Help Instruction File:

Conveyance Ditch 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).

Conveyance Ditch Module Overview

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1.0 Objective

In the AMDTreat program, a Conveyance Ditch is considered an ancillary component of a mine drainage treatment facility. A conveyance ditch can be utilized for numerous purposes at a treatment facility. For instance, they can be used to (1) direct mine drainage into either a passive or active treatment system from the source, (2) convey mine drainage from one treatment component (i.e. VFP) to another treatment component (i.e. pond), or (3) provide aeration of mine drainage including the off-gassing of dissolved carbon dioxide (decarbonation) as it flows along the conveyance ditch. Therefore, the AMDTreat program includes this module in order for the user to capture the costs associated with constructing conveyance ditch(es) at a mine drainage treatment facility.

The objectives of the overview are to (1) Provide an understanding for the application of a Conveyance Ditch(es) in mine drainage treatment facilities and (2) Provide an overview of the Conveyance Ditch Module to guide users in developing a cost estimate to construct this 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 **Conveyance Ditch Module Overview**.

2.0 Overview and Application

A basic understanding of the application, material and equipment requirements for a conveyance ditch component of a treatment system are required to develop an accurate cost estimate using the AMDTreat software. These topics are discussed below before discussing the Conveyance Ditch 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

As mentioned in Section 1.0, conveyance ditches can serve multiple functions depending on where they are situated at a treatment system, along with what material is used to construct and finish the ditch (i.e. aggregate or grass-lined). The following is a list of the multiple functions of a conveyance ditch:

1. Collect and/or direct the influent and/or effluent mine drainage into or away from the treatment system.
2. Provide erosion and sedimentation (E&S) control and direct storm runoff to a sedimentation pond at a treatment system.
3. Provide conveyance of the mine drainage from one treatment component to the next downstream component.
4. Provide alkaline addition (i.e. high calcium carbonate limestone used as the aggregate) to the mine drainage as it flows along the conveyance ditch.
5. Provide an environment for chemical reactions (i.e. oxidation and hydrolysis) to occur in the mine drainage between other treatment system components.
6. Provide aeration (i.e. cascading fashion) and off-gassing of dissolved carbon dioxide (decarbonation) from the mine drainage as if flows along the ditch.
7. Divert stormwater runoff around the treatment system components.

2.2 Configuration & Application

Engineering principles should be employed when considering the use of conveyance ditches as part of a treatment system. Conveyance ditches should be designed and constructed in order to convey flow without erosion of the excavated channel; therefore, the ditch must be able to handle the anticipated flow volume and associated velocities. Drawing or design software (e.g., AutoCAD, SEDCAD) may be beneficial in terms of obtaining the various dimensions of a conveyance ditch then using this information in AMDTreat to obtain the costing information. It is important to note that if a conveyance ditch is to be used for E&S and/or stormwater management purposes each state has their own requirements related to the sizing and lining of conveyance ditches, also referred to as channels, and the appropriate guidance materials should be referenced based on the project location. In general, conveyance ditches can be configured as an aggregate-lined (rip-rap) ditch or grass-lined ditch. Specific material utilized for constructing the ditch will depend on the function, bed slope, flow velocity, and applying the appropriate engineering practices. Additionally, liners such as non-woven geotextile can be placed down under the rip-rap lining material in order to provide a separation layer between the aggregate and excavated soil as well as to prevent erosion and/or limit infiltration of the mine drainage into the subsurface.

Another aspect of constructing a conveyance ditch involves the cross-section profile of the ditch. For instance, a ditch can be constructed in a trapezoidal-like shape (Figure 1) with a flat bottom (width) and sloped sides. The AMDTreat program assumes this trapezoidal shape is the default configuration being utilized for the conveyance ditch construction. However, if the user wishes to minimize the ditch footprint and expected flows are minimal the bottom width could be set to zero (0) in order to create a triangular shaped ditch also known as a "V" ditch. If a rock-lined (aggregate) ditch is being designed, the depth (or thickness) of aggregate lining along the cross-section profile of the ditch is also something to consider. In addition, the ditch length and bottom slope along the entire length is useful information that can provide the user with the elevation difference from beginning to end of the conveyance ditch.

