Help Instruction File:

Pumping Module Overview

Provided by the Office of Surface Mining Reclamation and Enforcement (OSMRE), the Pennsylvania Department of Protection (PADEP), the U.S. Geological Survey's (USGS) and the West Virginia Department of Environmental Protection (WVDEP).

Pumping Module Overview

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1.0 Objective
In the AMDTreat program, pumping is considered an ancillary treatment component of a mine drainage treatment facility. The construction of boreholes and installation of pumps and pipelines allow for the movement of influent water to the treatment site. Therefore, the AMDTreat program included this module to allow the user to capture the costs associated with constructing influent pumps, pump boreholes, control systems and conveyance pipelines, including pipeline appurtenances, as part of a mine drainage treatment facility.

The objectives of the overview are to (1) Provide an understanding of the application of pumping in mine drainage treatment facilities and (2) Provide an overview of the Pumping Module including guidance to users in developing a cost estimate to construct this treatment system component. This module, as well as most of the other AMDTreat modules, can also be applied to reverse cost model existing systems and system components to establish and evaluate future financial and investment decisions. The information is presented in two sections, **Overview and Application** and **Pumping Module Overview**.

2.0 Overview and Application
A basic understanding of the application and equipment requirements for both influent pump systems and conveyance pipelines are required to develop an accurate cost estimate using the AMDTreat software. These topics are discussed below before discussing the Pumping Module interface and functionality to provide the necessary context. The Overview and Application section is organized into two parts: (1) Functions and (2) Configuration & Application.

2.1 Functions
The following is a list of the potential functions of pumping on a mine/treatment site:

1. Control mine pool elevation(s).
2. Convey water to the treatment site.
3. Transfer or convey water between mine pools or discharge outfalls in order to control and or treat multiple mine drainage sources at a common location.

2.2 Configuration & Application
Engineering principles and manufacturer recommendations should be employed when considering the use of pumping as part of a treatment system. Pumps should be designed and constructed in order to convey mine water considering the following items in addition to the necessary flow rate:

1. Number of pumps/wells.
2. Size of well/borehole.
3. Drilling depth to mine pool.
4. Total dynamic head (TDH) pressure.
5. Pumping time (daily and annual).
6. Estimated pump efficiency.
7. Pipe fluid velocity.

It is highly recommended to work closely with a design engineer or pump manufacturer representative to ensure the most appropriate pump type, type of materials used in pump construction, and size is used for the application. Drawing or design software (e.g., AutoCAD) may be beneficial in terms of obtaining the various dimensions of a pumping system then using this information in AMDTreat to obtain the costing information.

The application of pumping systems at mine drainage treatment facilities will depend on the intended purpose. Most pumping applications in mine drainage treatment systems involve conveying water from an underground mine pool to the surface for treatment. Pumping allows the user to direct the mine water to an appropriate site with enough available land area for the necessary treatment system, most often an active chemical treatment facility but not exclusive of possible passive treatment alternatives as well. Pumping systems can also control mine pool elevations to prevent uncontrolled surface discharge of mine water. These are just a few examples for the application of pumping specifically for mine drainage treatment or mine pool control purposes. The AMDTreat program can be utilized to conceptually size these facilities as part of the treatment system and estimate the costs associated with them.

It should be noted that in the current version of AMDTreat the Pumping Module is designed to model one specific type of pump, a Vertical Turbine Lineshaft Pump (VTLP). These pumps have a drive motor on the surface connected by a drive shaft assembly to a turbine pump bowl assembly located downhole at the desired pumping depth (see Figures 1 and 2). In the experience of the AMDTreat team, VTLP pumps are the most common and most efficient type of high-capacity influent pumps used at mine drainage treatment facilities but other pump types do exist, such as submersible turbine pumps, and are employed at mine drainage treatment facilities. This underscores the aforementioned statement regarding consultation with design engineers and pump manufacturing experts when making conceptual and design choices. The following weblink will also assist the user by describing various types of high-capacity pumps:
Submersible vs. Lineshaft Vertical Turbine Pumps: Advantages and Limitations | WaterWorld

3.0 Pumping Module Overview

This section focuses on describing the specifics of the AMDTreat Pumping Module.

3.1 Layout and Workflow

In general, inputs are on the left-hand side of the module and calculated outputs are on the right. The module inputs on the left-hand side are generally arranged into three sections: (1) Vertical Turbine Pump Borehole, (2) Conveyance Pipeline, and (3) Vertical Turbine Pumps. The workflow for users is to begin at the top left-hand side and continue down on the left-hand side entering all the appropriate input parameters.

Module output is provided on the right-hand side of the module. Module outputs are arranged into four sections: (1) Sizing Summary, (2) Capital Cost, (3) Annual Cost, and (4) Net Present Value. The Sizing Summary section provides the Pipe Inside Diameter, Pipe Dynamic Losses, Total Dynamic Head, Pipe Total Dynamic Head Pressure, Pipe Pressure Class (SDR#), Pipe Fluid Velocity, Pump Flow Rate, Pump Shaft Horsepower, and Gravel Pipe Bedding Weight. The estimated cost to construct and maintain the pump, it's ancillary components and the Conveyance Pipeline including electric cost is provided under the Capital Cost and Annual Cost headings. The final output section includes the Net Present Value (NPV) analysis. This section provides an estimate of the total cost to operate and maintain a Pumping system component for a defined time period.

A general overview of the module input and output sections is presented below, however, users are directed to the numerous tool tips located in the module that provide additional detailed information, such as definitions of terminology. In most cases, the tool tips are accessed by clicking on the information icon ( ) in each of the subheadings in the module.

