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In-Conduit Hydropower Project Screening Tool

For Water Supply and Wastewater Treatment Facilities

User Manual and Instructions

Hydropower…more than just water through the system

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

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1 Introduction and Definitions

Hydro power harnesses the energy in falling water to produce mechanical or electrical power. In-conduit hydropower specifically harnesses the excess energy of water being used for a purpose other than energy generation. This can include water going into a water supply system or discharging from a wastewater treatment facility, which is the focus of this screening tool. Hydropower is a renewable source of power which does not emit greenhouse gasses, reduces our dependence on foreign energy sources, and promotes long-term sustainability. The installation of in-conduit hydropower has minimal environmental impacts as the water is already being used for another purpose. It also has a direct benefit to the surrounding community by offsetting electricity which would otherwise have to be purchased or by providing a source of revenue.

The screening tool has been developed such that a user can complete a preliminary evaluation of a potential hydroelectric generation facility. This will include estimates of power, energy, cost and financial viability based on user inputs.

1.1 Opening

The screening tool is an Excel based file which should be opened with Excel version 2007 or later. The file contains macros which must be enabled for full and accurate functionality of the tool.

Macros must be enabled to use the screening tool.

When a user opens an Excel file with macros, a message will appear below the ribbon which indicates that some content has been disabled. The user should select the "Options…" button and a window will appear as shown in Figure 1. The user should choose "Enable this content" from the pop-up window and then select "OK" to enable the macros in the file.

An alternate means of enabling macros for the screening tool is to complete the following steps (Excel 2007, 2010):

1. Click the Microsoft office button , and then click Excel Options.
2. Click Trust Center, click Trust Center Settings, and then click Macro Settings.
3. Click Enable all Macros

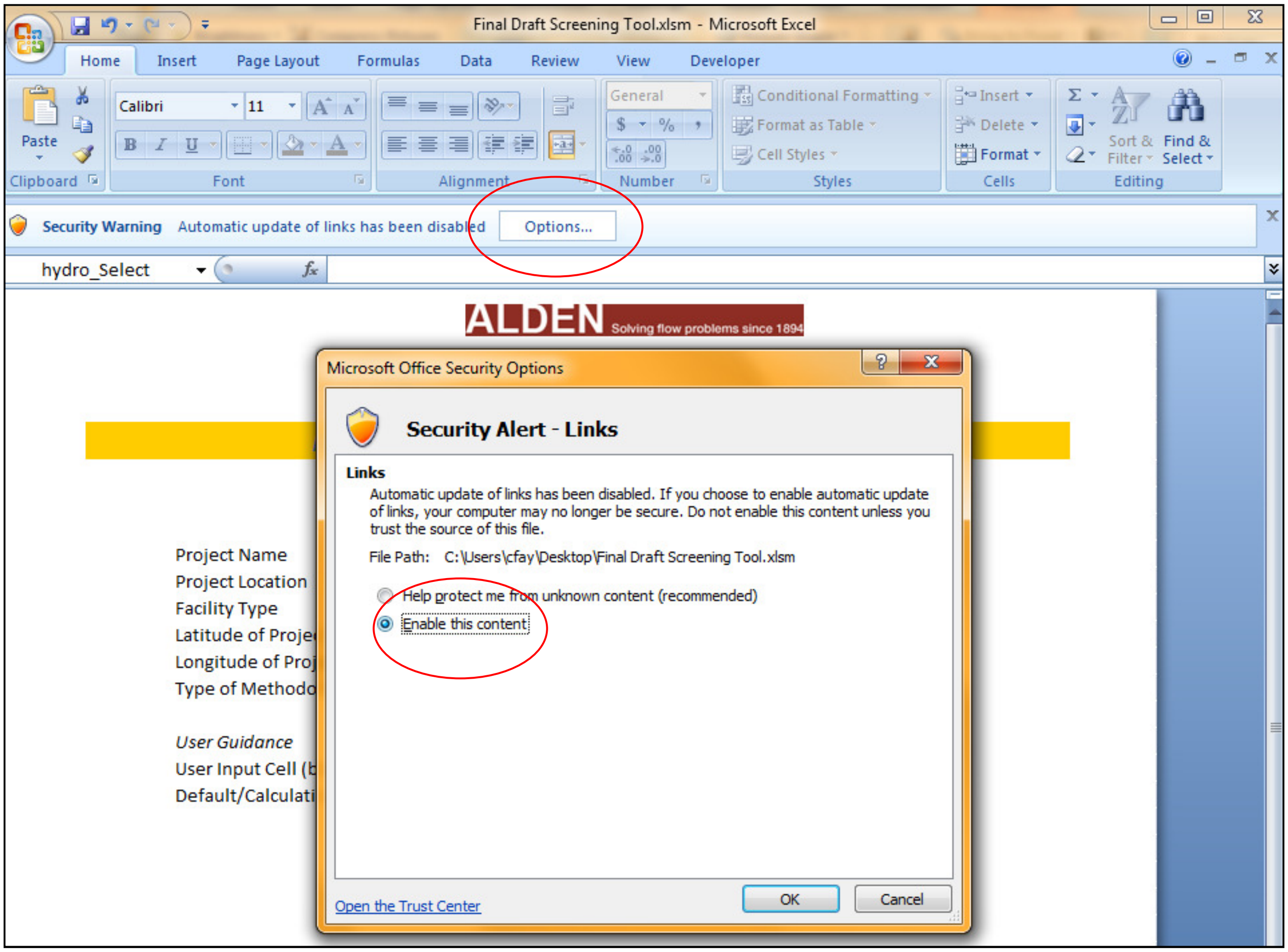


Figure 1. Guidance on enabling macros

The user is strongly encouraged to download a new version of the tool each time that a project will be evaluated to ensure that all defaults and options are in the original configuration.

1.2 Color Coding

Each worksheet should be completed row by row from top to bottom by entering values where required. The user should enter data into blue shaded worksheet cells. The green shaded cells are calculation or output cells which do not require user input. Cells that do not require input data are protected to prevent mistaken modification. The color coding for the cells is presented in Figure 2.

Significance	Cell Color
Input	
Calculation / Output	
Description / Units / Notes	

Figure 2. Screening Tool Cell Color Description

1.3 Tool Overview

Figure 3 provides an overview of the screening tool and shows its ability to evaluate a potential project in several different manners. Regardless of its “mode”, the screening tool will always show a “Cover” worksheet which requests basic project information as well as the general methodology for project evaluation. The three basic means of project to choose from include “Conventional Hydropower”, “Simplified Conventional Hydropower” and “Simplified Hydrokinetic”, which correlate to the layout shown in Figure 3. If the conventional hydropower option is selected, a series of seven additional worksheets will be visible and provide the user information on a variety of project features including hydrology, equipment, energy generation, cost, finances, and environmental benefits. If the simplified conventional hydropower option is selected, these same parameters are evaluated; however, the level of detail shown and the user options are limited. A simplified hydrokinetic option is also available and can be considered for some specific site conditions. The “simplified” options should be used when limited site information is available and an order of magnitude estimate is allowable for very preliminary project review. When either simplified option is selected, a single “Summary” worksheet will be visible in addition to the “Cover” worksheet.

For the purposes of the tool and this document, conventional hydropower is considered that which utilizes head or pressure for generation while hydrokinetic is considered a velocity based generation. In either case, the focus is on in-conduit installations for water supply or wastewater facilities. A more detailed discussion of these generation mechanisms can be found below.