The application of conveyance ditches at mine drainage treatment systems will depend on the intended purpose of the conveyance ditch. A passive treatment system may consist of several components such as VFPs, wetland(s), and pond(s); and, conveyance ditches may need to be installed to direct the mine drainage between each component. An active treatment system may utilize a conveyance ditch to mix caustic soda solution with mine drainage. For example, caustic soda can be dispensed into a conveyance ditch in order to allow mixing the with mine drainage as it flows along the ditch. In this scenario, in addition to the mixing the conveyance ditch can also provide aeration of the mine drainage as the caustic soda increases the pH and allows for the precipitation of metal oxides, i.e. iron hydroxide [$Fe(OH)_3$]. This would be a common arrangement for chemical treatment of mine drainage prior to entering another treatment component such as a settling pond where the precipitated solids are retained. These are just a few examples for the application of conveyance ditches specifically for mine drainage treatment purposes. The AMDTreat program can be used to utilize these structures as part of the treatment system and estimate the costs associated with them.

3.0 Conveyance Ditch Module Overview

This section focuses on describing the specifics of the AMDTreat Conveyance Ditch 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 side. The module inputs on the left-hand side are generally arranged into two sections: (1) Dimensions / Properties, and (2) Cost Information. 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 calculated ditch excavation volume, aggregate volume and weight if applicable, total ditch length, and elevation change of ditch bottom from beginning to end. The estimated cost to construct and maintain the conveyance ditch, along with the user specified components, 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 the conveyance ditch component(s) 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 (i) in each of the subheadings in the module.

3.2 Module Inputs

3.2.1 Dimensions / Properties: The user selects either an *Aggregate*-lined ditch and/or a *Grass*-lined, along with a specified *Ditch Length* for each type of ditch. The default ditch length is 100-feet, but the user can adjust this value according to the site plans. The ditch length will be used in the excavation volume calculation that is included in the Sizing Summary output. Please note, if the user plans to have multiple conveyance ditches as part of a project that have different physical dimensions, multiple Conveyance Ditch modules must be created in AMDTreat in order to capture accurate cost estimate information.

The descriptions of the items can be found in the tool tip for this section. Click on the information icon (i) on the right side of the Conveyance Ditch heading.

3.2.1.1 Ditch Bottom Width: The bottom width of the ditch can be set to zero or a maximum of 50-feet. If the bottom width is zero, a V-shaped ditch is the assumed and calculated shape of the ditch (Figure 3). If a width greater than zero is used, the ditch will have a trapezoidal shape (Figures 1 & 2). This input parameter applies to all sections of the specified ditch length even if the user selects both grass-lined and aggregate-lined ditch.

3.2.1.2 Average Slope of Ditch Bottom: This user input represents the average slope of the ditch bottom along the entire length of ditch from beginning to end. The unit of this input parameter is in feet/feet, where a value of 0.02 would represent a 2% slope or two feet of elevation drop over a 100 foot long ditch. It is typically recommended not to have the slope less than 0.01 (1.0%) in order to promote positive drainage and to reduce the deposition of solids/sediment within the ditch.

3.2.1.3 Ditch Depth: This user input represents vertical depth of the ditch from the top of the ditch embankment (original ground surface) to the ditch bottom (Figures 1, 2, & 3). Please note from Figures 1 & 3 that the ditch bottom is equivalent to the top of the aggregate lining not the excavated soil underneath the aggregate lining.

3.2.1.4 Aggregate Lining Depth: This user input represents the thickness or depth the aggregate is placed below the bottom of the ditch and up the side slopes to the top of the ditch (Figures 1 & 3). The thickness of the aggregate lining is often dictated by the rip-rap size used to line the ditch and from the applicable state regulatory authority.

