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FINAL REPORT
ECONOMIC ANALYSIS OF WATER HAULING FOR SOUTHWEST VIRGINIA COMMUNITIES

SPECIAL REPORT

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Virginia Water Resources Research Center
10 Sandy Hall
Blacksburg, VA 24061
(540)231-5624
FAX: (540)231-6673
e-mail: water@vt.edu
homepage address: **http://www.vwrrc.vt.edu/vwrrc/vwrrc.htm**

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Leonard A. Shabman, Director

Final Report

ECONOMIC ANALYSIS OF WATER HAULING FOR SOUTHWEST VIRGINIA COMMUNITIES

By

Dixie Watts Reaves
Tamim Younos
Kelly A. Ramsey

Virginia Water Resources Research Center
10 Sandy Hall
Virginia Tech
Blacksburg, Virginia 24061-0444

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TABLE OF CONTENTS

Acknowledgments iii

Executive Summary iv

Introduction 1

Objective 1

Methods

- **Water-Hauling Model** 1
- **Payment and Water Storage Alternatives** 2
- **Cost Descriptions** 2
- **Limitation of Serviceability** 3

User's Guide for Model Input

- **Alternative Scenarios** 3
- **Model Input Variables** 3

Using the Model: Illustrations

- **Trammel Gap Community** 7
- **Multi-Community** 8

APPENDIX A – Detailed Procedures for Model Development and Economic Analysis 9

APPENDIX B – Detailed Documentation of Model Illustrations Applications 23

1. **Model Application to Trammel Gap Community**
2. **Model Application to Multi-Community**
3. **Blank Worksheet**

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EXECUTIVE SUMMARY

Many households in outlying areas of several Southwest Virginia counties are currently unserved by public water supplies. Two Planning Districts in the area are working on a regional plan to extend public water mains to unserved areas. However, due to cost prioritization and the small number of households to be served, there are many communities where public water supplies cannot or would not be extended in the foreseeable future. The question then becomes how to provide a high-quality, reliable water source for these isolated households.

In many rural areas, most residences are able to depend on wells to supply household water. In some areas of the Virginia coalfields, this is also the case. Generally, however, Virginia coalfield geology does not support plentiful groundwater supplies. The area's primary subsurface aquifers are coal seams that are limited in their ability to supply groundwater. In areas of extensive underground coal-mining, these aquifers have been disrupted, and conventional wells are not possible.

Water hauling provides another potential water source. In many respects, however, water hauling is not a desirable means of supplying communities with household water. In rural communities that do not otherwise have access to high-quality, reliable groundwater and where providing public water is simply not possible, water hauling may be the best available alternative in the short run. However, the cost of water hauling often prevents its use even in such situations.

The objective of this project was to evaluate the economic feasibility of large-scale water hauling and distribution to small communities. A user-friendly computer model was developed to evaluate alternative scenarios. A large-scale water hauling system is a process where a tanker truck hauls a large quantity of treated drinking water to storage tanks in small communities. The water storage tanks can either be large community tanks (20,000 gallons in this analysis) or individual household tanks (5,000 gallons or less). The distribution system can be designed in such a way that, in later years, if the public water line is extended to the area, the community tank can be connected to the public water system. The individual tank alternative will provide each household with its own water storage.

The computer model (Microsoft Excel) was designed to estimate the cost to the customer per month for four different water-hauling scenarios and payment methods. *Alternative 1* calculates the cost of using a community tank with initial investment costs included in the monthly bill. The customer pays for both initial costs and operational costs. *Alternative 2* calculates the cost of using a community tank with initial investment costs not included in the monthly bill; therefore, the customer pays only the operational costs. Initial investment costs are assumed to be paid through a granting agency or local government. *Alternative 3* calculates the cost of using individual household tanks with initial investment costs included in the monthly bill. The customer pays for both initial costs and operational costs. *Alternative 4* calculates the cost of using individual household

tanks without initial investment costs included in the monthly bill. The customer pays only the operational costs.

The report explains the procedures used for developing the computer model, provides methods of economic analysis, and presents model demonstration examples. A diskette containing the computer model is attached to the report. It is expected that, by using the model and comparing results for alternative scenarios, the model user can determine the financial assistance needed to implement hauling of adequate and safe drinking water to affected communities.