3.2 Module Inputs

3.2.1 Vertical Turbine Pump Borehole: This section allows the user to select the *Number of Wells* and the borehole sizing and define the costs associated with the process.

3.2.1.1 Number of Wells - This user input allows the selection of the *Number of Wells* to be bored to the mine pool.

3.2.1.2 Inside Diameter - This user input allows the choice between 16, 24, 30, and 36-inch *Inside Diameter* boreholes for the drilling and casing installation cost ($/ft).

3.2.1.3 Borehole Sizing Multiplier - This user input allows the user to apply a multiplier to the borehole sizing to accommodate the drilling and well installation process.

3.2.1.4 Drilling Depth to Mine Pool - This user input represents the vertical depth, in feet, required to reach the mine pool from the surface.

The user should note that the Vertical Turbine Pump Borehole portion of the module only provides cost calculations based upon user selected values for *Number of Wells*, selected *Inside Diameter* and *Drilling Depth to Mine Pool*. Pump sizing is determined by selections made in the Conveyance Pipeline section below (primarily *Flow Rate* and *Total Static Head*). Consequently, once the horsepower (HP) rating has been calculated, the user should then consult with pump manufacturers or equivalent pump system experts to verify that the appropriately sized borehole has been selected and matched to the appropriate size pump.

3.2.2 Conveyance Pipeline (HDPE): This section contains selection options for pipeline (see Figure 3), appurtenances, and installation, as well as the *Total Static Head*, percentage of *Incidental Head Losses* and desired *Flow Rate*. As noted in the previous section, some of these values are also used by the AMDTreat program to calculate the required vertical turbine pump horsepower. The default values are based on prior experience of the AMDTreat team; however, these values can and should be adjusted according to the specific site conditions.

3.2.2.1 Flow Rate - The projected *Flow Rate* of mine water to be pumped. Note that if the user is envisioning the use of multiple pumps, the *Flow Rate* entered by the user should be divided by the number of pumps that are planned to be used. The AMDTreat program does not automatically do this based upon the number of wells selected in the Vertical Turbine Pump Borehole section of the Module (section 3.2.1 above). If multiple pumps are envisioned for the project, especially if they will be using separate conveyance pipelines, the user may opt to model the site by evaluating each pump system in separate AMDTreat Pumping Modules. The Help File for the Main User Interface (MUI) contains additional information for opening multiple modules.

3.2.2.2 Nominal Pipe Outside Diameter - The user is provided a dropdown menu with the pipe sizes of 8, 10, 12, 16 and 18-inch outside diameter options to choose from.

3.2.2.3 Estimated Iron Pipe Size (IPS) Standard Diameter Ratio (SDR) - The user is provided a dropdown menu with the *Standard Diameter Ratio (SDR)* values 7, 9, 11, 13.5 and 17. IPS is an older pipe sizing system based on the inside diameter of the pipe. SDR is a method of rating the durability of a pipe against pressure and it describes the correlation between the pipe diameter and the pipe wall thickness. Pipes with a lower SDR number can withstand higher pressures than the same diameter pipe having a higher SDR number. The AMDTreat program will guide the user in selecting the appropriate SDR rating for the pipe diameter selected and the operational conditions selected (head, flow rate, length of pipeline). The program will issue an error message if the SDR value selected by the user has an insufficient pressure rating. The program will also notify the user in the case where the SDR value selected results in a pipe selection having a pressure rating that significantly exceeds the expected operational pressures and where one or more higher SDR number pipes could be used to lower the estimated cost.

3.2.2.4 Total Static Head - This input allows the user to enter the *Total Static Head* pressure expected for the pumping system. *Total Static Head* is the difference in elevation between the liquid levels of the suction (intake), or the lowest achievable elevation of pumping in cases where the selected pump requires a given water level be maintained above the pump intake, and discharge of the pumping system.

3.2.2.5 Pipe Laying Length - This input allows users to set the total pipe length from the borehole to the discharge location for the pumping system.

3.2.2.6 Incidental Head Losses - This input represents the reduction in total head or pressure as a percent that results from fluid flowing through a piping system. The head loss that occurs in piping systems is based on the fluid velocity, pipe diameter and length, friction factor for the pipe roughness, and the Reynolds number representative of the flow. Bends/elbows, valves and other pipe fittings also play a role in the head losses experienced in a piping system. The default value provided can be changed by the user to more accurately reflect site specific conditions.

3.2.2.7 Pipe Bedding Thickness - This input represents the thickness of the gravel bed placed under the entire length of conveyance piping in order to provide support for the bottom portion of the pipe from the borehole to the discharge point.

3.2.2.8 Gravel Pipe Bedding Unit Cost - This input represents the unit cost per ton of gravel used for the pipe bedding installed under the conveyance piping.

3.2.2.9 Excavation Unit Cost - This input represents the excavation unit cost in dollars for the pipe trenching.

3.2.2.10 Backfill and Compaction Unit Cost - This input is the cost associated with backfill and compaction of the buried conveyance pipeline and is represented in dollars per cubic yard.

3.2.2.11 Air/Vacuum Release Assemblies - This input is an optional but recommended item associated with the conveyance pipeline that is installed at the high point(s) in the pipeline where air pockets accumulate and the air release valve allows the air to be released from the pipeline allowing for increased efficiency of the pipeline and pump and also provides protection from hydraulic shock (water hammer effect). The vacuum release value component of the assembly allows air to enter the pipeline when the pressure in the pipeline is less than the atmosphere and prevents collapse of the pipeline. The input for this item allows the user to specify the quantity and the cost per unit.