3.2.1.5 Aggregate Porosity: The porosity of the aggregate is used in order to calculate the weight (tons) of limestone needed to construct an aggregate-lined conveyance ditch. The bulk density is calculated from a limestone density (165.43 lbs/ft^3) and user specified porosity (Equation 1). The bulk density and volume of aggregate/limestone required for the ditch are used to calculate the tons of limestone needed for lining the conveyance ditch at the user-specified aggregate lining depth (Equation 2 and 3).

$$Aggregate\ Bulk\ Density\ \left(\frac{lbs}{ft^3}\right) = \left(1 - \frac{Aggregate\ Porosity}{100}\right) \times 165.43 \qquad \textbf{(1)}$$

3.2.1.6 Ditch Side Slope: The cross-sectional side slope of the ditch (Figures 1, 2, & 3). The units are horizontal to vertical (h:v); therefore, a value of 2 represents for every two units horizontally there is one vertical unit. The vertical unit (v) is always assumed to be one so the user is only specifying the horizontal unit (h) of the h:v ratio.

<u>Calculations for Sizing Summary Output</u>:

The following Equation (2) is used to calculate the volume of the conveyance ditch. This volume is calculated for an aggregate-lined or grass-lined conveyance ditch.

$$Ditch\ Volume\ (yds^3) = \Big((Ditch\ Bottom\ Width(ft) \times Ditch\ Depth(ft)) + Ditch\ Side\ Slope \times (Ditch\ Depth^2)\Big) \times Ditch\ Length(ft) \div 27 \qquad \textbf{(2)}$$

The following Equation (3) is used to calculate the total excavation volume of the conveyance ditch, including the aggregate volume. Please refer to Figures 1 & 3 for cross-sectional diagrams of the conveyance ditch with aggregate lining.

$$Excavation\ Volume\ (yds^3) = (Bottom\ Aggregate\ Width \times (Ditch\ Depth + Ditch\ Depth\ of\ Rock) + Ditch\ Side\ Slope \times ((Ditch\ Depth + Ditch\ Depth\ of\ Rock)^2) \times Ditch\ Length \div 27 \qquad \textbf{(3)}$$

The following Equations (4, 5, and 6) are used to calculate the tons of aggregate if the user selects to have an aggregate-lined ditch. Equation 4 first calculates the Ditch Slope Length, which is the length of the ditch bottom and side slopes in a cross-sectional view. Equation 5 then calculates the volume of the aggregate layer that will be placed throughout the whole length of the aggregate-lined ditch. Equation 6 calculates the tons of limestone that will be required for the user specified length of aggregate-lined conveyance ditch.

$$Aggregate\ Ditch\ Slope\ Length\ (ft) = Ditch\ Bottom\ Width + \left(\left(2 \times \left(Ditch\ Depth(ft) + Aggregate\ Lining\ Depth(ft)\right)\right) \times \sqrt{ditch\ side\ slope^2 + 1}\right) \quad (4)$$

$$Aggregate\ Volume\ (yds^3) = Excavation\ Volume - Ditch\ Volume \quad (5)$$

$$Aggregate\ Weight\ (tons) = \left(Aggregate\ Volume \times \frac{(Aggreagate\ Density \times 27)}{2000}\right) \quad (6)$$

3.2.1.7 Non-Woven Geotextile Length: This item referred to as geotextile material is commonly placed underneath an aggregate lined ditch to provide separation of the limestone from the excavated surface. The geotextile material helps to keep the aggregate from becoming buried and minimize erosion of the underlying excavated surface . Non-woven geotextile material requirements may vary by state and should be researched based on the project location.

3.2.1.8 Silt Fence or Filter Sock Length: Silt fence or filter sock is used as an erosion and sediment (E&S) control feature downslope of the disturbed area as the conveyance ditch is being constructed.

3.2.2 Costs:

This section goes over the unit costs for all the items associated with estimating the cost of constructing said the user specified conveyance ditch(es). The default values are based on prior experience of the AMDTreat team; however, these can and should be adjusted according to specific site conditions and current rates of each item.

3.2.2.1 Non-Woven Geotextile Unit Cost: This unit cost is based on the price ($) per square foot ($ft^2$) of the material. There are numerous options on the market for the non-woven geotextile item. The user should ensure to include the unit cost for the most appropriate geotextile material being used for the project.