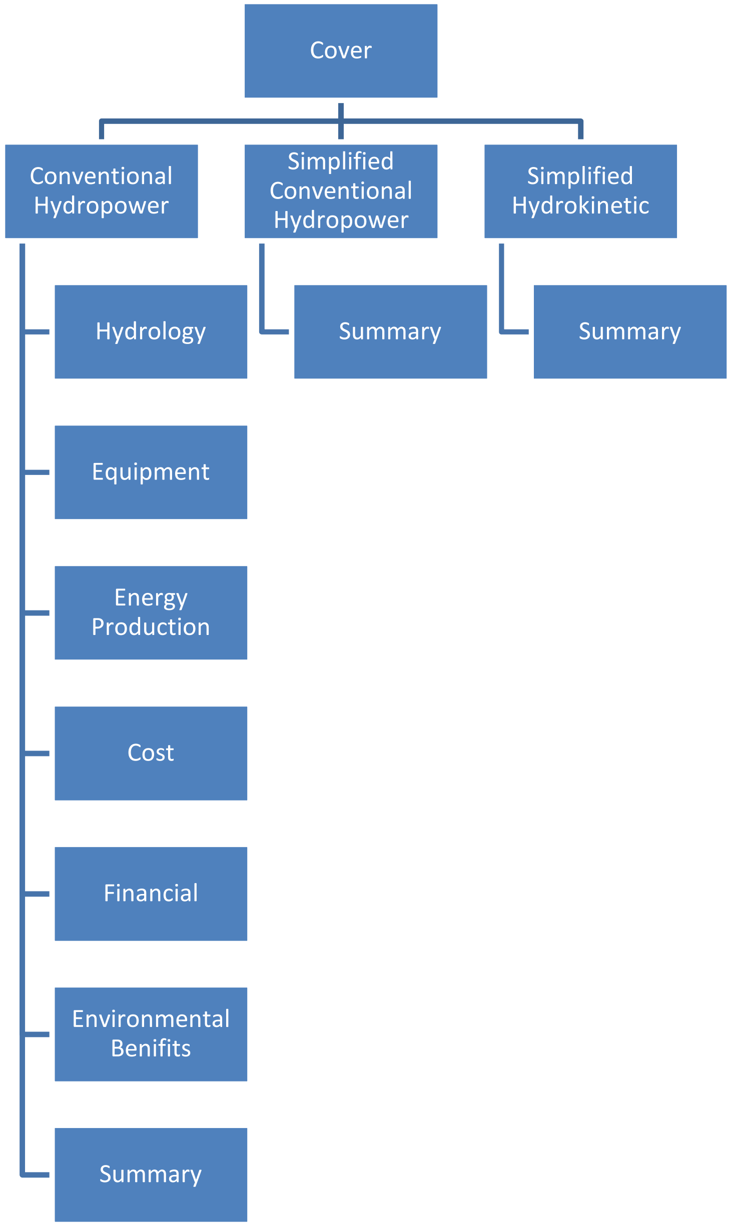


Figure 3. Screening Tool Flow Chart

1.4 Automatic / Manual

Throughout the screening tool, there are several locations where the user is presented with the option of whether to evaluate the project in an "automatic" or "manual" mode. If the "automatic" mode is chosen, default values for the application will be chosen and the user can move forward with the evaluation. If the "manual" mode is chosen the user can input information for a more site specific evaluation. The "automatic" mode should be utilized when the default input is the best information available. The "manual" mode should be used when the user has site specific information or input values which they feel are more representative than the defaults.

1.5 Units

Units are clearly marked in the screening tool in the column adjacent to the input column. Most measurements are listed once with a single unit type; however, pressure and flow rate are presented as both feet/pounds per square inch and cubic feet per second / gallons per minute, respectively. This is intended to facilitate both hydropower industry personnel and water/wastewater facility personnel during evaluation. All cost and financial information is presented in US dollars.

Table 1. Summary of units and abbreviations

Unit	Abbreviation
Cubic feet per second	cfs
Gallons per minute	gpm
Percent	%
Feet	ft
Pound per square inch	psi
Kilowatt	kW
Kilowatt-hour	kWh
US Dollar	$
Year	Yr
Pound	lb

1.6 Saving & Printing

When saving the screening tool, standard Excel saving procedures should be used for macro based workbooks. A new file name will be required such that the “master” cannot be altered. The user can save the file anywhere which Excel files are typically located including hard drive, flash drive, CD, etc.

To print the files, standard Excel procedures should be used. The standard print size will be 8.5X11 with a print quality of 600 dpi. Although some functions will be limited, the user can change print settings to meet their individual needs if necessary.

1.7 Hydropower & Hydrokinetic Power

Hydropower turbines produce renewable power by harnessing the energy available in falling water. The energy of the moving water rotates the blades of a turbine which rotates a generator The power produced is a function of the available head, flow and system efficiency and is calculated as shown in Equation 1.

$$P = \frac{QHe}{11.81} \tag{1}$$

Where:

P = Power (kW)

Q = Flow (cfs)

H = Head (ft)

e = Efficiency

Hydrokinetic turbines produce renewable power by harnessing the kinetic energy in moving water. The concept is similar to that of a wind turbine; however, since water is 832 times denser than air the power density is significantly larger. Hydrokinetic generation is primarily a function of velocity and is calculated as shown in Equation 2:

$$P = 0.5e\rho AV^3 \tag{2}$$

Where:

P = Power (W)

e = Efficiency

p = Density of water (1000 kg/m^3)

A = Intercepted flow area (m^2)

V = Water Velocity (f/s)

An evaluation of hydrokinetic energy may be applicable for sites with free surface (not pressurized) water conveyance. It is most likely that the primary consideration for evaluation would be at the outfall structure of a wastewater treatment facility as most water supply systems will be piped and/or have head conditions.

2 Screening tool Instructions

The following section provides guidance on utilizing the screening tool. For each evaluation type, there is a discussion of the workbooks included. Regardless of the evaluation type, the "Cover" worksheet will be present.

The cover page provides a user input for basic project information including the name, location, facility type, latitude and longitude, as well as the methodology that the screening tool will utilize.

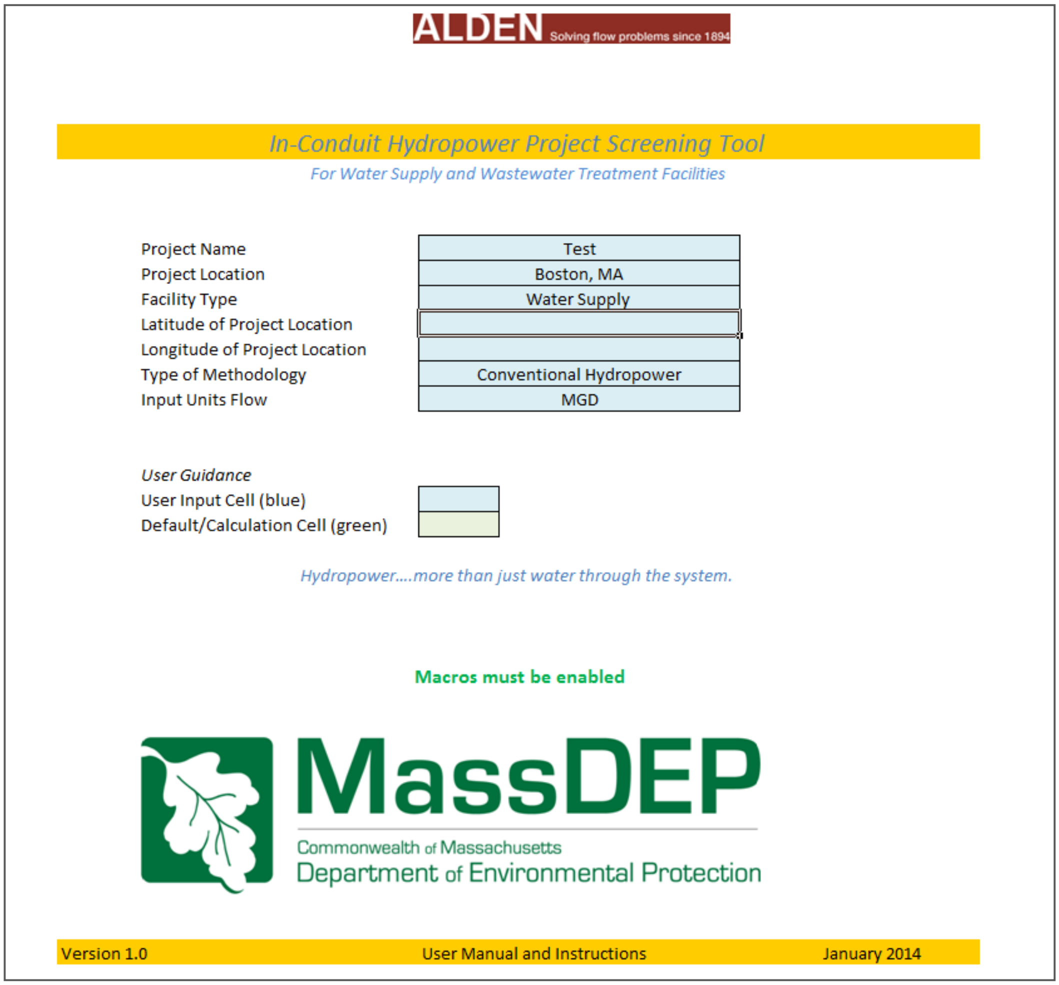


Figure 4: "Cover" worksheet – All methods

1. Project Name: Input

   This cell is the name of the proposed project that will be analyzed by the screening tool. The input does not affect the numerical results of the screening tool and can be chosen as any name.

2. Project Location: Input

   This cell input is the Town & State where the proposed project is located. This input does not affect the numerical results of the screening tool.

3. Facility Type: Input

   This cell is a drop down list that the user can pick whether the proposed project will be located at a water supply or wastewater treatment facility. This input does not affect the numerical results of the screening tool.

4. Latitude of Project Location: Input

   This cell input is the geographic coordinate that specifies the north-south position of the proposed Project. This input does not affect the numerical results of the screening tool.

5. Longitude of Project Location: Input

   This cell input is the geographic coordinate that specifies the east-west position of the proposed Project. This input does not affect the numerical results of the screening tool.

6. Type of Methodology: Input

   Consists of a drop down list from which the user can select one of three options for project evaluation: "Conventional Hydropower", "Simplified Conventional Hydropower" and "Simplified Hydrokinetic". If the "Conventional Hydropower" option is selected, a series of seven additional worksheets will be visible and provide the user information on a variety of project features including hydrology, equipment, energy generation, cost, finances, and environmental benefits. If the simplified conventional hydropower option is selected, these same parameters are evaluated; however, the level of detail shown and the user options are limited. A simplified hydrokinetic option is also available and can be considered for some specific site conditions for velocity based generation. The "simplified" options should be used when limited site information is available and an order of magnitude estimate is allowable for very preliminary project review.