3.2.3 Vertical Turbine Pumps: This section allows the user to provide specific information related to a proposed or existing Vertical Turbine Pump, which are commonly used to pump water from an underground mine pool to the surface for treatment. This specific information includes the *Number of Pumps*, *Pump Efficiency*, *Pump Sizing Safety Factor*, *Concrete* and *Electrical Unit Costs*, operational times, *Pump* and *Pipeline Maintenance Factors*, and if a *Soft Start/Variable Frequency Drive (VFD)* is desired are all used to estimate the pump size, Capital Cost, and Annual Costs.

3.2.3.1 Number of Pumps - This input allows the user to select the number of vertical turbine pumps for the project. As mentioned above, the AMDTreat pumping module does not divide the user selected flow rate entered in the Conveyance Pipeline section (Section 3.2.2.1) by the Number of Pumps the user selects in this section. Consequently, in certain modeling and costing scenarios, the user may opt to model the site by evaluating each pump system in a separate AMDTreat Pumping Module. The Help File for the MUI contains additional information for opening and working multiple modules.

3.2.3.2 Estimated Pump Efficiency - This input allows the user to specify the efficiency of a pump if it is known based on the manufacturer's information. The overall efficiency of a centrifugal pump (a Vertical Turbine Pump is a type of centrifugal pump) is the ratio of the water (output) power to the shaft (input) power. Most medium and large sized centrifugal pumps have efficiencies ranging from 75 to 93%.

3.2.3.3 Pump Sizing Safety Factor - This input allows the user to add a safety factor in determining the appropriate size of the pump for the specific application. Therefore, if the calculations for sizing a pump determine that the pump shaft horsepower should be 20 HP and the user specifies a sizing safety factor of 0.20, the resulting pump shaft horsepower will be 20 x 1.2 = 24 HP as an example.

3.2.3.4 Concrete Unit Cost - This input allows the user to adjust the unit cost of concrete based on dollars per cubic yard ($\$/yd^3$).

3.2.3.5 Electrical Unit Cost - This input allows the user to enter their current electricity rate in dollars per Kilowatt-hour ($/kWh).

3.2.3.6 Daily Pumping Time - This input allows the user to adjust the operational time by specifying the number of hours per day (hrs/day) that the pumps are operated to estimate the annual costs of the pumping system.

3.2.3.7 Annual Pumping Time - This input allows the user to adjust the operational time by specifying the number of days per year (days/yr) that the pumps are operated to estimate the annual costs of the pumping system.

3.2.3.8 Pipeline Maintenance Factor - This input allows the user to incorporate a maintenance factor that is calculated by multiplying the user specified factor by the capital cost of the conveyance pipeline, which provides an annual cost for maintaining the pipeline system.

3.2.3.9 Pump Maintenance Factor - This input allows the user to incorporate a maintenance factor that is calculated by multiplying the user specified factor by the capital cost of the pump(s), which provides an annual cost for maintaining the pump system.

3.2.3.10 Soft Start/VFD - This input is an optional item the user can choose to include in the pump design referred to as a *Soft Start/Variable Frequency Drive (VFD)* system. The *Soft Start/VFD* are installed on the motor of the pump and the VFD allows the user to control or adjust the flow rate of the pump, while the soft start component is beneficial when there is an emergency backup generator system needed as it can reduce the size of the generator needed due to the very high starting torque on vertical turbine pumps. Figure 4 is a photo of a *Soft Start/VFD* system for a mine water pumping system. If the user keeps the box checked the cost of a *Soft Start/VFD* system is included in the Capital Cost for the pumping system. Additionally, VFD's can significantly reduce system operational costs as they can allow for much more precise mine pool operational control. For example, during low flow seasonal conditions pumping rates can often be reduced thus reducing electrical costs, treatment chemical utilization, sludge generation and over pumping (excessively lowering) of the mine pool. In many instances mine pools that are held within a narrow range of operating levels show significant improvement in raw water quality over time as compared to similar pools where flooded elevation can fluctuate significantly. Lastly, the decision to include *Soft Start/VFD* systems may depend upon the utility company providing electrical service. In many cases for new applications, due to electrical load utility companies may or will require these systems on all motors above a given HP rating. Contacting the utility provider in advance of project design is recommended.

3.3 Module Outputs

3.3.1 Sizing Summary: The Sizing Summary section displays important calculated module outputs, such as estimates of pipe inside diameter, pipe dynamic losses, total dynamic head, pipe total dynamic head pressure, pipe pressure class (SDR#), pipe fluid velocity, pump flow rate, pump shaft horsepower, and the weight of bedding gravel needed for the Conveyance Pipeline.

3.3.2 Capital Cost: This section provides the estimated Capital Costs for the various components of the pumping system and the total estimated Capital Cost to install the pumping component of a treatment system.

3.3.3 Annual Cost: The Annual Cost section provides an estimate of the Annual Cost to operate and maintain the pumping component of the treatment system. Three specific items make up the Annual Costs of the pumping system including Electrical, Pump Maintenance, and Pipeline Maintenance. Each are shown under the Annual Cost section to calculate the total Annual Cost.

3.3.4 Net Present Value: The NPV section determines the cost to operate a treatment system component over a specified time period. The NPV calculates the present-day financial investment required to generate the income to pay for future operation and equipment/materials replacement costs. Both **Financial Variables** and **Cost Categories** are required to calculate the NPV.

3.3.4.1 Financial Variables - The *Term of Analysis*, *Inflation Rate*, and *Rate of Return* are three variables used in the NPV calculations. The default values for these terms are shown under the *Net Present Value* section of each module. Users must access the *Net Present Value* menu at the top of the MUI to change the default values as they would apply to all modules used for an entire treatment system. While NPV is determined for each AMDTreat module activated by the user, the goal is to determine a total NPV for an entire mine drainage treatment system project (a collection of cost estimates for individual modules creates a treatment system project in AMDTreat). Therefore, a single value for *Term of Analysis*, *Rate of Return*, and *Inflation Rate* is applied to all modules and cannot vary between modules.