3.2.2.2 Ditch Aggregate Unit Cost: The delivered unit cost of aggregate or rip-rap (based on a cost per unit weight), which is assumed to be limestone material for this module. The user can adjust the unit cost to an appropriate value based on the regionally available aggregate materials and costs.

3.2.2.3 Ditch Aggregate Placement Unit Cost: Typically, the cost associated with placing the aggregate in a conveyance ditch is not covered under the Ditch Aggregate Unit Cost; therefore, a separate line item is included to capture the cost to place the aggregate within the conveyance ditch at the appropriate thickness (based on a cost per unit volume).

3.2.2.4 Temporary Ditch Lining Unit Cost: In order to temporarily stabilize the excavated ditch area prior to being seeded for a grass-lined conveyance ditch, material such as jute matting, coir matting, or curled wood matting must be installed. Therefore, this line item is included by default in the AMDTreat program. The temporary ditch lining item is not included for aggregate-lined conveyance ditches since the non-woven geotextile followed by the aggregate is typically placed upon excavating the ditch to the appropriate dimensions. The calculated area for the temporary lining is based on the calculated ditch area (length and width of conveyance ditch). Please note, if the user determines to not include a temporary lining, the unit cost can be zeroed out in order to exclude this cost. The applicable state regulatory authority literature for erosion and sediment control should be referenced to ensure the appropriate temporary ditch lining and vegetation material is used based on the expected ditch velocities.

3.2.2.5 Excavation Unit Cost: This represents the unit cost to excavate the earthen material for the conveyance ditch. The units are on a cubic yard basis ($\$/yd^3$). The specific equipment (i.e. bulldozer, excavator) is not specified or assumed in AMDTreat. The user should consider the equipment type and associated unit cost of that particular equipment.

3.2.2.6 Revegetation Unit Cost: The revegetation unit cost would represent the cost associated with seeding and mulching the conveyance ditch immediately following excavation. The applicable state regulatory authority literature for erosion and sediment control should be referenced to ensure the appropriate vegetation material is used based on the expected ditch velocities.

3.2.2.7 Silt Fence or Filter Sock Unit Cost: This represents the unit cost for the erosion and sediment control feature to be placed downslope of the disturbed area for the conveyance ditch construction.

3.3 Module Outputs

3.3.1 Sizing Summary: The Sizing Summary section displays important calculated module outputs, such as estimates of ditch excavation volume, aggregate volume and weight, total ditch length, ditch bottom elevation change (beginning to end), and the clear and grub area.

3.3.2 Capital Cost: This section provides the estimated costs for the various items and the total estimated capital cost to construct the Conveyance Ditch component of a treatment system site.

3.3.3 Annual Cost: This section provides an estimate of the annual cost to operate and maintain the Conveyance Ditch component of the treatment system. For the *Operation and Maintenance* annual costs, the user can select to have AMDTreat estimate the annual cost by taking a percentage of the capital cost or entering a known or Flat Fee annual cost.

3.3.4 Net Present Value: The Net Present Value (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 main user interface 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 default 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 7). 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.

$$\text{Cost to rebuild pump motor in 20 years} =$$
$$\text{Present Day Cost} \times (100\% + \text{Inflation Rate})^{20} = \$20{,}000 \times (100\% + 5\%)^{20} = \$53{,}065 \quad \textbf{(7)}$$

- Annual Operation and Maintenance Cost: By default, AMDTreat transcribes the annual O&M cost from the Annual Cost section to the Net Present Value section. The program assumes the module is being used to first 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/materials 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 of 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 7 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 7 years to determine the amount of money required to cover the cost of replacing 25% of the limestone layer every 7 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. AMDTreat 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. The AMDTreat Team held discussions on personal experience to develop a list of recapitalization recommendations. Users may have different experience and opinions than those listed.

Aggregate: The default Life Cycle of aggregate is set at 10 years and the default Replacement percentage is fifty percent (50%). The user can adjust these default values as appropriate.