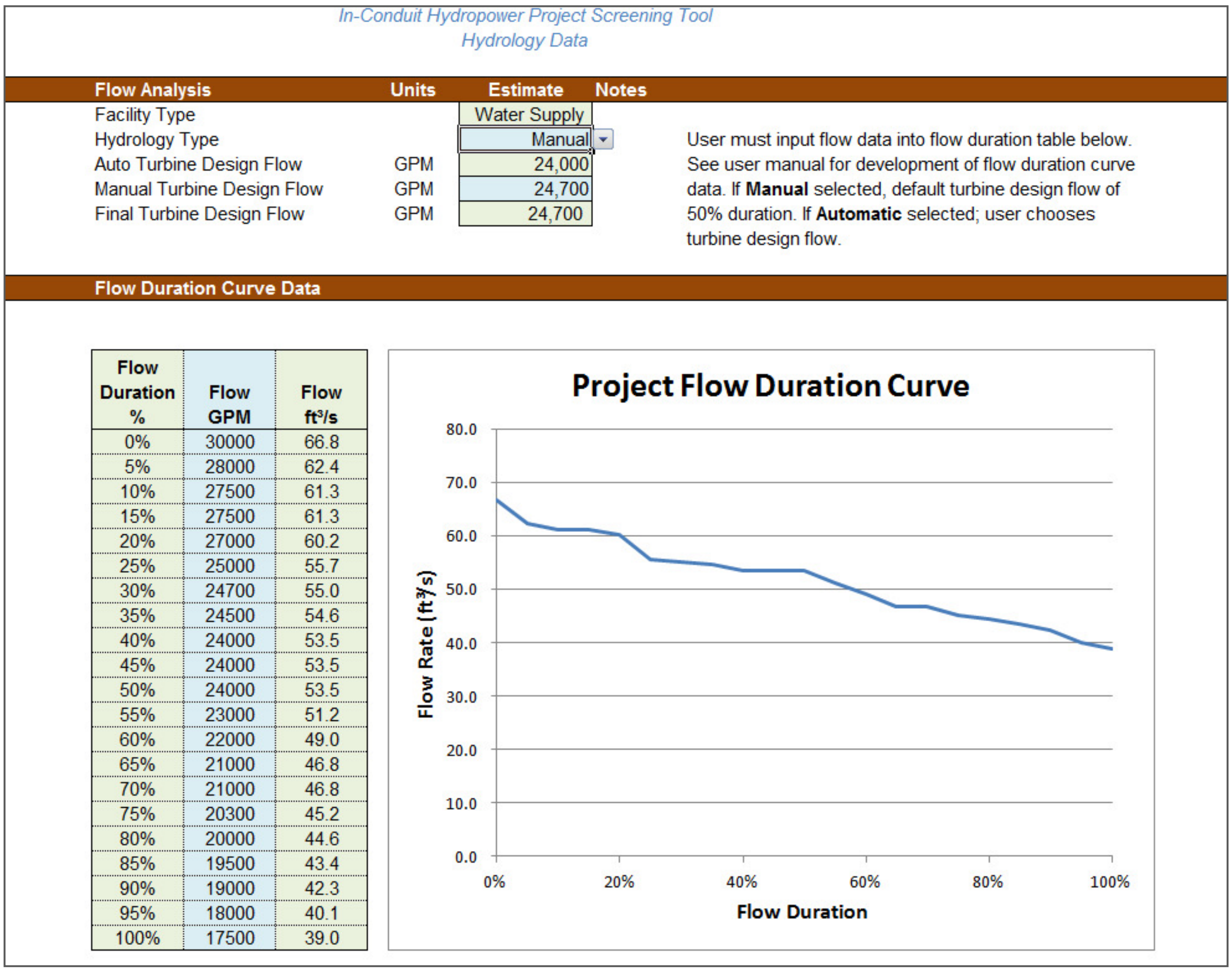
7. Flow Units: Input

   This cell allows the user to define the input units for flow measurement. The user can choose between million gallons per day (MGD) and gallons per minute (GPM). Regardless of whether the units are MGD or GPM, the flow rate will be converted to cubic feet per second (cfs) within the screening tool and that is what will be used for internal calculations. This input does not affect the numerical results of the screening tool.

2.1 Conventional Hydropower Detailed

2.1.1 Hydrology

The “Hydrology” analysis worksheet provides the place for the user inputted Hydrology of the proposed In-Conduit Hydropower Project. The hydrology evaluation will show the quantity and timing of water flowing through a Wastewater Treatment Plant or Water Supply Facility throughout the year. The user must input a flow duration data and choose a turbine design flow.



In-Conduit Hydropower Project Screening Tool
Hydrology Data

Flow Analysis	Units	Estimate	Notes
Facility Type		Water Supply	
Hydrology Type		Manual	User must input flow data into flow duration table below. See user manual for development of flow duration curve data. If **Manual** selected, default turbine design flow of 50% duration. If **Automatic** selected; user chooses turbine design flow.
Auto Turbine Design Flow	GPM	24,000	
Manual Turbine Design Flow	GPM	24,700	
Final Turbine Design Flow	GPM	24,700	

Flow Duration Curve Data

Flow Duration %	Flow GPM	Flow ft³/s
0%	30000	66.8
5%	28000	62.4
10%	27500	61.3
15%	27500	61.3
20%	27000	60.2
25%	25000	55.7
30%	24700	55.0
35%	24500	54.6
40%	24000	53.5
45%	24000	53.5
50%	24000	53.5
55%	23000	51.2
60%	22000	49.0
65%	21000	46.8
70%	21000	46.8
75%	20300	45.2
80%	20000	44.6
85%	19500	43.4
90%	19000	42.3
95%	18000	40.1
100%	17500	39.0

Figure 5. “Hydrology” Worksheet – Conventional Hydropower

1. Facility Type: Reference

   This cell refers to the “Cover” worksheet and displays the facility type identified. The cell will indicate whether the Project will be located at a water supply or wastewater treatment facility. This cell does not require any user input.

2. Hydrology Type: Input

   This cell is a drop down list from which the user must choose whether the turbine design flow will be automatically chosen or user defined (manual). Should the user choose "Automatic", the turbine design flow will be taken as the 50% duration flow. Should the user choose "Manual", the user will be required to input a value from the flow duration curve.

3. Auto Turbine Design Flow: Calculation

   This cell is locked and cannot be modified by the user. The cell looks up and returns the 50% duration flow from the flow duration curve when "Automatic" is selected as the method for choosing the turbine design flow.

4. Manual Turbine Design Flow: Input

   If "Manual" is selected as the hydrology type, a user defined value for the turbine design flow is inputted here. The manually defined value can be any value from the flow duration curve; however, a value between the 25% and 75% duration is typical. If the manual method of choosing a turbine flow has been selected, the user must input a value in this cell.

5. Final Turbine Design Flow: Calculation

   Regardless of the hydrology type pursued, this cell will display the final turbine design flow. The cell evaluates the hydrology type and displays the respective flow rate. This cell chooses between the automatic and manual turbine design flows and does not require any user input.

6. Flow Duration Data Table: Input

   Facility flow data must be inputted into the Flow Duration Data Table and is the basis for understanding the facility flow conditions and turbine design flow. The user must provide the gpm flow data in 5% durations ("Flow GPM/MGD") adjacent to the "Flow Duration (%)" column which is already provided. The "Flow cfs" column will automatically calculate based on the user input. A description of how to create a flow duration curve based on a set of flow data is provided in Appendix A. The user should input the flow data ("Flow GPM/MGD") representative of what would be available to the turbine.

2.1.2 Equipment

The "Equipment" worksheet is where the equipment selection for the In-Conduit Hydropower Project occurs. The equipment type will directly influence the power and average annual energy generation as it defines the efficiency and operating range of the turbine. The user must either choose a turbine type or answer a series of questions which result in an automatic turbine selection.

In-Conduit Hydropower Project Screening Tool
Equipment Data

Small Hydro Turbine Characteristics	Units	Estimate	Notes/Range
Head	PSI	30.0	
Turbine Flow (Max)	(ft^3/s)	55.0	If **Automatic**, turbine type will be
Turbine Flow (Min)	(ft^3/s)	27.5	automatically selected based on site
Turbine Selection		Automatic	characteristics. If **Manual**, user will specify
Automatic Turbine Type Selection		Kaplan	turbine type.
Manual Turbine Type Selection		Propeller	
Turbine Type		Kaplan	
Turbine Efficiency at Max Operating Point	(%)	89%	

Percent Duration Flow	Turbine Efficiency
0%	0.89
5%	0.90
10%	0.91
15%	0.91
20%	0.91
25%	0.92
30%	0.93
35%	0.93
40%	0.91
45%	0.91
50%	0.89
55%	0.84
60%	0.75
65%	0.56
70%	0.35
75%	0.00
80%	0.00
85%	0.00
90%	0.00
95%	0.00
100%	0.00

Figure 6. "Equipment" Worksheet – Conventional Hydropower

1. Head: Reference

   The head is the average water pressure available to operate the turbine in and is a user input. It is important to consider how much water pressure will be required downstream of the turbine for system operations including water conveyance and facility operations. Any residual pressures required are not available to the turbine and should be included in the available head value.

2. Turbine Flow (Max): Reference

   This cell is the turbine design flow and is a reference to the hydrology worksheet. The turbine design flow represents the maximum flow rate which the turbine is hydraulically capable of generating with. Any available flows which exceed this value will not be used for generation. This input is automatically retrieved from the "Hydrology" worksheet and the cell does not require any user input.