INTRODUCTION

Many households in outlying areas of several Southwest Virginia counties are currently unserved by public water supplies. Options for these communities include: 1) extending public water mains from the existing service areas; 2) rainfall harvesting and cistern storage; 3) developing alternative water sources such as mine cavity water; and 4) hauling and distribution of treated water. In some cases, wells are an option, although Virginia coalfield geology does not support plentiful groundwater supplies in many cases. Two Planning Districts in the area are developing a regional plan to extend public water mains to unserved areas. However, due to cost prioritization and the small number of households to be served, there are many communities where public water supplies cannot or would not be extended in the foreseeable future. Rainfall harvesting-cistern storage and water hauling remain as viable options for many of these isolated small communities.

OBJECTIVE

The implementation of water hauling and distribution is limited by its economic feasibility. The objective of this project was to evaluate the economic feasibility of large-scale water hauling and distribution to small communities. A user-friendly computer model was designed to evaluate alternative scenarios.

A large-scale water hauling system is a process where a tanker truck hauls a large quantity of treated drinking water to storage tanks in small communities. The water storage tanks can either be community tanks (20,000 gallons in this analysis) or individual household tanks (5,000 gallons or less). The 20,000-gallon tank will provide the individual households with treated drinking water through a distribution system to each household. The distribution system can be designed in such a way that, in later years, if the public water line is extended to the area, the distribution system is already in place and the community tank can be connected to the public water system. The individual tank alternative will provide each household with its own water storage.

METHODS

Detailed procedures for the design of the computer model and economic analysis for alternative water-hauling scenarios and payment methods are documented in Appendix A. A brief description of the methods is given below.

Water Hauling-Distribution Model

A computer model (Microsoft Excel) was designed to estimate the monthly cost to the customer for different water-hauling scenarios and payment methods. It is expected that, by using the model and comparing results for alternative scenarios,

the model user can determine the financial assistance needed to implement hauling of adequate and safe drinking water to affected communities.

Payment and Water Storage Alternatives

To optimize the comparability of distributing drinking water by water hauling, two water storage alternatives and two payment alternatives were included in the Excel model. Water storage alternatives include either a 20,000-gallon community tank or individual household tanks. The 20,000-gallon tank would provide water to the entire community, while the individual tanks would provide water to each household within the community. The payment alternatives depend on whether initial investment costs are included with operational costs in the monthly customer bill. If not included in the monthly bill, initial investment costs must be covered by outside funding sources.

The model user will enter the water-hauling costs that are relevant for his/her community into the '***Inputs***' sheet of the model. Once these community-specific costs are entered, the model will calculate the monthly cost to the customer for four alternatives: community tank with all costs paid by the customer; community tank with only operational costs paid by the customer; individual tanks with all costs paid by the customer; and individual tanks with only operational costs paid by the customer.

The sheet, '***Community Tank Initial Costs***', quantifies the initial investment costs that are included in the community tank water-hauling system.

The sheet, ***'Individual Tank Initial Costs'***, quantifies the initial investment costs included in the individual household tank water-hauling system.

Cost Descriptions

The costs of water hauling include initial investment costs and operational and maintenance costs. The operational and maintenance costs vary with the water usage of each household in the community and the number of miles between the community and the treated water source. The variable miles between the communities and the water source will affect the cost of fuel, maintenance, and the truck driver salary and truck insurance.

The major initial investment cost for water hauling is the cost of a water-hauling truck. For the community tank water storage alternative, the initial investments include the cost of the waterline, the water meters, gate valves, gravel, fencing, site survey and deed preparation, design, easements, permits, bidding, and miscellaneous installation and construction costs. For the individual water storage alternative, the initial investments include the purchase and installation cost of the tanks and pipe distribution system to each household.

For economic analysis, nominal dollar values were used, except for the inflation-adjusted salary of the truck driver. Straight-line depreciation was used for tanks, waterlines, and the truck.

Limitation of Serviceability

Due to safety standards regulated by the Virginia Department of Health and the limitation of a tank size of 20,000 gallons, no more than 15 households per community can be served with a single community tank. High initial investment costs place a restraint on the application of a water hauling system. Since a water-hauling truck's useful life is only five years and the purchase value of the truck is very high, the expectation of having the customers pay for the truck is not reasonable. Also, the operational cost of the driver's salary, depending on the percentage of overall job time the driver spends on water hauling, is very high and causes the monthly cost to the households to be excessive. Financial assistance to initiate reliable water hauling to these small communities will be necessary.

USER'S GUIDE FOR MODEL INPUT

Alternative Scenarios

Four alternative water-hauling scenarios were examined.

Alternative 1: calculates the cost of using a community tank with initial investment costs included in the monthly bill. The customer pays for both initial costs and operational costs.

Alternative 2: calculates the cost of using a community tank with initial investment costs not included in the monthly bill, therefore the customer only pays for the operational costs. Initial costs must be covered by some outside funding source.