Non-Woven Geotextile: The geotextile defaults were set as the same as the Aggregate defaults because it is assumed the non-woven geotextile will be installed with the aggregate that is to be replaced.

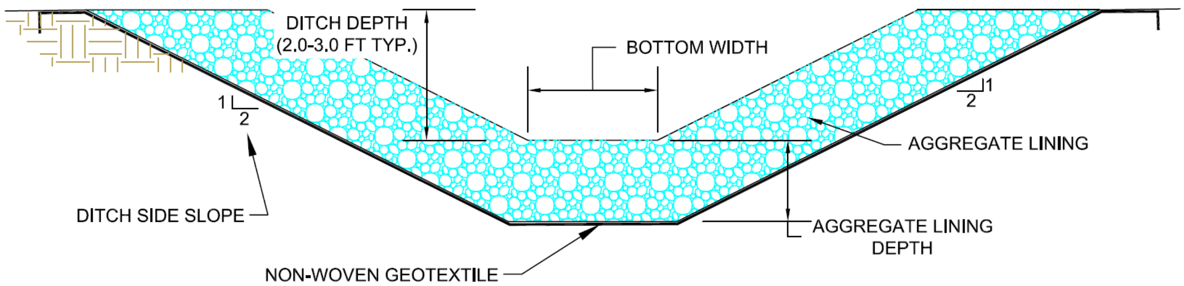
Revegetation and Temporary Ditch Lining: The default Life Cycle is set at 10 years and the default Replacement percentage is 25 percent. This represents revegetation and temporary ditch lining that will be required as portions of conveyance ditch may need replaced. The user can adjust these default values as appropriate.

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 Conveyance Ditch module.

1. The main assumption to consider in this module consists of the conveyance ditch as a trapezoidal or "V" shape and how it is constructed. This shape will affect the excavation volume and associated costs. Figure 1, 2, and 3 are illustrations of the assumed conveyance ditch shape for this module.

4.0 Figures



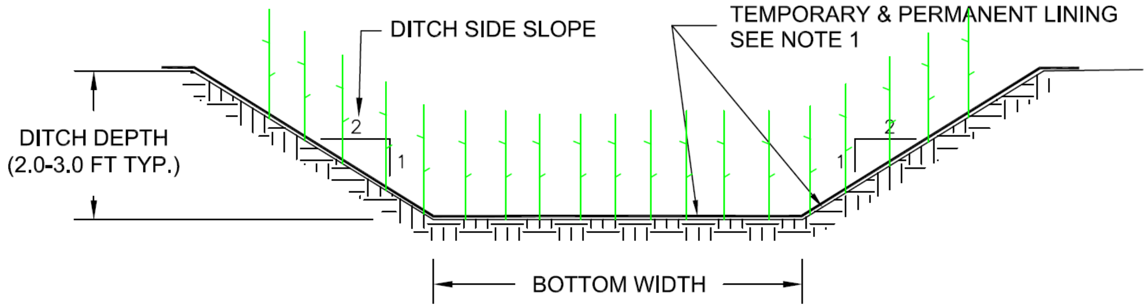
NOTES:

1. THE AVERAGE SLOPE OF DITCH BOTTOM IS THE AMOUNT OF VERTICAL DROP IN ELEVATION IN FEET OVER A DEFINED HORIZONTAL DISTANCE OR DITCH LENGTH IN FEET. THEREFORE, IF A DITCH HAS A ONE FOOT VERTICAL DROP IN ELEVATION OVER ITS ENTIRE HORIZONTAL LENGTH OF 100 FEET, THE AVERAGE SLOPE OF THE DITCH BOTTOM IS 1 / 100 = 0.01 FT/FT OR SINCE THE UNITS ARE THE SAME WE CAN REFER TO THE SLOPE AS A FRACTION OR PERCENT IF MULTIPLIED BY 100 (0.01 X 100 = 1.0%).
2. THE DEPTH OF DITCH TO WHICH THE AGGREGATE LINING WILL PLACED UP TO IS ASSUMED TO BE EQUAL TO THE USER-SPECIFIED DITCH DEPTH AS ILLUSTRATED IN THE SECTION DRAWING.
3. AGGREGATE LINING DEPTH SHOULD BE CALCULATED BY A DESIGN ENGINEER AND IS BASED ON THE EXPECTED FLOW, VELOCITY AND AGGREGATE SIZE TO BE USED. PLEASE REFER TO THE APPLICABLE STATE STANDARDS FOR DITCH SIZING AND LINING CRITERIA.