- Term of Analysis: The time period used by the NPV calculation to determine the financial investment required to pay for all future costs of the treatment system.

- Inflation Rate: Represents the average price increase of goods and services over time. AMDTreat uses the inflation rate to calculate the future cost of the annual operation and maintenance (O&M) and recapitalization items.

- Rate of Return: Describes the expected profit on an investment.

3.3.4.2 Cost Categories - For each treatment module, AMDTreat provides a list of recommended equipment and materials that require recapitalization. In addition, AMDTreat provides recommendations (default values) for *Life Cycle* and *Replacement Percentage*. Users can click on the default values for *Life Cycle* or *Replacement Percentage* and use the +/- buttons to change the default values. In addition, users can select *Custom Cost* and enter a new cost to represent the current cost of the equipment. Users can add new recapitalization items or deactivate/delete existing items for calculating the NPV.

An example of how the recapitalization variables are used to determine NPV is to consider the following hypothetical scenario. Assume a vertical turbine pump has a *Life Cycle* of 50 years but requires the pump motor to be rebuilt every 20 years. Assume the present-day cost to purchase the motor is $500,000, and the cost to remove, rebuild, and reinstall the pump motor is $20,000. Now assume we want to determine the amount of investment required today (NPV) to generate the income to pay for the future cost of rebuilding the pump motor over a 50-year *Term of Analysis*, which is also equal to the *Life Cycle* of the pump. Assume an *Inflation Rate* of 5.0% and *Rate of Return* of 8.1%. The goal is to place the money in a relatively secure investment vehicle to generate 8.1% annually. The NPV will calculate the size of investment required to generate income for future costs.

There are several ways to model the replacement cost. One way is to replace 4% of the present-day cost of the pump (4% of $500,000 = $20,000) with a *Life Cycle* of every 20 years. If the *Term of Analysis* is 50 years, then the entire pump would not require recapitalization since the *Life Cycle* of the pump is 50 years. However, the motor would require two replacements (50 years / 20 years = 2.5 rounded down to 2).

To determine the NPV to recapitalize rebuilding of the motor, AMDTreat calculates the future cost to rebuild the motor at each *Life Cycle*, 20 and 40 years. The program uses the

Inflation Rate to inflate the present-day default cost to rebuild the motor in 20 and 40 years from now. While the present-day cost to rebuild the pump motor is $20,000, the future cost to rebuild the motor in 20 years at a 5.0% *Inflation Rate* is $53,065 and $140,799 in 40 years (Equation 1). Assuming an 8.1% *Rate of Return*, the 50-year NPV for the pump is $17,422. In other words, an initial investment of $17,422 is needed at an annual *Rate of Return* of 8.1% to generate the investment income required for the two motor rebuilds over the 50-year *Life Cycle* of the pump.

$$\textit{Cost to rebuild pump motor in 20 years} = \\ \textit{Present Day Cost} \times (100\% + \textit{Inflation Rate})^{20} = \$20{,}000 \times (100\% + 5\%)^{20} = \$53{,}065 \quad \textbf{(1)}$$

- Annual Operation and Maintenance Cost: By default, AMDTreat transcribes the annual O&M cost from the Annual Cost section to the NPV section. The program assumes the module is being used to estimate the Annual Cost for a treatment system component, so it automatically transcribes the Annual Cost to the NPV section. If this is not the case or the user wants to use some other Annual Cost, the "Use Custom" box can be selected to allow the user input of a different Annual Cost to utilize in the NPV calculation.

- Recapitalization Cost: Certain treatment system components, especially mechanical and water conveyance equipment, require periodic replacement. The recapitalization cost of an item is an estimate of the amount of money required to pay for future replacement costs for the item. In addition to the Financial Variables described above, three additional values are required to calculate the NPV of recapitalization costs, the Present-Day Equipment Cost, the *Life Cycle*, and the *Replacement Percentage*.

- Default Cost: This represents the current cost to purchase the equipment or material.

- Life Cycle: The time frame between equipment or material replacement is termed as its *Life Cycle*. Some equipment manufacturers provide recommended *Life Cycles* for their equipment to provide consumers with an estimate of how long the equipment is expected to be operational. Some *Life Cycles*, such as those used for treatment media (limestone), are based on best professional judgement. Some operators prefer to periodically purchase and replace equipment before failure to preserve the continuity of operations, while others wait until failure to replace an item.

- Replacement Percentage: The *Replacement Percentage* is an adjustment factor to the Default Cost to accommodate situations where the entire piece of equipment or all the material does not require recapitalization. For example, a passive treatment component may be designed to contain enough limestone to neutralize the acidity load for 20 years, however, the accumulation of metal hydroxide precipitates within the void space of the limestone layer may require that 25% of the limestone be replaced every seven years to prevent hydraulic failure such as plugging or short-circuiting. For this scenario, the initial cost of the limestone making up the limestone layer is discounted by 75% and assigned a *Life Cycle* of seven years to determine the amount of money required to cover the cost of replacing 25% of the limestone layer every seven years over the *Term of Analysis*.

3.3.4.3 Rationale for Recapitalization Recommendations - Recapitalization recommendations are based on professional experience of the AMDTreat Team and may not apply to all situations. Users are encouraged to customize the recapitalization assumptions to their treatment scenario. AMDTeat Team members are located in Pennsylvania and West Virginia and have collective experience in design, funding, and/or operation/maintenance for over 100 passive treatment systems. Users may have different experience and opinions than those listed.