Alternative 3: calculates the cost of using individual household tanks with initial investment costs included in the monthly bill. The customer pays for both initial costs and operational costs.

Alternative 4: calculates the cost of using individual household tanks without initial investment costs included in the monthly bill. The customer only pays for the operational costs. Initial costs must be covered by some outside funding source.

Model Input Variables

The model is organized in rows (which are numbered) and columns (which are lettered). At the intersection of a row and column is a cell (for example, A1).

Rows represent different variables that can be entered by the community. Individual users will enter the input values that are appropriate for that particular community.

The input variables are included in the first sheet of the workbook labeled '***Inputs***'. The inputs are variables associated with water hauling. Rows 4 through 32 are inputs associated with the community, water hauling driver, inflation and depreciation factors, treated water cost, and truck. These values must be entered regardless of the customer payment alternative chosen. Rows 33 through 44 are input values that are relevant when individual household tanks are used as the treated drinking water storage facilities. Rows 52 through 79 are input values that are relevant when community tanks are used as the treated drinking water community storage facility.

Community

Cells **B5** to **I5** are assigned to the community name (up to eight communities) for which the economic analysis will be conducted. Cell **B7** is assigned to the number of communities that will be involved in water hauling. The number of households in each community is entered in cells **B10** to **B17**. The number of round-trip miles to each community from the treated drinking water source is entered in cells **C10** to **C17**. The average daily water usage for households in each community is entered in cells **D10** to **D17**.

Water Hauling Driver

Column B, rows 21 to 23 are assigned to the water-hauling driver. The salary of the driver for the first year of water hauling is entered in cell **B21**. The percentage of time the driver spends on water hauling versus the total time spent on the job is entered in cell **B22**. For example, if the driver spends 10 hours out of a 40 hour work week hauling water and the rest of the time flushing streets, the percentage he spends on water hauling is equal to (10 hours/40 hours)*100, or 25 %. Cell **B23** provides the option for even distribution of the driver's salary between the served communities, or weighted salary distribution between the served communities. For example, if community A is 20 miles and community B is 50 miles from the treated water source, in weighted distribution, community B will pay more for the salary since the driver spends more time on hauling water to community B.

Inflation and Depreciation Factors

Column E, rows 21 to 23 are assigned to inflation and depreciation factors. Inflation is incorporated into the driver's salary. Deprecation factors are used to depreciate initial costs over a specified time period. The inflation rate is entered in cell **E21**. Cell **E22** specifies the number of years of water system use that have been completed. For example, if the system is in its first year of use, zero will be

entered in cell **E22**. If the system is in its sixth year of use, five will be entered in cell **E22**. The number of years expected to pay off the initial debts of the system is entered in cell **E23**.

Water Cost

Cell **B26** indicates the cost of treated water per gallon from the drinking water source.

Truck

Columns B, D, and F, rows 29 to 32 are assigned to the water hauling truck variables. The volume of water, or truck capacity, in gallons is entered in cell **B29**. If a water hauling truck is purchased, the purchase cost is entered in cell **D29.** If an existing water truck needs modification to become a community water hauling truck, the modification cost is entered in cell **D29**. The approximate cost of truck maintenance per mile is entered in cell **F29**. The cost of fuel per gallon is entered in cell **B30**. The time required to fill the truck with treated water is entered in cell **D30**. Cell **D30** is not required for the economic analysis and is only used to determine the amount of time the driver spends on water hauling per week. The cost of truck insurance per year is entered in cell **F30**. The truck's gas mileage is entered in cell **B31**. The average speed of the truck in miles per hour, when full of water, is entered in cell **D31**. Cell **D31** is not required for the economic analysis and is only used to determine the amount of time he driver spends on water hauling per week.

Cell **F31** provides the option for even distribution of the truck insurance cost between served communities or weighted distribution between served communities, as with the water-hauling driver.

The salvage value and useful life of the truck are used in depreciating the water-hauling truck and are entered into cells **B32** and **D32**, respectively.

Individual Household Tank Costs and Factors

Rows 33 through 44 are input values for individual household tanks. The input variables are entered only when individual household tanks are used as the treated drinking water storage facilities.