TYPICAL AGGREGATE–LINED CONVEYANCE DITCH SECTION

NO SCALE

Figure 1: Diagram of Aggregate-Lined Conveyance Ditch.



NOTES:

1. THE TEMPORARY LINING STABILIZES THE EXCAVATED FACE OF THE DITCH UNTIL THE VEGETATION SUFFICIENTLY GROWS WOULD BE SPECIFIED BY THE DESIGN ENGINEER BASED ON THE APPLICABLE STATE STANDARDS FOR DITCH SIZING AND LINING CRITERIA. TYPICAL TEMPORARY LINING MATERIALS ARE JUTE MAT, CURLED WOOD MAT, COCONUT FIBER, & SYNTHETIC MAT.
2. THE PERMANENT LINING WOULD BE A GRASS-LEGUME MIXTURE VEGETATIVE LINING AS DEFINED BY THE APPLICABLE STATE STANDARDS.

TYPICAL GRASS–LINED CONVEYANCE DITCH SECTION

NO SCALE

Figure 2: Diagram of Grass-Lined Conveyance Ditch.

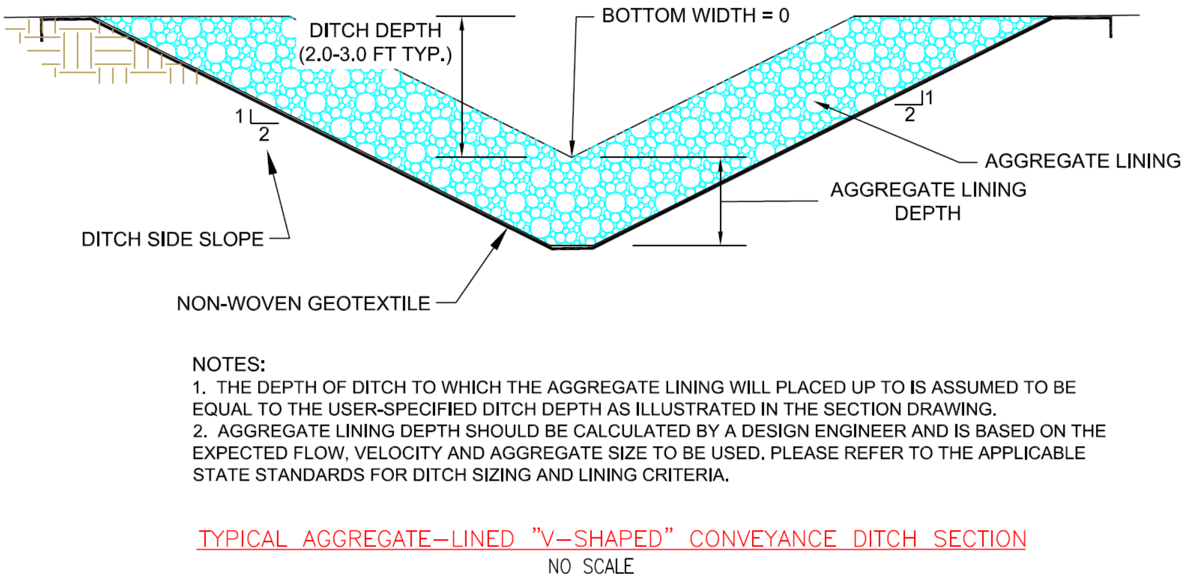


Figure 3: Diagram of V-shaped (zero bottom width) Aggregate-Lined Conveyance Ditch.

Figure 4: Photograph of Aggregate-lined ditch.

Figure 5: Photograph of Aggregate-lined ditch.