3. Turbine Flow (Min): Calculation

   This cell is the minimum turbine flow and is calculated based on the turbine design flow and the turbine type. Anytime the available flow is below this value, the turbine will not operate due to insufficient generation flow. This input is automatically calculated and the cell does not require any user input.

4. Turbine Selection: Input

   This cell is a drop down list from which the user must choose whether the turbine type will be automatically chosen or user defined (manual). Should the user choose "Automatic", a pop-up query window (Figure 7) will appear with questions which will lead to a preferred turbine type. Should the user choose "Manual", the user will be required to choose a turbine type from a drop down list.

   The user must first define the facility type as either a water supply or wastewater treatment facility. This will define the first question regarding flows but will not impact subsequent questions.

   The three questions which the user will be asked in if "Automatic" is selected are:

   - Flows
     a. Water supply – Do the flows vary throughout the day? Is the flow intermittent?
     b. Wastewater – Is there a diurnal pattern, do flows drop off significantly at night, or do average daily flows vary significantly month to month?
   - Will the turbine discharge continue to be piped or be discharged to atmosphere?
   - Approximate project head (psi)?

   There are many different types of turbines of which one may be more suitable for particular conditions than another. Some turbines have a wider range of operation than others and can accommodate wider ranges in flow than others. If there are wide ranges in the flow rates available to the turbine throughout the year, the user should choose "yes" in the query box. Conversely, if the flow rates are relatively consistent throughout the day, the user should select "no". Some turbines must discharge to atmosphere (free surface) for operation while others must discharge to a vacuum. The user must indicate what the anticipated site conditions will be and whether or not the turbine discharge flow will continue to be pressurized after discharge or if a free surface discontinuity is acceptable. Finally, turbines typically have specific ranges of head (pressure) in which operation is suitable. The user must input the same head value provided in the "Head" input cell to finalize the automatic turbine selection.

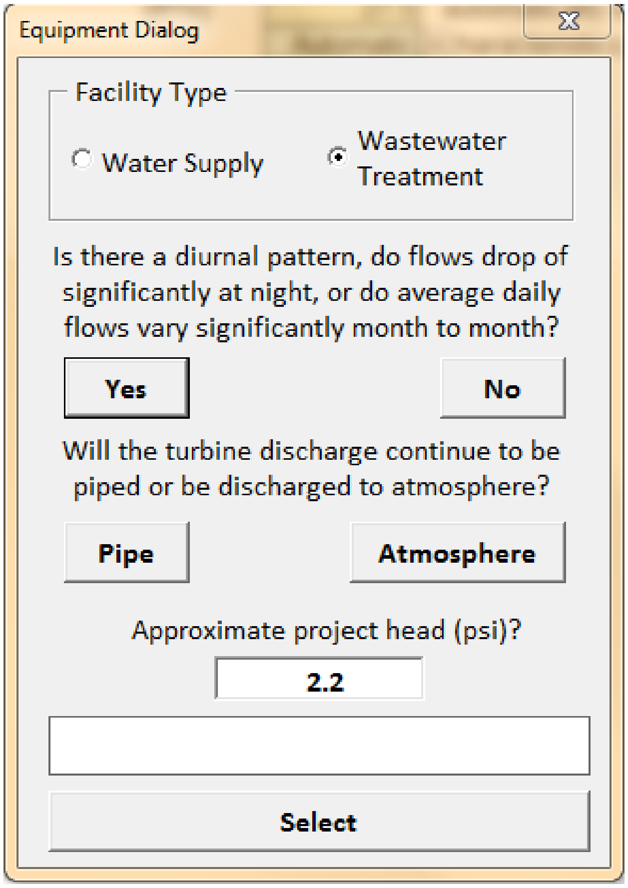


Figure 7. "Equipment" Worksheet Pop-Up Query – Conventional Hydropower

5. Automatic Turbine Selection: Calculation

   The cell uses the query results from the pop-up window to determine an appropriate turbine type and automatically inputs it. This cell is locked and cannot be modified by the user.

6. Manual Turbine Selection: Input

   If "Manual" is selected as the turbine selection type, the user must select one of the six turbine options from the drop down list.

7. Turbine Type: Calculation

   Regardless of the turbine selection methodology pursued, this cell will display the final turbine type. The cell evaluates the selection methodology and displays the respective flow rate. This cell chooses between the automatic and manual turbine selection options and does not require any user input.

8. Turbine Efficiency at Max Operating Point: Calculation

   This is the approximate turbine efficiency at the turbine design flow. This cell estimates the efficiency as a function of the type of turbine selected for the project and does not require any user input.

9. Turbine Efficiency Table: Calculation

   The efficiency of a turbine will vary depending on the actual generating flow rate compared to its design flow rate. To estimate annual energy generation, the turbine performance over a range of flow conditions must be estimated. Based on the selected turbine type, the efficiency over a range of percent flows will populate the turbine efficiency table.

2.1.3 Energy Model

The "Energy Model" worksheet is where estimated annual energy generation of the system is calculated. The energy model is critical in understanding system performance and financial returns. The energy model calculates based on the availability of resources throughout the year as well as associated efficiencies and operating ranges.

In-Conduit Hydropower Project Screening Tool
Energy Production

Site Conditions	Units	Estimate	Notes
Project Name		Test	
Project Location		Boston, MA	
Head	(ft)	69	
Turbine Type		Propeller	
Turbine Flow (Max)	(ft³/s)	55	
Turbine Flow (Min)	(ft³/s)	28	
Turbine Efficiency at Max Operating Point	(%)	91%	
Generator Efficiency	(%)	95%	95% to 98%
Annual Run Time	(%)	95%	93% to 98%
Peak Power	(kW)	279	
Average Annual Energy	(kWh)	1,981,300	

Estimated Average Annual Energy Generation

Percent Duration	Flow (cfs)	Generation Flow (ft³/s)	Percent Gate	Turbine Efficiency (%)	Power (kW)	Energy (kWh)
0%	67	55	100%	91%	265	116,300
5%	62	55	100%	91%	265	116,300
10%	61	55	100%	91%	265	116,300
15%	61	55	100%	91%	265	116,300
20%	60	55	100%	91%	265	116,300
25%	56	55	100%	91%	265	116,300
30%	55	55	100%	91%	265	116,300
35%	55	55	99%	88%	254	111,500
40%	53	53	97%	88%	249	109,200
45%	53	53	97%	88%	249	109,200
50%	53	53	97%	88%	249	109,200
55%	51	51	93%	82%	223	97,600
60%	49	49	89%	78%	203	88,800
65%	47	47	85%	78%	193	84,700
70%	47	47	85%	78%	193	84,700
75%	45	45	82%	70%	168	73,500
80%	45	45	81%	70%	165	72,400
85%	43	43	79%	63%	145	63,500
90%	42	42	77%	63%	141	61,900
95%	40	40	73%	55%	117	51,200
100%	39	39	71%	55%	114	49,800

Figure 8. "Energy Generation" Worksheet – Conventional Hydropower

1. Project Name: Reference

   This cell refers to the "Cover" worksheet and displays the name of the proposed project that will be analyzed by the screening tool. This cell does not require any user input.

2. Project Location: Reference

   This cell refers to the "Cover" worksheet and displays the location of the proposed project that will be analyzed by the screening tool. This cell does not require any user input.

3. Head: Reference

   This cell converts the head value inputted on the "Equipment" worksheet and converts it from psi to feet, which is more commonly used in hydropower applications. This cell does not require any user input.

4. Turbine Type: Reference

   This cell refers to the "Equipment" worksheet and displays the final turbine type chosen. This cell does not require any user input.

5. Turbine Flow (Max): Reference

   This cell refers to the "Equipment" worksheet and displays the maximum hydraulic capacity of the turbine (turbine design flow). Any available flows exceeding this value will not be eligible for generation as they will exceed the turbine capacity. This cell does not require any user input.

6. Turbine Flow (Min): Reference

   This cell refers to the "Equipment" worksheet and displays the minimum hydraulic capacity of the turbine. If the available generating flow falls below this value, the turbine will not be operable. This cell does not require any user input.

7. Turbine Efficiency at Max Operating Point: Reference

   This cell refers to the "Equipment" worksheet and displays the turbine efficiency at its maximum operating point. This cell does not require any user input.

8. Generator Efficiency: Input

   The user must input a generator efficiency which represents the mechanical to electrical conversion efficiency. Recommended values range between 95% to 98% depending upon the type of generator utilized by the project.

9. Annual Run Time: Input

   This cell is a user defined input. This is the percent of the year that the hydroelectric generating unit will be available for operations. An estimate of the unavailability of the unit due to maintenance and repair of both the hydroelectric system and the water supply/wastewater treatment systems should be incorporated here. Recommended range is between 93% to 98% but can vary more significantly depending on the project specific conditions.

10. Peak Power: Calculation

    This cell estimates the peak power output of the hydropower system based on the available head, turbine design flow and efficiencies. This input is automatically calculated and the cell does not require any user input.

11. Average Annual Power: Calculation

    This cell estimates the average annual energy generation of the proposed hydropower system by summing the twenty intervals estimated in the "Average Annual Energy Generation" table. This input is automatically calculated and the cell does not require any user input.