By default, AMDTreat includes a list of five recapitalization items for typical underground mine pool pumping systems. Users can delete or modify any of the default recapitalization items by either deselecting the item or by setting the *Replacement Percentage* to zero. If the item is deselected the total cost for the item will still be shown but the cost will be subtracted from the NPV, shown in the NPV Heading. For example, the default value for the *Life Cycle* of a Pump is 10 years due to wear and tear of consistent use. However, users may opt to decrease the *Life Cycle* and *Replacement Percentage* to match the cost of rebuilding the motor periodically (i.e. every seven years) rather than replacing the entire pump. Users are free to fully customize the replacement items, including adding new items or deleting default items.

Borehole: The default *Life Cycle* for borehole is set at 75 years and the default *Replacement Percentage* is one hundred percent (100%). The user can adjust these default values as appropriate or input a *Custom Cost* if known such as for an existing system.

Pipeline: The default *Life Cycle* for the pipeline component is set at 75 years and the default *Replacement Percentage* is one hundred percent (100%). The user can adjust these default values as appropriate or input a *Custom Cost* if known such as for an existing system.

Control/SCADA: The default *Life Cycle* for the control/SCADA system for the pumping equipment is set at 10 years and the default *Replacement Percentage* is one hundred percent (100%). The user can adjust these default values as appropriate or input a *Custom Cost* if known such as for an existing system.

Pump: The default *Life Cycle* of the pump itself is set at 10 years and the default *Replacement Percentage* is one hundred percent (100%). This represents a complete replacement of the pump, but it is common and less expensive for operators to rebuild the motor component of the pump every so many years and as a result the cost of rebuilding the motor could be determined, divided by the cost of the entire pump and that percentage used as the *Replacement Percentage* at the desired frequency the motor needs rebuilt (e.g., seven years).

VFD: The default *Life Cycle* of the VFD component of the pumping system is 10 years and the default *Replacement Percentage* is one hundred percent (100%). The user can adjust these default values as appropriate or input a *Custom Cost* if known such as for an existing system.

3.4 Assumptions of Design Sizing and Costs

AMDTreat is a cost estimation model that uses assumptions to provide treatment sizing and both capital and annual cost estimates. While there are many assumptions in the program, the assumptions that follow are important for the Pumping Module.

1. It should be noted that the in the current version of AMDTreat the Pumping Module is designed to model one specific type of pump, a VTLP. These pumps have a drive motor on the surface connected by a drive shaft assembly to a turbine pump bowl assembly located downhole at the desired pumping depth. In the experience of the AMDTreat team, VTLP pumps are the most common and most efficient type of high-capacity influent pumps used at mine drainage treatment facilities but other pumps types do exist, such as submersible turbine pumps, and are employed at mine drainage treatment facilities. This underscores the aforementioned statements regarding consultation with design engineers and pump manufacturing experts when making conceptual and design choices.

2. Note that if the user is envisioning the use of multiple pumps, the *Flow Rate* entered by the user should be divided by the *Number of Pumps* that are planned to be used. In addition, also note that the AMDTreat program does not automatically do this based upon the number of wells selected in the Vertical Turbine Pump Borehole section of the Module (section 3.2.1). If multiple pumps are envisioned for the project, especially if they will be using separate Conveyance Pipelines, the user may opt to model the site by evaluating each pump system in a separate AMDTreat Pumping Module. The Help File for the MUI contains additional information for opening and working multiple modules.

3. The user should note that the Vertical Turbine Pump Borehole portion of the module only provides cost calculations based upon user selected values for *Number of Wells*, selected *Inside Diameter* and *Drilling Depth to Mine Pool*. Pump sizing is determined by selections made in the Conveyance Pipeline section (primarily *Flow Rate* and *Total Static Head*). Consequently, once the HP rating has been calculated, the user should then consult with pump manufacturers or equivalent pump systems experts to verify that the appropriately sized borehole has been selected and matched to the appropriate size pump.

4.0 References

WaterWorld online reference publication [Home | WaterWorld]

Groundwater and Wells 3rd edition, 2007, Johnson Screens div Weatherford Corp, 812 pp

