.)	61.6
Thrust Constant (K)	40.0
Bowl O.D. (IN.)	21.0

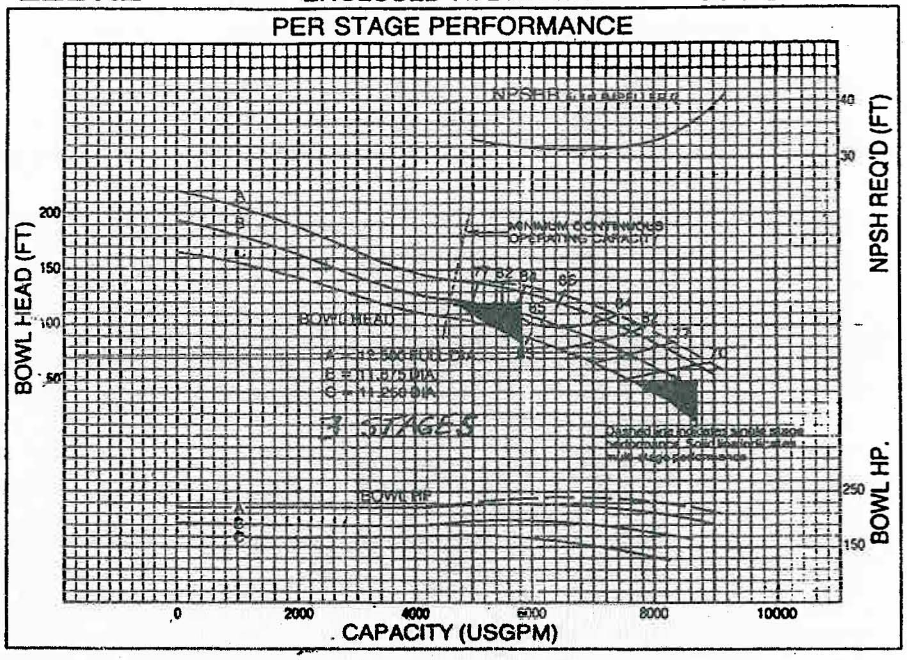
NOTES

Performance indicated based on cold water with a specific gravity of 1.0.

* Standard construction.

** Minimum submergence over lip of bell to prevent vortexing.

Efficiency improvements are available in certain instances. Please contact the factory.



22BKH ENCLOSED TYPE IMPELLER 1770 RPM

NO. OF STAGES	EFF. CHANGE (NO. OF POINTS)
1	−0
2	−0
3	−0

HORSEPOWER WILL BE EFFECTED BY CHANGE IN EFFICIENCY

PERFORMANCE FOR:
Bowl Pattern No.: 547900-A-R0
Imp. Pattern No.: 547903-A-R1

PUMP DATA

Shaft Dia. (IN.)	2¹⁵⁄₁₆
Maximum Sphere (IN.)	1½
Maximum Head (FT.)*	601
Min. Submergence (IN.)**	48
Impeller Wt. (LBS.)	61.6
Thrust Constant (K)	40.0
Bowl O.D. (IN.)	21.0

NOTES

Performance indicated based on cold water with a specific gravity of 1.0.

* Standard construction.

** Minimum submergence over lip of bell to prevent vortexing.

Efficiency improvements are available in certain instances. Please contact the factory.