12. Annual Energy Generation Table: Calculation

    This table automatically evaluates twenty discrete periods of time to estimate the average annual energy generation. The first column lists 5% intervals from 0 to 100% while the second column references the associated flow rate from the "Hydrology" worksheet. The third column evaluates the available flow and range of turbine flows to assign actual flow to the turbine. The fourth column compares the actual turbine flow to the turbine design flow and calculates a percent gate value which is associated with turbine efficiency. The fifth column looks up the efficiency of the turbine as a function of the percent gate and turbine type such that the power can be calculated for that particular flow rate in column six. The last column calculates the average annual energy generation estimated based on the estimated power and 1/20 of the hours in a year.

2.1.4 Cost Analysis

The "Cost" worksheet is where the initial capital investment required to design and construct the project is estimated. The estimate can be completed using a simple \$/kW guideline or a more detailed estimate can be completed by inputting a series of project costs. The value estimated will be used in the financial analysis to estimate project viability.

In-Conduit Hydropower Project Screening Tool
Cost Data

Formula Costing Method	Units	Estimate	Notes
Cost Methodology		Automatic	

Automatic	Units		Notes
Cost Guideline	(\$/kW)	\$ 9,000	
Peak Power	(kW)	0	
Initial Capital Investment	(\$)	-	
Annual O&M	(\$)	\$ 6,000	

Manual	Units		Notes
Costs			
Contractor Mobilization / Demobilization			
Temporary Sediment and Erosion and Traffic Control		\$ -	
Equipment		\$ -	
Site Preparation		\$ -	
Temporary Facilities		\$ -	
Project Materials and Civil Construction (vault, bypass, valve, etc)		\$ -	
Construction Dewatering & Groundwater Control		\$ -	
Materials and Construction		\$ -	
Electrical System and Controls		\$ -	
Programming and Commissioning		\$ -	
Provision of Hydroelectric Generating Equipment and Warranty		\$ -	
Interconnection		\$ -	
Engineering Design and Field Engineering		\$ -	
Permitting		\$ -	
Contingency Percentage		10%	10%-40%
Contingency		\$ -	
Initial Capital Investment			
Total		\$ -	
Annual O&M			
Operations			
Maintenance			
Administration			
Legal and Accounting			
Insurance			
Misc.			
Total		\$ -	

Figure 9. "Cost" Worksheet – Conventional Hydropower

1. Cost Methodology: Input

   This cell is a drop down list from which the user must choose whether project costs will be automatically chosen or user defined (manual). Should the user choose "Automatic", the costs will estimated based on predefined $/kW values. Should the user choose "Manual", the user will be required to input a series of values to estimate the total project cost and annual operations and maintenance (O&M) costs. In "Automatic" mode, the user should fill out items 2-5 below and skip the remaining items on the sheet. In "Manual" mode, the user should skip items 2-5 below and focus on inputting individual cost data.

2. Cost Guideline: Input

   When "Automatic" is chosen as the costing methodology, the user must define the $/kW value used for estimating using the slide bar. Research in previous portions of this project indicated that the installed cost of a project can range between about $3,000/kW and $12,000/KW which indicates significant variation. If the user does not have indication as to project cost it is recommended that the midpoint value of about $7,500/kW is used.

3. Peak Power: Reference

   This cell refers to the "Energy Production" worksheet and displays the estimated peak power generation of the system. This cell does not require any user input.

4. Initial Capital Investment: Calculation

   This cell calculates the initial capital investment when "Automatic" cost methodology is chosen. The cell calculates based on the estimated peak power of the system and the cost guideline value chosen by the user.

5. Annual O&M: Input

   When "Automatic" is chosen as the costing methodology, the user must define the estimated annual operations and maintenance (O&M) cost using the slide bar. Research in previous portions of this project indicated that the installed cost of a project can range between about $2,000/year and $10,000/year. If the user does not have indication as to project cost it is recommended that the midpoint value of about $4,000/year is used.

6. Costs / Initial Capital Investment: Input

   When "Manual" is chosen the user should provide estimates of a range of itemized project costs such as equipment, interconnection, and permitting, among others. The user will have the option to define the % contingency that will be used and it is recommended that the value used is between 10% and 40% depending on the confidence in estimated values. The "Contingency" cell will automatically calculate based on the inputted costs and chosen contingency value. The initial capital investment is estimated as a summation of all of the inputted costs as well as the contingency. The itemized cost data requires user input; however, the final estimated initial capital investment will automatically calculate and does not require user input.

7. Annual O&M: Input

When "Manual" is chosen the estimated annual operations and maintenance (O&M) cost using the slide bar. Research in previous portions of this project indicated that the installed cost of a project can range between about $3,000/year and $10,000/year. If the user does not have indication as to project cost it is recommended that the midpoint value of about $4,000/year is used. The itemized O&M cost data requires user input; however, the total estimated O&M will automatically calculate and does not require user input.

2.1.5 Financial Analysis

The "Financial Analysis" worksheet is where the project financial viability is evaluated. Based on the financing term, the yearly evaluation columns will adjust and calculations for the financing period will be displayed. Simple payback period, average annual project benefit over the financing term, and an output results chart will be calculated for the user's review.

In-Conduit Hydropower Project Screening Tool
Financial Evaluation

Annual Energy Balance	Units		Notes
Project Name		Test	
Project Location		Boston, MA	
Average Annual Energy	(kWh)	3,962,300	
Energy Use		Onsite	
Energy Type		Retail	

Financial Parameters	Units		Notes
Project Start-Up Year	(yr)	2010	
Peak Power	(kw)	559	
Average Annual Energy	(kWh)	3,962,300	
Initial Avoided Cost of Energy (Retail)	($/kWh)	$ 0.10	$0.07 - $0.17
Initial ISO Energy Value (Wholesale)	($/kWh)	$ 0.04	$0.03 - $0.05
Assumed Annual Power Rate Escalator	(%)	2.0%	
Initial REC Value	($/kWh)	$ 0.02	
REC Escalator	(%)	2.0%	
Initial O&M Costs	($/yr)	$ 6,000	
Cost Escalator	(%)	4.0%	
Initial Capital Investment		$ 1,675,500	
Grant Funding Value		$ 25,000	
Total Finance		$ 1,650,500	
Assumed Finance Rate	(%)	5%	
Financing Term	(yr)	30	
Average Annual Project Benefit Over Finance Period	($)	$525,431	
Simple Payback Period	(yr)	3.1	

Proforma						
Annum	2010	2011	2012	2013	2014	2015
Project Year	1	2	3	4	5	6
Annual Income						
ISO Energy Value (Wholesale)	$0.040	$0.041	$0.042	$0.042	$0.043	$0.044
Avoided Cost of Energy (Retail)	$0.100	$0.102	$0.104	$0.106	$0.108	$0.110
Power Sales Income	$396,230	$404,155	$412,238	$420,482	$428,892	$437,470
REC Value	$0.020	$0.020	$0.021	$0.021	$0.022	$0.022
REC Income	$79,246	$80,831	$82,448	$84,096	$85,778	$87,494
Estimated Annual Income	$475,476	$484,986	$494,685	$504,579	$514,671	$524,964
Annual Expenses						
Estimated Total O&M Expenses	$6,000	$6,240	$6,490	$6,749	$7,019	$7,300
Financing						
Income Before Loan and Interest Paym	$469,476	$478,746	$488,196	$497,830	$507,651	$517,664
Uniform Annual Financing Payment	($106,323)	($106,323)	($106,323)	($106,323)	($106,323)	($106,323)
Annual Benefit	$363,153	$372,423	$381,873	$391,507	$401,328	$411,341

Figure 10. "Financial" Worksheet – Conventional Hydropower

1. Project Name: Reference

   This cell refers to the "Cover" worksheet and displays the name of the proposed project that will be analyzed by the screening tool. This cell does not require any user input.

2. Project Location: Reference

   This cell refers to the "Cover" worksheet and displays the location of the proposed project that will be analyzed by the screening tool. This cell does not require any user input.

3. Average Annual Energy: Reference

   This cell refers to the "Energy Production" worksheet and displays the annual energy generation estimated for the project. This cell does not require any user input.

4. Energy Use: Input

   This cell is a drop down list from which the user must choose whether the energy will be used on-site or sold to the grid. Energy which is used on-site is used to offset energy which would otherwise be purchased and typically has a higher value that than sold to the grid. The user must evaluate the distance from the generation site to the on-site use location as well as the annual demand compared to the annual generation to evaluate if on-site use is feasible.

5. Energy Type: Calculation

   This cell provides an alternative terminology for the energy use. On-site energy is often referred to as retail while energy sold to the grid can be referred to as wholesale. This cell evaluates the energy use selection and provides the alternative terminology for user convenience.

6. Project Start-Up Year: Input

   The user must define the first year of operations for the project. This year is used in the proforma analysis to track items such as loan periods, inflation and other time based factors.

7. Peak Power: Reference

   This cell refers to the "Energy Production" worksheet and displays the estimated peak power generation of the system. This cell does not require any user input.

8. Average Annual Energy: Reference

   This cell refers to the "Energy Production" worksheet and displays the estimated average annual energy generation of the system. This cell does not require any user input.