5.0 Figures

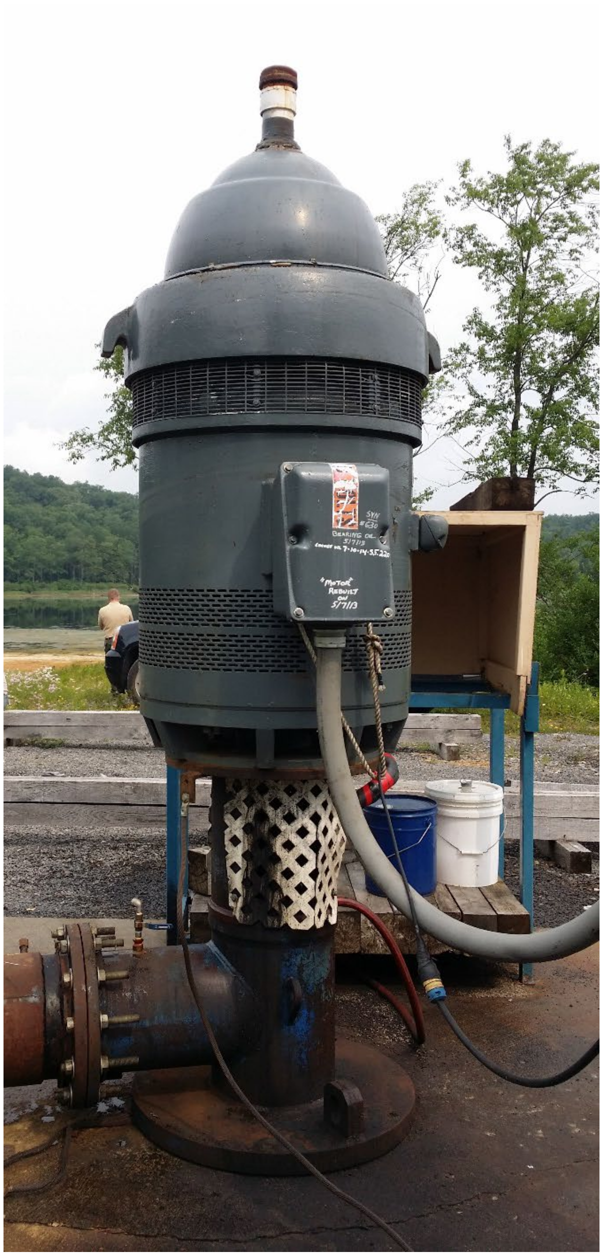

Figure 1. Vertical Turbine Pump at a mine site in West Virginia used to pump water from an underground mine pool to the surface for treatment at an active chemical treatment facility.

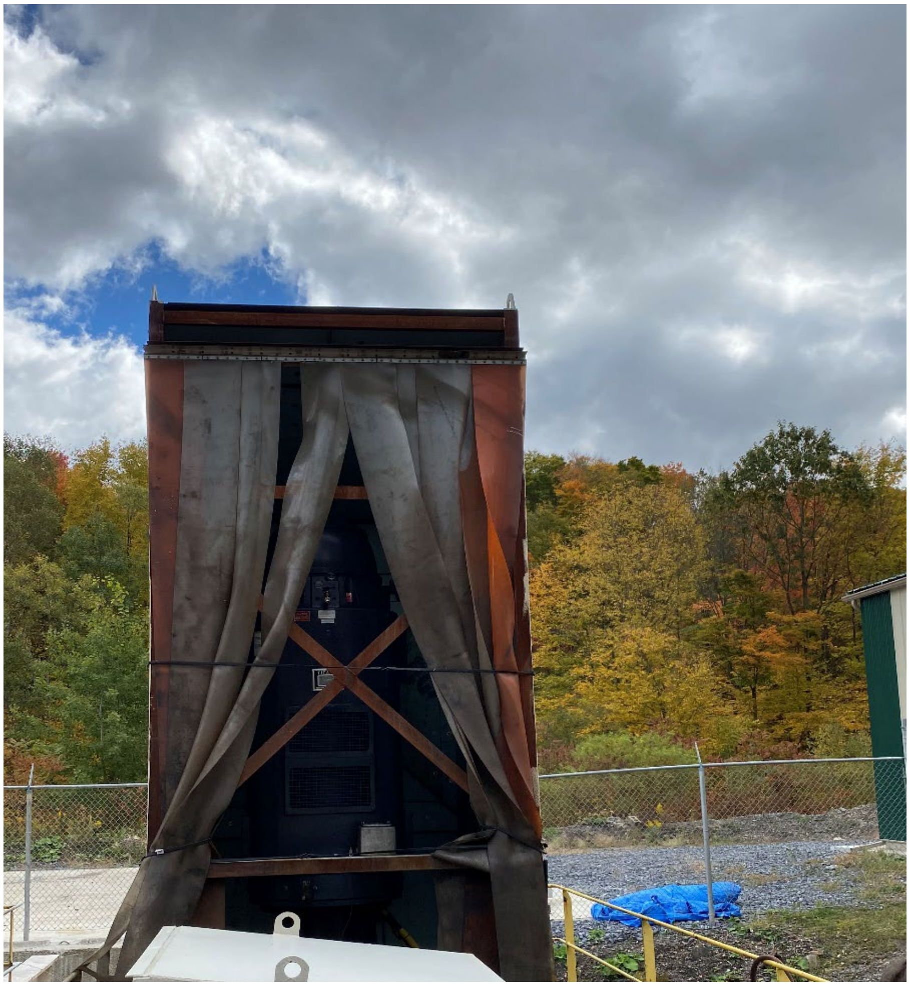

Figure 2. Vertical Turbine Pump housed in an enclosure for noise suppression and to reduce weathering at a mine site in Pennsylvania used to pump water from an underground mine pool to the surface for treatment at an active chemical treatment facility.