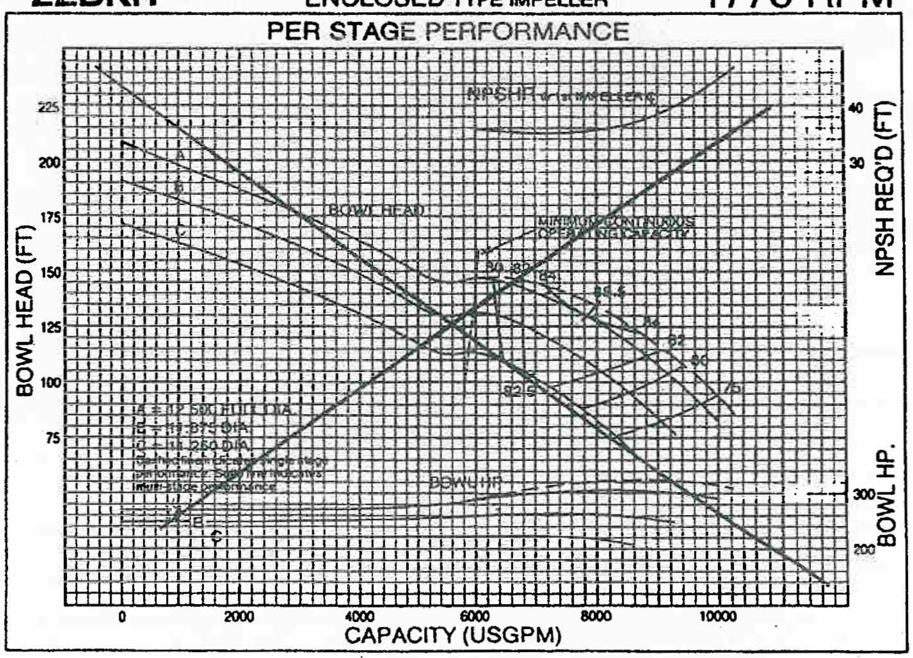
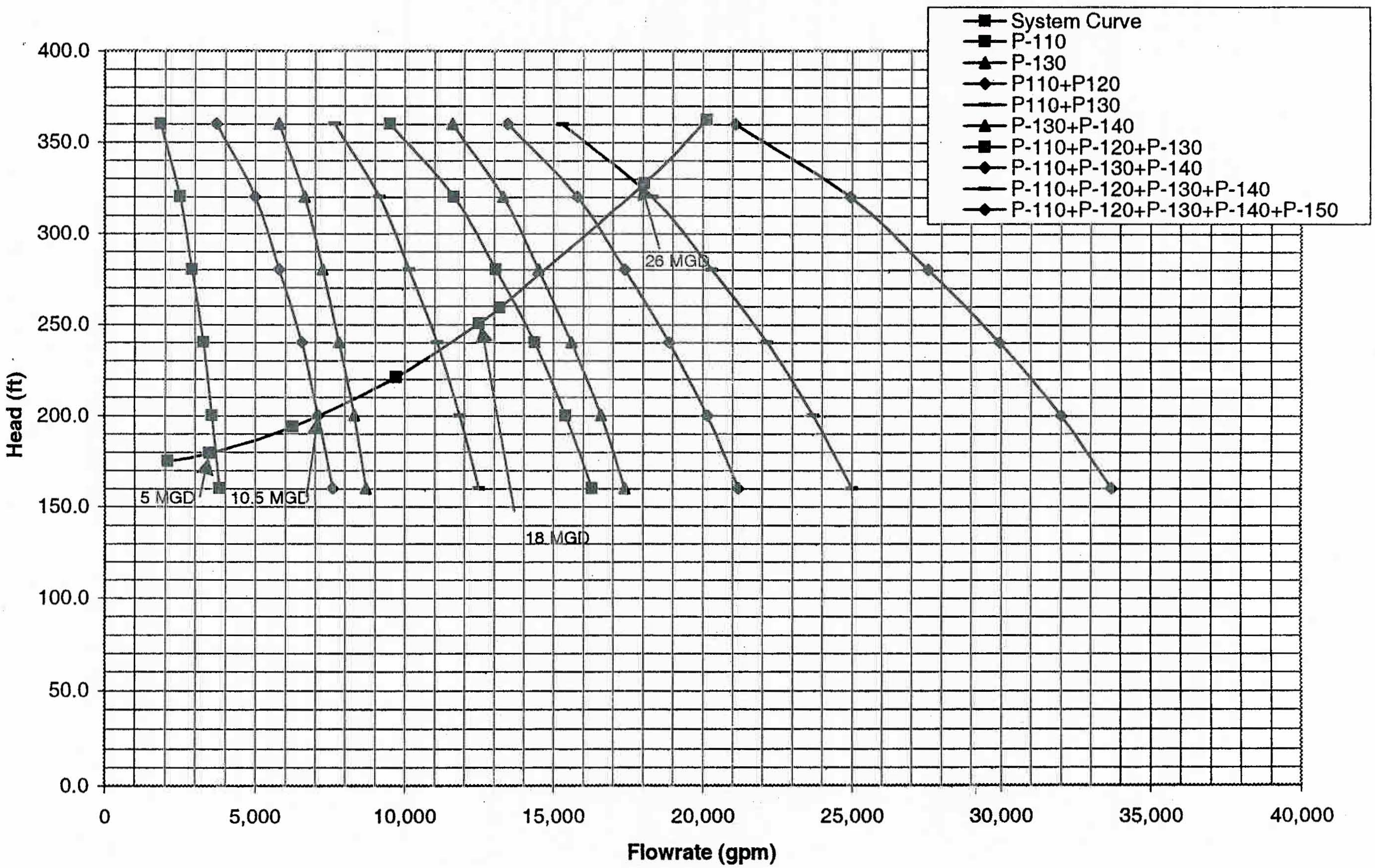