9. Initial Avoided Cost of Energy (Retail): Input

   The user must define the value of retail energy for use in the proforma and other financial analysis. This value should reflect the cost of the energy which would otherwise have to be purchased in the project start up year. Typically, the value of retail energy is about $0.07 to $0.17/kWh; however, the user can determine an actual value by reviewing utility bills.

10. Initial ISO Energy Value (Wholesale): Input

    The user must define the average value of wholesale energy for use in the proforma and other financial analysis. This input should reflect the value of energy sold to the grid (local utility) in the project start up year. Unless a contract has been acquired, the value of wholesale energy fluctuates based on supply and demand. Therefore, this input should reflect the average annual value of electricity. Typically, wholesale energy is valued between $0.03 and $0.05/kWh although contracts may be available which increase this value.

11. Assumed Annual Power Rate Escalator: Input

    In this cell, the user has the option to define an escalation rate associated with the value of energy. Not all energy use scenarios will have escalation rates. A wholesale contract may have a clause for an escalator which would typically be on the order of 1%-2%. Retail rates are a function of the cost of power and without a contract, wholesale rates will not have an escalator. However, the cost of energy generally increases over time. Therefore, a low value escalator (0.5%)

can be inputted into this cell to represent energy value inflation. If this cell is left blank, a more conservative estimate will be made.

12. Initial REC Value: Input

    The user must define the initial Renewable Energy Certificate (REC) value for use in the proforma and other financial analysis. Typically, the value of RECs is on the order of $0.02-$0.04/kWh; however, the market can be volatile and values vary as a function of the geographic location which they are sold in.

13. REC Escalator: Input

    In this cell, the user has the option to define an escalation rate associated with any project RECs. Not all REC contracts will have escalation rates; if there is one, the escalation rate will be defined in the REC sales contract and is typically on the order of the rate of inflation.

14. Initial O &M Costs: Reference

    This cell refers to the "Cost" worksheet and displays the estimated total annual operations and maintenance cost for the system. This cell does not require any user input.

15. Cost Escalator: Input

    The user must input the inflation rate to be applied to O&M costs such that the change in cost is reflected over time. Federally reported interest rates have been about 2% for several years; however, the user can choose to input any value.

16. Initial Capital Investment: Reference

    This cell refers to the "Cost" worksheet and displays the estimated total project cost for the system. This cell does not require any user input.

17. Grant Funding Value: Input

    The user must input any grant funding or other means of direct cost reduction in this cell. The value inputted into this cell will be reduced from the estimated initial capital investment and will not be considered when calculating payments.

18. Total Finance: Calculated

    This cell calculates the total project cost which must be financed based on the estimated initial capital investment less any grant funding. This input is automatically calculated and the cell does not require any user input.

19. Assumed Finance Rate: Input

    The user must input the financing rate associated with any loans or other borrowed capital. This value will be one factor in estimating the annual payments on monies financed and can be a factor in determining project viability. Federal prime interest rates have been at or below about 4.5% for several years; it is likely that a municipal entity will be able to finance at rates below prime.

20. Financing Term: Input

    The user must define the number of years which any necessary capital will be financed over. The finance period must be inputted as a period between 1 and 30 years. Based on this value, the adjacent proforma analysis will automatically adjust to reflect this period.

21. Average Annual Project Benefit over Finance Period: Calculation

    This cell looks up each of the calculated annual benefit of the project over the finance period and provides an average. This input is automatically calculated and the cell does not require any user input.

22. Simple Payback Period: Calculation

    This cell is calculated based on the total financed and the average annual project benefit over the finance period. The calculation should be one consideration when evaluating a projects' viability. This input is automatically calculated and the cell does not require any user input.

2.1.6 Environmental Benefits

The "Environmental Benefits" worksheet is where the annual reduction in emissions due to the hydroelectric generation is estimated. In addition to emission avoidance, hydropower generation provides long-term sustainability for communities and reduces dependence on foreign energy sources.

In-Conduit Hydropower Project Screening Tool
Environmental Benefit

Energy Production			Notes
Average Annual Energy	(kWh)	3,962,300	

Environmental Benefit			Notes
Carbon Dioxide	(lb/kWh)	1.52	
Sulfur Dioxide	(lb/kWh)	0.008	
Nitrogen Oxides	(lb/kWh)	0.0049	
Avoided Annual Carbon Dioxide Emissions	(lbs)	6,022,696	
Avoided Annual Sulfur Dioxide Emissions	(lbs)	31,698	
Avoided Annual Nitrogen Oxides Emissions	(lbs)	19,415	

Figure 11. "Environmental Benefit" Worksheet – Conventional Hydropower

1. Average Annual Energy: Reference

   This cell refers to the "Energy Production" worksheet and displays the estimated average annual energy generation of the system. This cell does not require any user input.

2. Carbon Dioxide: Calculation

   This cell provides an Environmental Protection Act (EPA) based value for the pounds of carbon dioxide emissions released for every kilowatt-hour of energy produced at a fossil fuel based generation facility.

3. Sulfur Dioxide: Calculation

   This cell provides an Environmental Protection Act (EPA) based value for the pounds of sulfur dioxide emissions released for every kilowatt-hour of energy produced at a fossil fuel based generation facility.

4. Nitrogen Oxides: Calculation

   This cell provides an Environmental Protection Act (EPA) based value for the pounds of nitrogen oxides emissions released for every kilowatt-hour of energy produced at a fossil fuel based generation facility.

5. Avoided Annual Carbon Dioxide Emissions: Calculation

   This cell calculates the estimated pounds of annual avoided carbon dioxide emissions resulting from the hydroelectric generating facility as compared to a fossil fuel based generation system.

6. Avoided Annual Sulfur Dioxide Emissions: Calculation

   This cell calculates the estimated pounds of annual avoided sulfur dioxide emissions resulting from the hydroelectric generating facility as compared to a fossil fuel based generation system.

7. Avoided Annual Nitrogen Oxides Emissions: Calculation

   This cell calculates the estimated pounds of annual avoided nitrogen oxide emissions resulting from the hydroelectric generating facility as compared to a fossil fuel based generation system.

2.1.7 Summary

The final worksheet in the conventional hydropower series is a summary of important project information. All data has been calculated in previous worksheets and is referenced on the summary sheet.

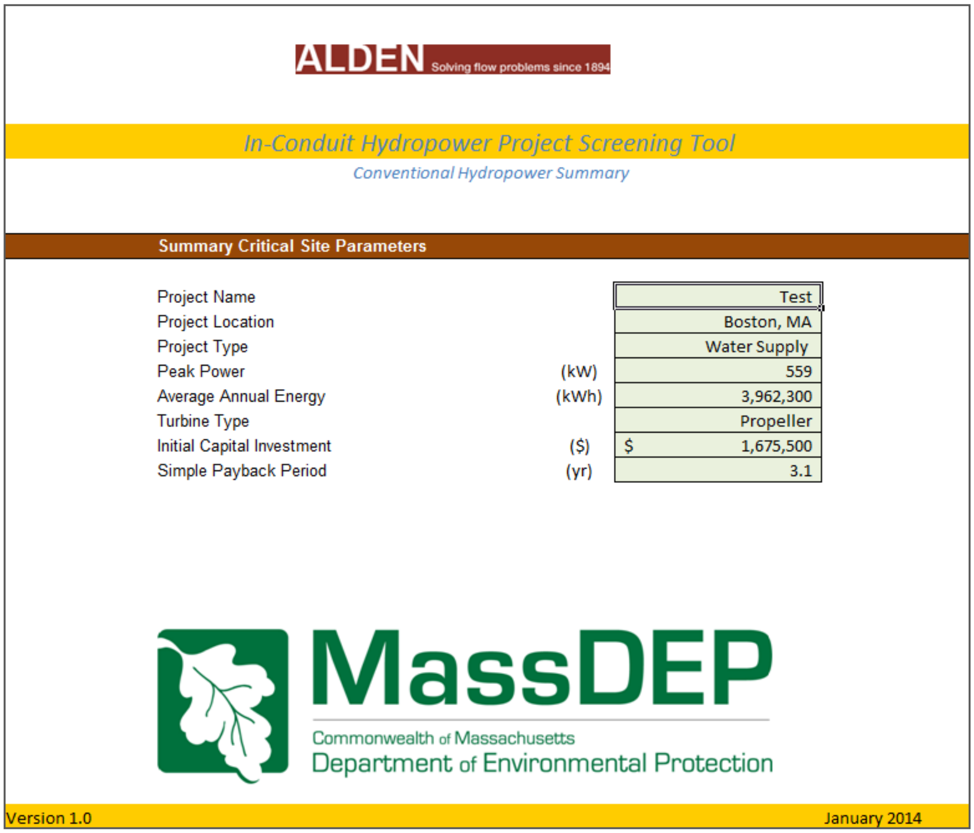


Figure 12. "Summary" Worksheet – Conventional Hydropower

2.2 Simplified Conventional Hydropower

The Simplified Conventional Hydropower evaluation aims to reduce the level of effort required to complete a preliminary evaluation. This worksheet has limited user inputs and options compared to the more detailed conventional hydropower evaluation. In addition, rather than requiring a flow duration curve for evaluation, only a single value is required to set the turbine design flow.