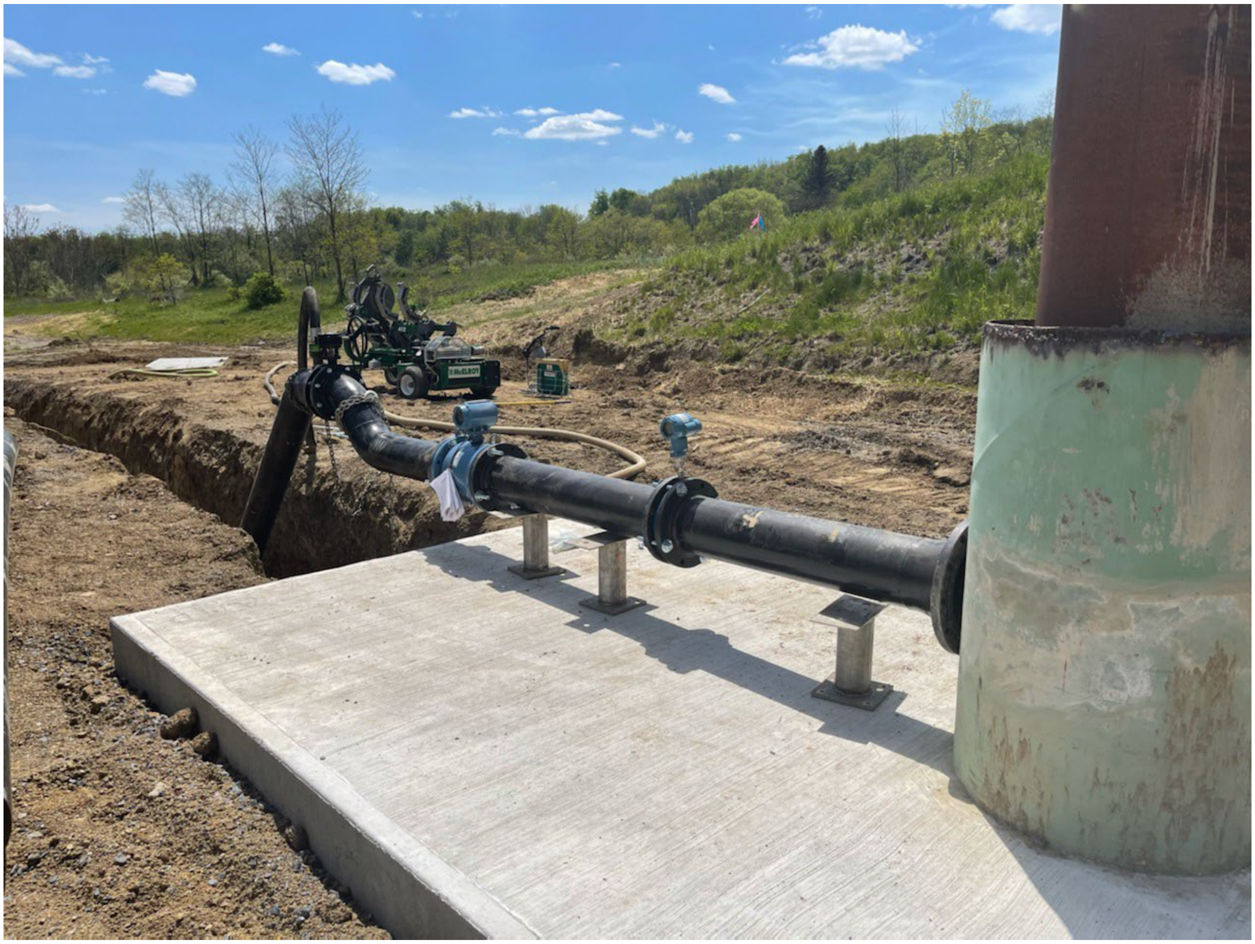

Figure 3. New installation for a Vertical Turbine Pump showing concrete pad, surface borehole casing, inner borehole casing and conveyance piping connection fittings at a mine site in Pennsylvania used to pump water from an underground mine pool to the surface for treatment at an active chemical treatment facility.

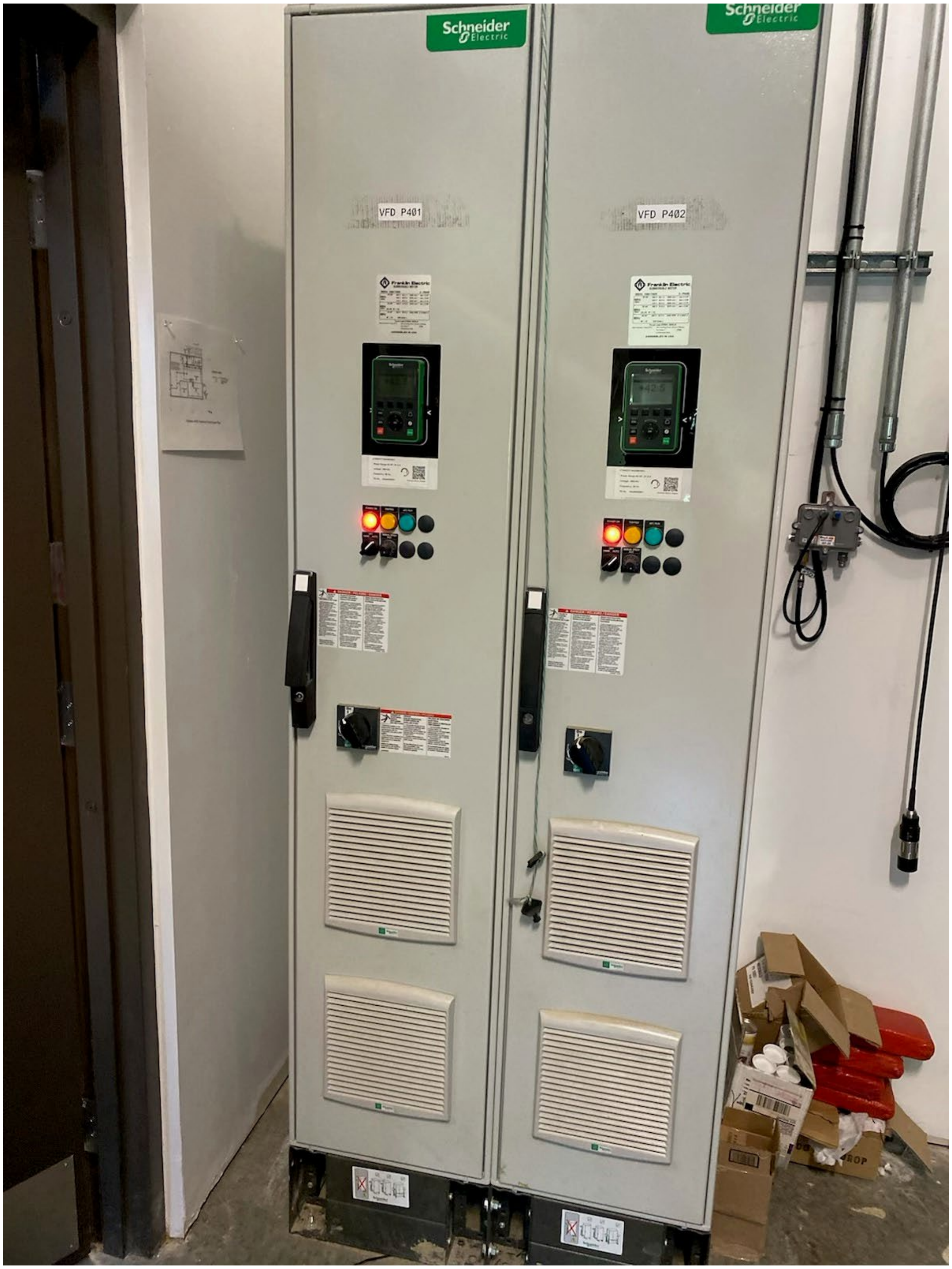
Schneider Electric
Schneider Electric
VFD P401
VFD P402