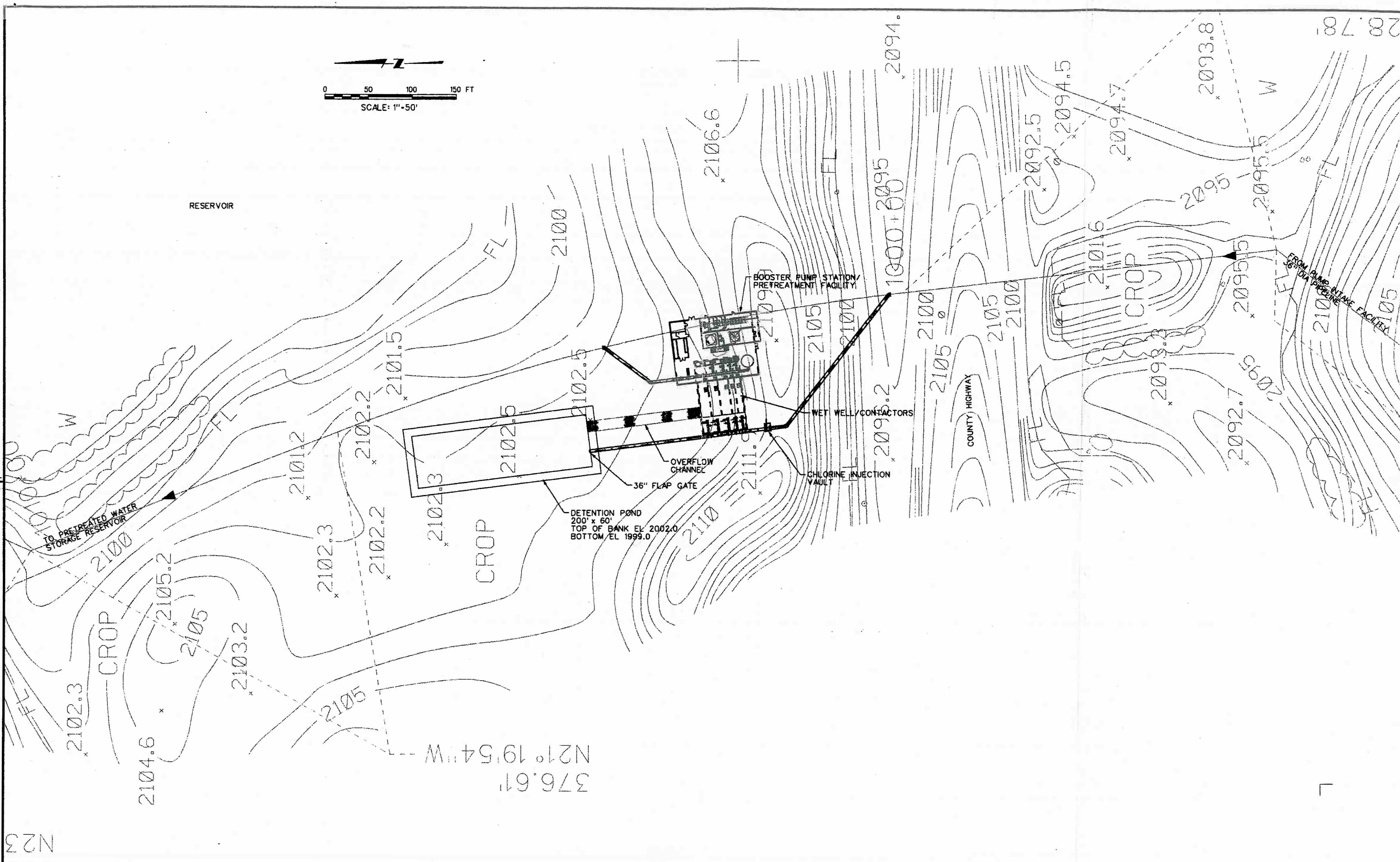