In-Conduit Hydropower Project Screening Tool
Simplified Conventional Hydropower Energy and Benefit Analysis

Available Energy Analysis	Units		Notes
Average Head Available	(PSI)	30	
Average Annual Daily Flow	GPM	30,000	
Average Annual Daily Flow	(cfs)	66.8	Fill in Blue input cells to estimate project financial and environmental benefits
Turbine Selection		Automatic	
Automatic Turbine Type Selection		Kaplan	
Manual Turbine Type Selection		PAT	
Turbine Type		Kaplan	
Annual Capacity Factor	(%)	75%	
Power Output	(kW)	349	
Annual Power Generation	(kWh)	2,294,100	
Financial Analysis	**Units**		
Cost Guideline	($/kW)	$ 10,500	
Estimated Initial Capital Investment	($)	$ 3,666,400	
Estimated Annual O&M	($/yr)	$ 3,000	
Energy Rate	($/kWh)	$ 0.14	
REC Availability		yes	
Financing Term	(yr)	20	
Financing Rate	(%)	6%	
Project Financial and Environmental Benefits	**Units**		
Average Annual Project Benefit Over Finance Period	($)	$130,300	
Simple Payback Period	(yr)	28	
Avoided Annual Carbon Dioxide Emissions	(lb/yr)	3,487,000	
Avoided Annual Sulfur Dioxide Emissions	(lb/yr)	18,400	
Avoided Annual Nitrogen Oxides Emissions	(lb/yr)	11,200	

Figure 13. "Summary" Worksheet – Simplified Conventional Hydropower

1. Average Head Available: Input

   The head is the average water pressure available to operate the turbine in psi and must be inputted by the user in this cell. It is important to consider how much water pressure will be required downstream of the turbine for system operations including water conveyance and facility operations. Any residual pressures required are not available to the turbine and should be included in the available head value.

2. Average Annual Daily Flow: Input

   The user must input a turbine design flow in this cell. If a flow duration curve is available, it is recommended that the user review it and choose a flow between 25% and 75% duration based on the shape of the curve. If a flow duration curve is not available, the average daily flow is suggested.

3. Average Annual Daily Flow: Calculation

   This cell converts the turbine design flow measured in MGD/GPM to cfs which is more commonly used in hydropower applications. This cell does not require any user input.

4. Turbine Selection: Input

   This cell is a drop down list from which the user must choose whether the turbine type will be automatically chosen or user defined (manual). Should the user choose “Automatic”, a pop-up query window (Figure 14) will appear with three questions which will lead to a preferred turbine type. Should the user choose “Manual”, the user will be required to choose a turbine type from a drop down list.

   The user must first define the facility type as either a water supply or wastewater treatment facility. This will define the first question regarding flows but will not impact subsequent questions.

   The three questions which the user will be asked in if “Automatic” is selected are:

   - Flows
     a. Water supply – Do the flows vary throughout the day? Is the flow intermittent?
     b. Wastewater – Is there a diurnal pattern, do flows drop off significantly at night, or do average daily flows vary significantly month to month?
   - Will the turbine discharge continue to be piped or be discharged to atmosphere?
   - Approximate project head (psi)?

   There are many different types of turbines of which one may be more suitable for particular conditions than another. Some turbines have a wider range of operation than others and can accommodate wider ranges in flow than others. If there are wide ranges in the flow rates available to the turbine throughout the year, the user should choose “yes” in the query box. Conversely, if the flow rates are relatively consistent throughout the day, the user should select “no”. Some turbines must discharge to atmosphere (free surface) for operation while others must discharge to a vacuum. The user must indicate what the anticipated site conditions will be and whether or not the turbine discharge flow will continue to be pressurized after discharge or if a free surface discontinuity is acceptable. Finally, turbines typically have specific ranges of head (pressure) in which operation is suitable. The user must input the same head value provided in the “Head” input cell to finalize the automatic turbine selection.

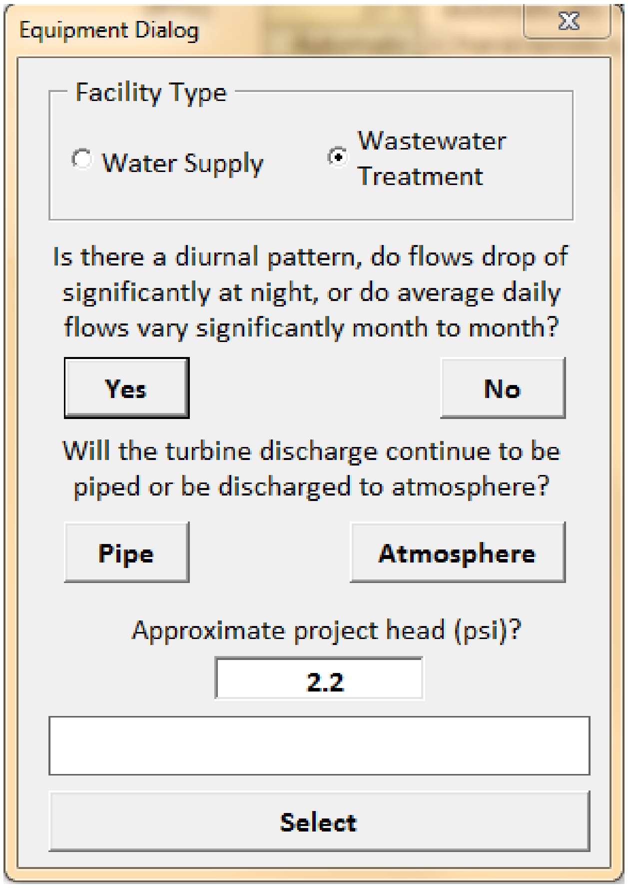


Figure 14. "Summary" Worksheet Pop-Up Query –Simplified Conventional Hydropower

5. Automatic Turbine Type Selection: Calculation

   The cell uses the query results from the pop-up window to determine an appropriate turbine type and automatically inputs it. This cell is locked and cannot be modified by the user.

6. Manual Turbine Type Selection: Input

   If "Manual" is selected as the turbine selection type, the user must select one of the six turbine options from the drop down list.

7. Turbine Type: Calculation

   Regardless of the turbine selection methodology pursued, this cell will display the final turbine type. The cell evaluates the selection methodology and displays the respective flow rate. This cell chooses between the automatic and manual turbine selection options and does not require any user input.

8. Annual Capacity Factor: Default

   This is the percentage of the year which the unit is operating at its peak capacity. This value can be estimated as the amount of time that the turbine design flow is available for generation in combination with an estimate of downtime due to maintenance and repair of the hydroelectric system and the water supply/wastewater treatment system. If data is unavailable, this value can be estimated between 50% and 90%. Although this is higher than a typical hydroelectric installation, in-conduit flows tend to be more consistent than those in a natural hydrologic system.

9. Power Output: Calculation

   This cell estimates the peak power output of the hydropower system based on the available head, turbine design flow and efficiencies. This input is automatically calculated and the cell does not require any user input.

10. Annual Power Generation: Calculation change title to energy not power

    This cell estimates the average annual energy generation as a function of the peak power generated, the total hours in a year and the annual capacity factor. Because the annual capacity factor only considers peak capacity run time, it provides a factor of conservation in estimates.

11. Cost Guideline: Input

    The user must define the $/kW value used for estimating the total project cost using the slide bar. Research in previous portions of this project indicated that the installed cost of a project can range between about $3,000/kW and $12,000/KW which indicates significant variation. If the user does not have indication as to project cost it is recommended that the midpoint value of about $7,500/kW is used.

12. Estimated Initial Capital Investment: Calculation

    This cell calculates the initial capital investment based on the estimated peak power of the system and the cost guideline value chosen by the user.

13. Estimated Annual O&M: Input

    The user must define the estimated annual operations and maintenance (O&M) cost using the slide bar. Research in previous portions of this project indicated that the installed cost of a project can range between about $3,000/year and $10,000/year. If the user does not have indication as to project cost it is recommended that the midpoint value of about $4,000/year is used.

14. Energy Rate: Input

    The user must define the value of energy for use in the financial analysis. If the energy can be used on-site, the value should reflect the cost of the energy which would otherwise have to be purchased in the project start up year. If the energy will be sold to the grid, the value should reflect the average wholesale value of energy. Typically, the value of retail energy is about $0.07 to $0.17/kWh; however, the user can determine an actual value by reviewing utility bills. Typically, the value of wholesale (grid) energy is $0.03 and $0.05/kWh.

15. REC Availability: Input

    The user must choose from the drop down list whether or not RECs are available for the project. Should RECs be available, it is assumed that $0.03/kWh is the value of RECs.

16. Financing Term: Input

    The user must define the number of years which any necessary capital will be financed over. The finance period must be inputted as a period between 1 and 30 years. Based on this value, the proforma calculations will automatically adjust to reflect this period.

17. Financing Rate: Input

    The user must input the financing rate associated with any loans or other borrowed capital. This value will be one factor in estimating the annual payments on monies financed and can be a factor in determining project viability. Federal prime interest rates have been at or below about 4.5% for several years; it is likely that a municipal entity will be able to finance at rates below prime.

18. Average Annual Project Benefit Over Finance Period: Calculation

    This cell looks up each of the calculated annual benefit of the project over the finance period and provides an average. This input is automatically calculated and the cell does not require any user input.

19. Simple Payback Period: Calculation

    This cell is calculated based on the total financed and the average annual project benefit over the finance period. The calculation should be one consideration when evaluating a projects' viability. This input is automatically calculated and the cell does not require any user input.