Figure 4. Soft Start/VFD units (2) for two 150 HP submersible mine water withdraw pumps at a mine site in Pennsylvania used to pump water from an underground mine pool to the surface for treatment at an active chemical treatment facility.

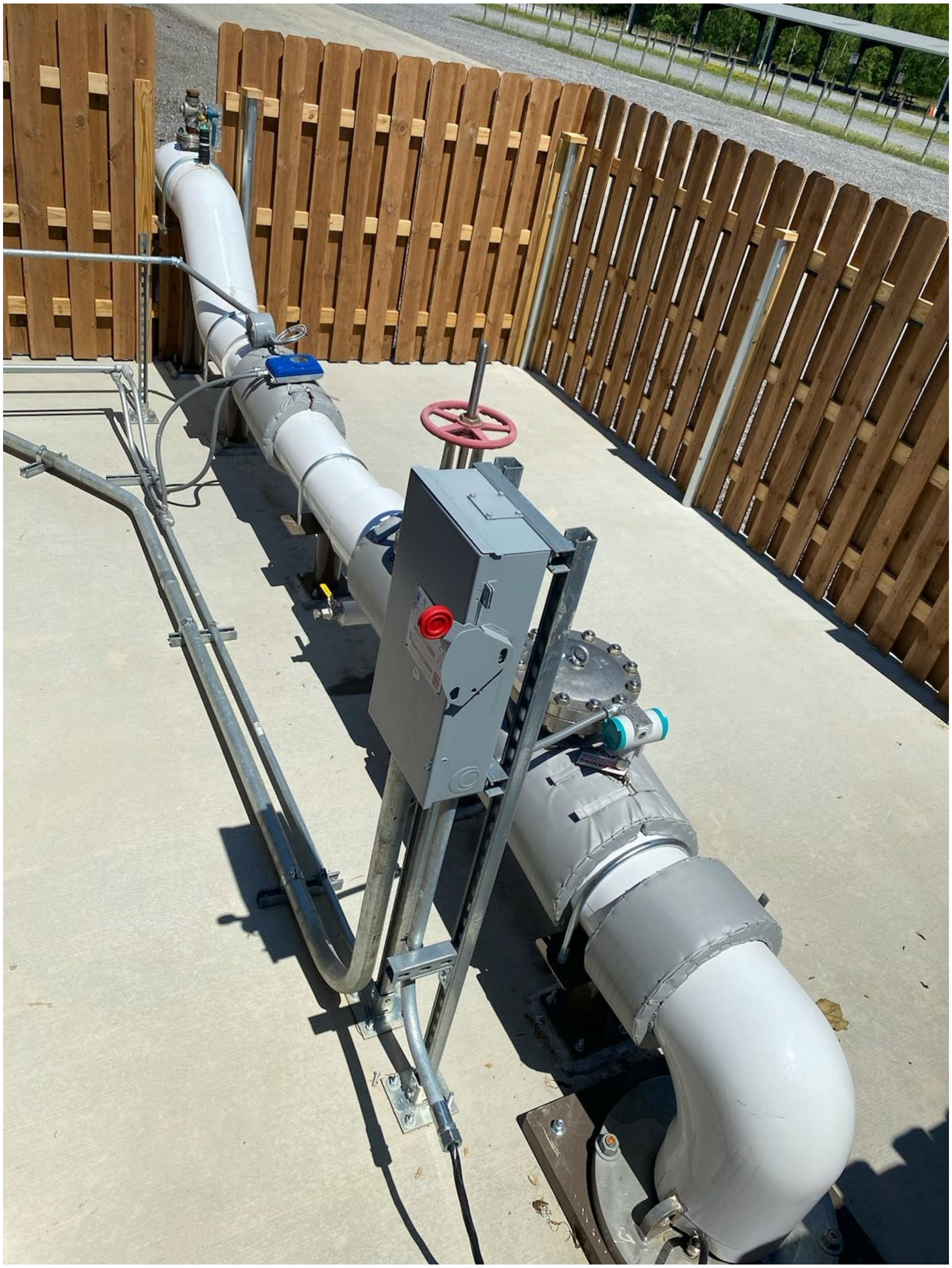

Figure 5. Concrete pad showing conveyance pipeline connection, electrical service and monitoring and telemetric equipment for a submersible turbine pump at a mine site in Pennsylvania used to pump water from an underground mine pool to the surface for treatment at an active chemical treatment facility.