FIGURE 3

P-130, P-140, P-150

FIGURE 4 - PUMP CURVES BOOSTER STATION





REV	DATE	BY	DESCRIPTION

HOUSTON ENGINEERING, INC.

MWH
MONTGOMERY-WATSON HARZA

SCALE

WARNING
0 ½ 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED
DRAWN
CHECKED

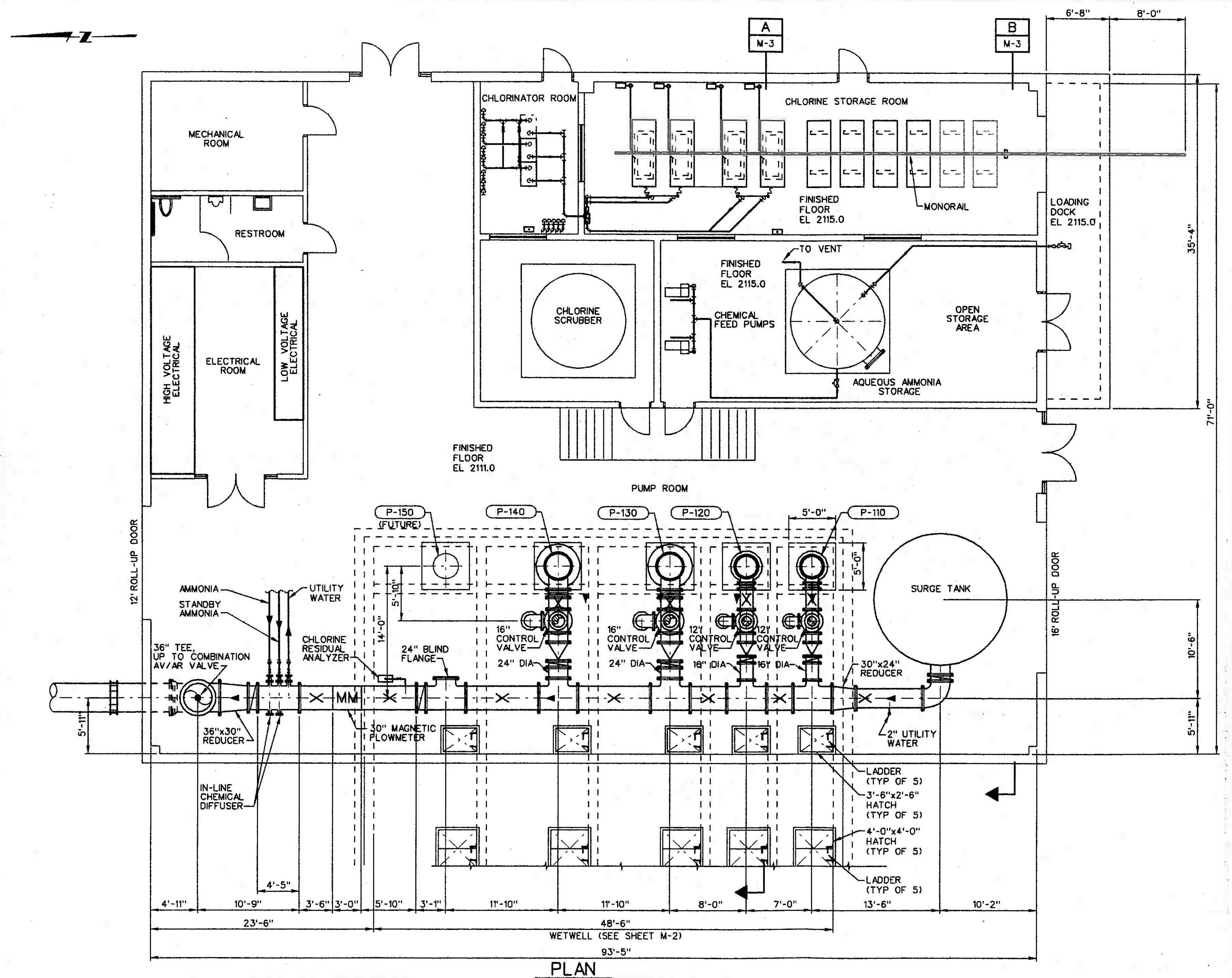
NORTHWEST AREA WATER SUPPLY

CONTRACT 4-1A
NORTHWEST AREA WATER SUPPLY PROJECT
BOOSTER PUMP STATION/PRETREATMENT FACILITY
SITE PLAN

SHEET
BPS/PTE
C-1

Job No: 1690128