The average capacity of the household tanks in gallons for households in each community is entered in cells **B37** to **B44**. The average cost of the household tank and associated distribution system for households in each community is entered in cells **C37** to **C44**. The average cost of installing the household tank and associated distribution system for households in each community is entered in cells **D37** to **D44**. The average salvage value of the tank for households in each community is entered in cells **E37** to **E44**. The average useful life of the

household tank and distribution system for households in each community is entered in cells **F37** to **F44**. The average cost of maintenance per year of the household tank and associated distribution system for households in each community is entered in cells **G37** to **G44**. The average time required to fill all the household tanks within each community in minutes is entered in cells **H37** to **H44**. Cells **H37** to **H44** are not required for the economic analysis and are only used to determine the amount of time the driver spends on water hauling per week.

Community Tank Costs and Factors

Rows 52 through 79 are input values for a community tank. The input variables are entered only when a community tank is used as the treated drinking water storage facility of the community.

The items in column A, rows 52 through 59 indicate costs that do not change with each community. The cost of a water meter is entered in cell **C52** and a gate valve in cell **C53**. The cost of one foot of installed waterline is entered in cell **C54**. The salvage value and useful life of the waterline are entered into cell **C55** and **C56**, respectively. The cost of one 20,000-gallon community tank is entered in cell **C57**. The salvage value and useful life of the community tank are entered into cell **C58** and **C59**, respectively. The average time required to fill the community tank within each community in minutes is entered in cell **F52**. Cell **F52** is not required for the economic analysis and is only used to determine the amount of time the driver spends on water hauling per week.

The cost of the site survey and deed preparation of the tank site for each community is entered in cells **B62** to **B69**. The cost of the fence and gravel of the tank site for each community is entered in cells **C62** to **C69**. The costs of design, easements, permits and bidding are entered in cells **D62** to **D69.** The miscellaneous installation costs, such as fittings, are entered in cells **E62** to **E69**. The number of valves needed for each community is entered in cells **B72** to **B79**. The cost of miscellaneous maintenance per year for each community is entered in cells **C72** to **C79**. The cost of tank maintenance per year for each community is entered in cells **D72** to **D79**. The cost of waterline maintenance per year for each community is entered in cells **E72** to **E79**. The number of feet of waterline needed for each community is entered in cells **F72** to **F79**.

USING THE MODEL: ILLUSTRATIONS

Illustration 1. Analysis of Water Hauling to the Trammel Gap Community

The Trammel Gap community in Dickenson County is a cluster of ten houses situated on an isolated ridge at an elevation of about 2800 feet above the sea level. Due to its high elevation and coal mining activities within the ridge, this community has no public water system or adequate groundwater. A public water line exists at the toe of the mountain. However, it is estimated that extending the public water system to the ridge will cost at least $30,000 per household. At present, residents of Trammel Gap obtain their drinking water by means of rooftop rainfall collection-cistern storage, or the water is hauled to individual household storage tanks by truck from a water treatment plant which is located approximately five miles from the community.

The model developed for this project was applied to an economic analysis of water hauling to the Trammel Gap community. Detailed input information is documented in Appendix B1. Results for the four alternative scenarios are presented below.

Alternative	Cost/household/month
1	$405.60
2	$221.54
3	$376.16
4	$208.59

Illustration 2. Analysis of Water Hauling to Multiple Communities

It was assumed that, by using a water truck and driver to serve several communities, the cost per household would be reduced. This scenario was applied to water hauling to Trammel Gap and Frying Pan communities, and three other hypothetical communities (A, B, C). Detailed input information for this scenario, where five communities are served, is documented in Appendix B2. Results in terms of cost per household per month ($) are presented below.

	Community				
Alternative	1	2	3	4	5
1	$124.34	134.46	97.01	109.49	121.97
2	72.18	96.21	58.76	71.24	83.73
3	95.88	108.60	73.61	85.27	96.94
4	61.64	83.49	48.49	60.16	71.82

Summary

Results of the economic analysis indicate that water hauling is not an economically feasible option for these isolated households, if only one community is served or when customers are responsible for all initial costs. Cost per household can significantly be reduced when several communities participate in water hauling. Some form of grant or subsidization is required to make water hauling economically feasible for the individual households being served, regardless of the kind of tank system that is put in place.

Appendix A

Detailed Procedures for Model Development and Economic Analysis

ASSUMPTIONS AND EQUATIONS

Presented in this appendix are the equations used to calculate the various components of operational and initial costs for each alternative. Following each equation, in bold, is the corresponding Excel equation, indicating the Excel sheet name and cell for each equation component. Each section below corresponds to a sheet in the Excel model.

Table 1 shows the Excel names for the variables that are entered by the model user, as well as the cell location. Note that all of these variables are entered in the **'Inputs'** sheet.