20. Avoided Annual Carbon Dioxide Emissions: Calculation

    This cell calculates the estimated pounds of annual avoided carbon dioxide emissions resulting from the hydroelectric generating facility as compared to a fossil fuel based generation system. These estimates are based on EPA values.

21. Avoided Annual Sulfur Dioxide Emissions: Calculation

    This cell calculates the estimated pounds of annual avoided sulfur dioxide emissions resulting from the hydroelectric generating facility as compared to a fossil fuel based generation system. These estimates are based on EPA values.

22. Avoided Annual Nitrogen Oxide Emissions: Calculation

    This cell calculates the estimated pounds of annual avoided nitrogen oxide emissions resulting from the hydroelectric generating facility as compared to a fossil fuel based generation system. These estimates are based on EPA values.

2.3 Simplified Hydrokinetic

The Simplified Hydrokinetic evaluation provides a user the opportunity to understand the potential for hydrokinetic energy generation at a project location. The worksheet focuses on an installation at a wastewater treatment facility outfall; however, the sheet can be used for other applications as well. A more detailed hydrokinetic evaluation series was not developed because hydrokinetic generation is typically significantly more difficult to make financially viable than conventional hydropower.

In-Conduit Hydropower Project Screening Tool
Hydrokinetic Turbine Energy and Benefit Analysis

Available Energy Analysis	Units		Notes
Average Velocity	(ft/s)		Fill in Blue input cells to estimate project financial and environmental benefits
Average Wetted Depth	(ft)		
Channel Configuration		Circular	
Channel Average Width (Rectangular Channel Only)	(ft)		
Channel Average Depth (Rectangular Channel Only)	(ft)		
Channel Average Diameter (Circular Channel Only)	(ft)		
Intercepted Flow Area	(ft^2)	0	
Capacity Factor	(%)	60%	
Power Output	(kW)	#DIV/0!	
Annual Power Generation	(kWh)	#DIV/0!	
Financial Analysis	**Units**		**Notes**
Cost Guideline	($/kW)	$ 7,250	
Estimated Initial Capital Investment	($)	#DIV/0!	
Estimated Annual O&M	($/Yr)	$ 8,000	
Energy Rate	($/kWh)	0.14	
REC Availability		No	
Financing Term	(yr)	27	
Assumed Financing Rate	(%)	5%	
Project Financial and Environmental Benefits	**Units**		**Notes**
Average Annual Project Benefit Over Finance Period	($)	#DIV/0!	
Simple Payback Period	(yr)	#DIV/0!	
Avoided Annual Carbon Dioxide Emissions	(lbs)	#DIV/0!	
Avoided Annual Sulfur Dioxide Emissions	(lbs)	#DIV/0!	
Avoided Annual Nitrogen Oxides Emissions	(lbs)	#DIV/0!	

Figure 15. "Summary" Worksheet – Simplified Hydrokinetic

1. Average Velocity: Input

   This is a user input. Hydrokinetic power is generated based on water velocity. This value is an estimate of the average velocity based on average flow, width and depth of the channel or pipe.

2. Average Wetted Depth: Input

   This is a user input and is the average depth of water in the channel or pipe at the wastewater treatment facility.

3. Channel Configuration: Calculation

   The user must choose from a drop down list and defines the geometry of the wastewater treatment facilities outfall structure as rectangular or circular.

4. Channel Average Width (Rectangular Channel Only): Input

   This is a user input and is the average width of the wastewater treatment facility's outfall structure. This cell is applicable to rectangular channels only.

5. Channel Average Depth (Rectangular Channel Only): Input

   This is a user input and is the average depth of the wastewater treatment facility's outfall structure. This cell is applicable to rectangular channels only.

6. Channel Average Diameter (Circular Channel Only): Input

   This is a user input and is the average diameter of the wastewater treatment facility's outfall structure. This cell is applicable to circular outfalls only.

7. Intercepted Flow Area: Calculation

   This is the total area intercepted by the turbine blades within the wetted cross section. This cell is calculated and does not require any user input.

8. Capacity Factor: Input

   This is the percentage of the year which the unit is operating at its peak capacity. This value can be estimated as the amount of time that the turbine design velocity is available for generation in combination with an estimate of downtime due to maintenance and repair of the generation system and the water supply/wastewater treatment system. If data is unavailable, this value can be estimated between 50% and 90%.

9. Power Output: Calculation

   This cell estimates the peak power output of the hydrokinetic system based on the intercepted flow area, and water velocity. This input is automatically calculated and the cell does not require any user input.

10. Annual Power Generation: Calculation

    This cell estimates the average annual energy generation as a function of the peak power generated, the hours in a year and the annual capacity factor. Because the annual capacity factor only considers peak capacity run time, it provides a factor of conservation in estimates

11. Cost Guideline: Input

    The user must define the $/kW value used for estimating the total project cost using the slide bar. Minimal information was available regarding installed cost of hydrokinetic projects primarily due to the limited number of installations. Therefore, the cost guidelines for conventional hydropower are used which range from about $3,000/kW and $12,000/KW. Generally, the cost of a hydrokinetic installation is higher than that of a conventional hydropower system. If the user does not have indication as to project cost it is recommended that a value of about $10,000/kWh is used.

12. Estimated Initial Capital Investment: Calculation

    This cell calculates the initial capital investment based on the estimated peak power of the system and the cost guideline value chosen by the user.

13. Estimated Annual O&M: Input

    The user must define the estimated annual operations and maintenance (O&M) cost using the slide bar. Research on conventional hydropower projects indicated that the installed cost of a project can range between about $2,000/year and $10,000/year. If the user does not have an indication as to project cost it is recommended that the midpoint value of about $4,000/year is used.

14. Energy Rate: Input

    The user must define the value of energy for use in the financial analysis. If the energy can be used on-site, the value should reflect the cost of the energy which would otherwise have to be purchased in the project start up year. If the energy will be sold to the grid, the value should reflect the average wholesale value of energy. Typically, the value of retail energy is about $0.07 to $0.17/kWh; however, the user can determine an actual value by reviewing utility bills. Typically, the value of wholesale (grid) energy is $0.03 and $0.05/kWh.

15. REC Availability: Input

    The user must choose from the drop down list whether or not RECs are available for the project. Should RECs be available, it is assumed that $0.03/kWh is the value of RECs.

16. Financing Term: Input

    The user must define the number of years which any necessary capital will be financed over. The finance period must be inputted as a period between 1 and 30 years. Based on this value, the proforma calculations will automatically adjust to reflect this period.

17. Assumed Financing Rate: Input

    The user must input the financing rate associated with any loans or other borrowed capital. This value will be one factor in estimating the annual payments on monies financed and can be a factor in determining project viability. Federal prime interest rates have been at or below about 4.5% for several years; it is likely that a municipal entity will be able to finance at rates below prime.

18. Average Annual Project Benefit Over Finance Period: Calculation

    This cell looks up each of the calculated annual benefit of the project over the finance period and provides an average. This input is automatically calculated and the cell does not require any user input.

19. Simple Payback Period: Calculation

    This cell is calculated based on the total financed and the average annual project benefit over the finance period. The calculation should be one consideration when evaluating a projects' viability. This input is automatically calculated and the cell does not require any user input.

20. Avoided Annual Carbon Dioxide Emissions: Calculation

    This cell calculates the estimated pounds of annual avoided carbon dioxide emissions resulting from the hydroelectric generating facility as compared to a fossil fuel based generation system. These estimates are based on EPA values.

21. Avoided Annual Sulfur Dioxide Emissions: Calculation

    This cell calculates the estimated pounds of annual avoided sulfur dioxide emissions resulting from the hydroelectric generating facility as compared to a fossil fuel based generation system. These estimates are based on EPA values.

22. Avoided Annual Nitrogen Oxide Emissions: Calculation

    This cell calculates the estimated pounds of annual avoided nitrogen oxide emissions resulting from the hydroelectric generating facility as compared to a fossil fuel based generation system. These estimates are based on EPA values.

APPENDIX A FLOW DURATION CURVE DEVELOPMENT

Description

A flow duration curve is a graphical representation that shows the percentage of time that flow in a stream is likely to equal or exceed a particular value.

Development Instructions

The following provides step by step instructions to take a set of flow data and turn it into a flow duration curve. Most spreadsheet software will be suitable for analysis; however excel is typically utilized.

1. Rank (sort) the column of flow rates from highest to lowest value (Column A)
2. In the adjacent column (next to each flow rate), assign a rank value to each flow rate. i.e. 1, 2, 3, 4….n (Column B)
3. In the next adjacent column, calculate the exceedence probability of each flow rate as follows (Column C):

$$P = 100 * \frac{R}{(n+1)}$$

   Where:

   P = Probability that a particular flow will be equaled or exceeded for a specific percentage of the year

   R = Flow value ranking

   n = total number of flow rate data points

4. Plot the flow rate data (Column A, Y axis) against the exceedence probability (Column C, X axis) to develop the flow duration curve
5. The tabular data required for the conventional hydropower evaluation is a reduction of the data developed in steps 1-3 as it is only showing 20 of the flow duration curve data points. To develop this, look up the percent durations required (5%, 10%, 15%....95%, 100%) and identify the adjacent flow rate to make a simplified set of data.