File: \\usboils-server\Projects\naws\sa-7\pretreatment\civ\sa7c01.dgn
Plot Date: 30-DEC-2003 11:32
mrwein

mrwein
Plot Date: 30-DEC-2003 11:33



PLAN

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Job No: 1690128

REV	DATE	BY	DESCRIPTION

HOUSTON ENGINEERING, INC.
MWH
MONTGOMERY WATSON HARZA

SCALE: 3/16" = 1'-0"

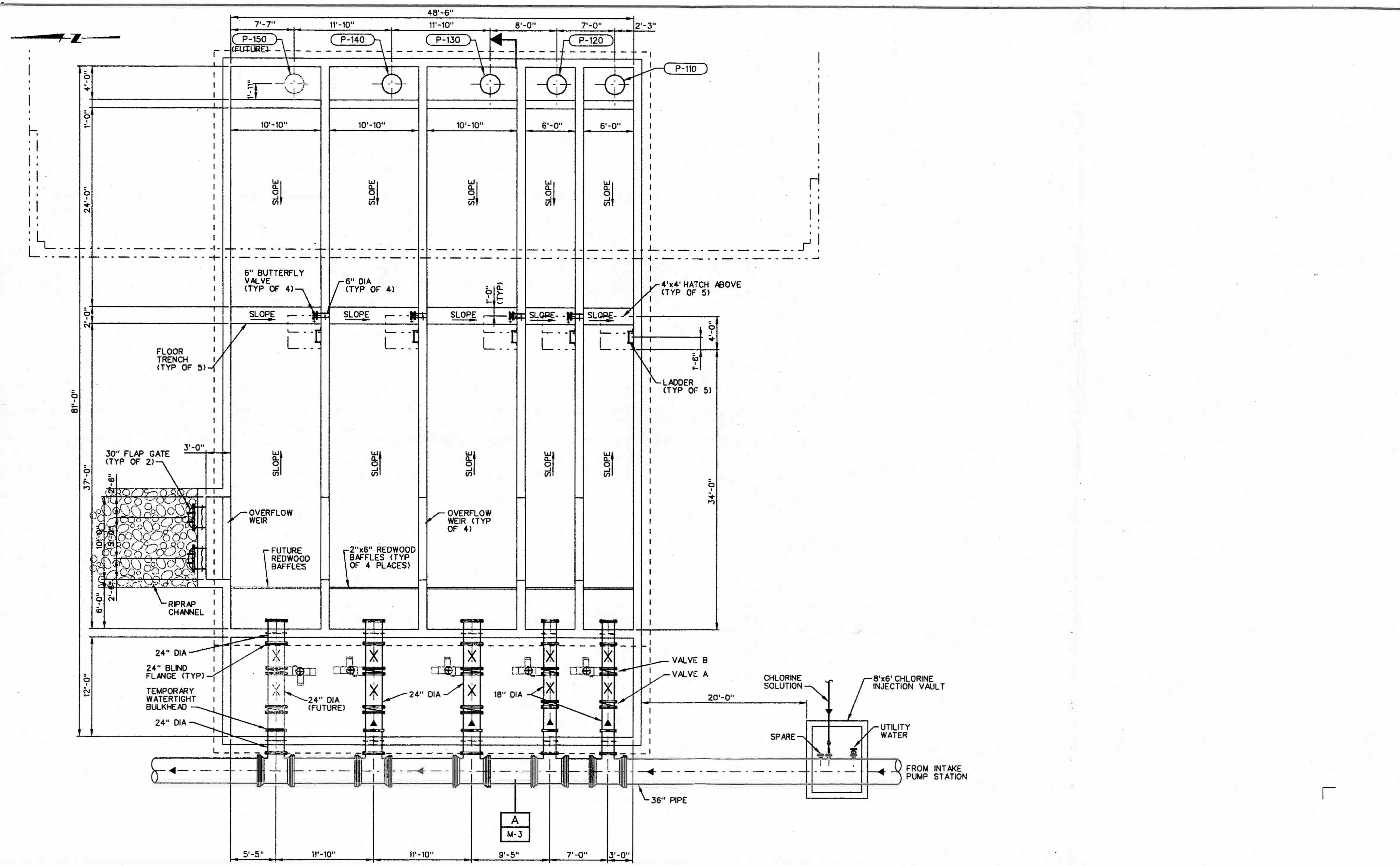
WARNING: 0 1/2 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED P. NAYLOR
DRAWN P. HUNTER
CHECKED S. GILBERT

NORTHWEST AREA WATER SUPPLY

CONTRACT 4-1A
NORTHWEST AREA WATER SUPPLY PROJECT
BOOSTER PUMP STATION/PRETREATMENT FACILITY
BUILDING PLAN

SHEET BPS/PTE M-1



mrwaln Plot Date: 30-DEC-2003 11:33

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Job No: 1690128

REV	DATE	BY	DESCRIPTION

HOUSTON ENGINEERING, INC.

MWH MONTGOMERY WATSON HARZA

SCALE: 3/16" = 1'-0"

WARNING: 0 1/2 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED P. NAYLOR
DRAWN P. HUNTER
CHECKED S. GILBERT

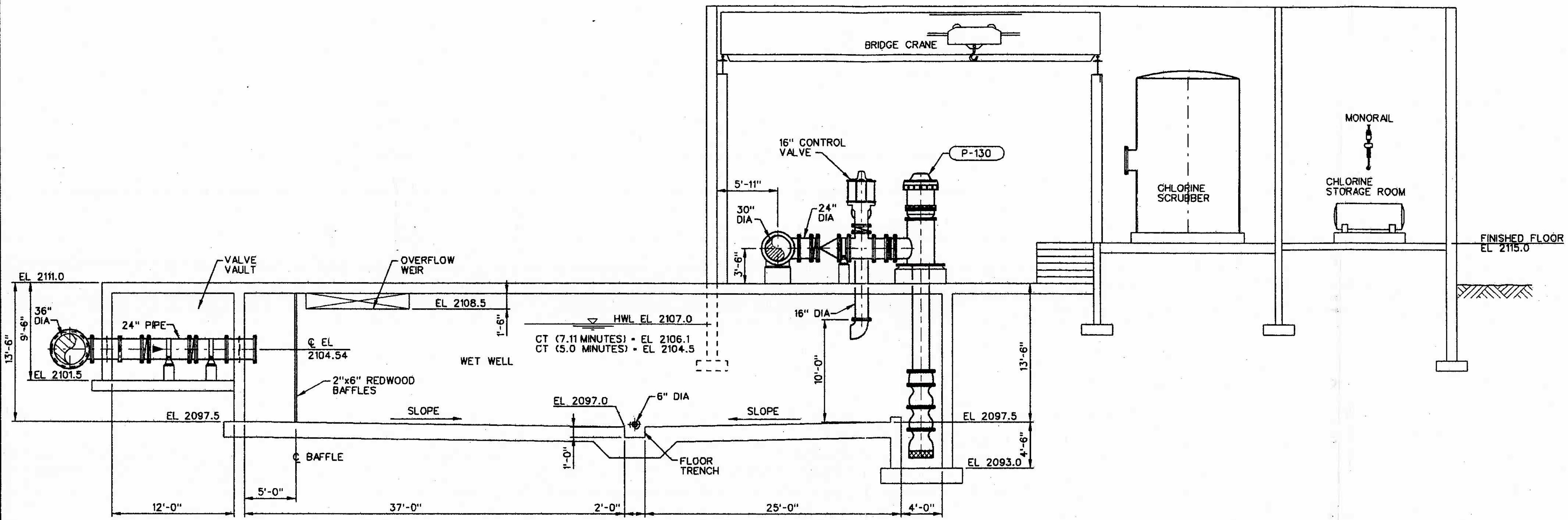
NORTHWEST AREA WATER SUPPLY

CONTRACT 4-1A

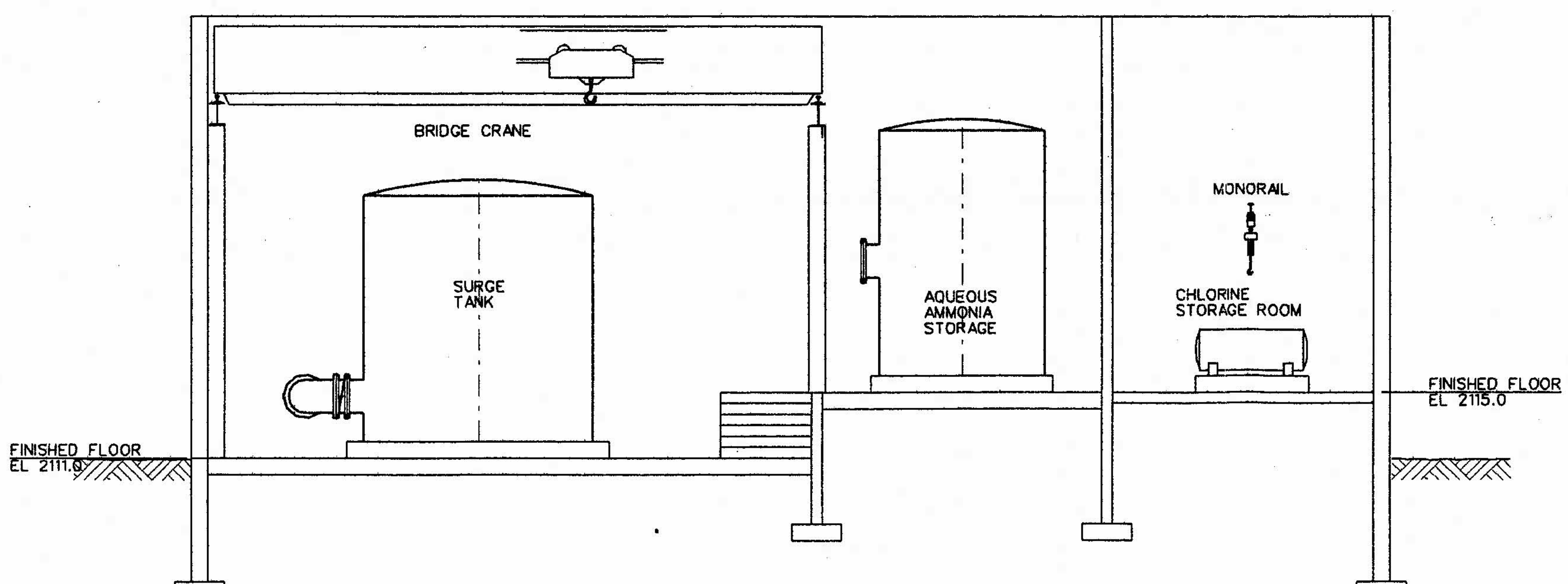
NORTHWEST AREA WATER SUPPLY PROJECT
BOOSTER PUMP STATION/PRETREATMENT FACILITY
WET WELL PLAN

SHEET BPS/PTE M-2

mrwein
Plot Date: 30-DEC-2003 11:34



SECTION A
SCALE: 3/16" = 1'-0"
M-1,2



SECTION B
SCALE: 3/16" = 1'-0"
M-1

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Job No: 1690128

REV	DATE	BY	DESCRIPTION

HOUSTON ENGINEERING, INC.
MWH MONTGOMERY WATSON HARZA

SCALE AS NOTED

WARNING 0 1/2 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED P. NAYLOR
DRAWN P. HUNTER
CHECKED S. GILBERT

NORTHWEST AREA WATER SUPPLY

CONTRACT 4-1A
NORTHWEST AREA WATER SUPPLY PROJECT
BOOSTER PUMP STATION/PRETREATMENT FACILITY
SECTIONS

SHEET BPS/PTE M-3