Table 1: Variable Names

cost_fuel	=Inputs!$B$30		percent	=Inputs!$B$22
cost_w	=Inputs!$B$26		salary	=Inputs!$B$21
driver_wd	=Inputs!$B$23		tank_cost	=Inputs!$C$57
h_1	=Inputs!$B$10		tank_life	=Inputs!$C$59
h_2	=Inputs!$B$11		tank_sal	=Inputs!$C$58
h_3	=Inputs!$B$12		time_comt	=Inputs!$F$52
h_4	=Inputs!$B$13		time_truck	=Inputs!$D$30
h_5	=Inputs!$B$14		truck_cost	=Inputs!$D$29
h_6	=Inputs!$B$15		truck_gal	=Inputs!$B$29
h_7	=Inputs!$B$16		truck_insur	=Inputs!$F$30
h_8	=Inputs!$B$17		truck_life	=Inputs!$D$32
i	=Inputs!$E$21		truck_maint	=Inputs!$F$29
line	=Inputs!$C$54		truck_mpg	=Inputs!$B$31
line_life	=Inputs!$C$56		truck_mph	=Inputs!$D$31
line_sal	=Inputs!$C$55		truck_salvage	=Inputs!$B$32
meter	=Inputs!$C$52		truckins_wd	=Inputs!$F$31
n	=Inputs!$E$22		valve	=Inputs!$C$53
nocom	=Inputs!$B$7		yr	=Inputs!$E$23

I. ALTERNATIVE 1:
Community Tank, initial costs **included** in customer's monthly bill

This section identifies the assumptions and equations used to calculate the total costs of the water hauling system that utilizes a community tank. Operational and initial costs are summed to determine the total monthly cost to the customer.

The calculations in this section are for sheet '**Alternative 1**'. Within the Excel equations, if a sheet name does not precede the cell location, then the cell is located in the **'Alternative 1'** sheet.

Assumptions:

1. A two-day water supply must be stored in the community tank at all times.
2. One 20,000-gallon tank is used per community.

3. Straight-line depreciation is used.

Equations:

<u>Operational Costs</u>

1. Daily Water Usage per Community in gallons per day (gpd), = (Daily Water Usage per Household)*(Number of Households per Community)

[B6= (Inputs!B10)*(Inputs!D10)]

2. Number of Days to Deplete Water Supply (days), x,

$$= \left[\frac{(20{,}000 gal. - ((Daily Water Usage / Community) * 2 days))}{Daily Water Usage / Community} \right]$$

[C6 = (20000-(B6*2))/B6]

3. Number of Trips per Refill Day, T, $= \left[\frac{Daily Water Usage/community}{Truck Capacity} \right] \bullet x$

The number of trips must be a whole number. Therefore, if the number of trips per refill day is less than 1, the Excel model will round up to 1; if the number of trips is greater than one but not a whole number, the Excel model will round up to the nearest whole number.

[D6 = IF(((B6*C6/Inputs!B29)<1),1,roundup(B6*C6/Inputs!B29),0)]

4. Number of Miles per Year to Service each Community (miles) = (Roundtrip Miles to each Community)*(T)*(365 days)/(x)

[E6 = ((Inputs!C10)*D6*365)/C6]

5. Driver time required per week (hours per week) = ((Number of miles per year to service each community)/(average speed of truck when full of water (mph))*(7/365)) + ((time required to fill truck and tank with treated water (minutes))*(T)*(7 days/x)*(hour/60 minutes))

[F6 =((E6/(Inputs!D31))*(7/365))+((Inputs!D30+Inputs!F52)*D6*7/(60*C6))]

6. Truck Insurance (Weighted:) = (Cost of truck insurance)*((Number of Miles per Year to Service each Community) /Total Number of Miles to Service all Communities)

Truck Insurance (Evenly Distributed:) = (Cost of truck insurance) /(Number of Communities)

[B17 = IF(Inputs!F31=1,Inputs!F30*($E6/(SUMIF($E6:$E13,">0",$E6:$E13))), (Inputs!F30/Inputs!B7))]

7. Cost of Truck Fuel per year per community = ((Cost of fuel per gallon)/(Truck mileage per gallon))*(Number of Miles per Year to Service the Community)

[B18 = (Inputs!B30/Inputs!B31)*E6]

8. Cost of Truck Maintenance per year per community = (Cost of truck maintenance per mile)*(Number of Miles per Year to Service the community)

[B19 = Inputs!F29*E6]

9. Truck Driver Salary (Weighted:) = (Salary of Driver)*($(1+i)^n$)*((Number of Miles Per Year to Service the community) /Total number of miles to service for all communities)*(percent of job driver spends on water hauling)*(0.01)

Truck Driver Salary (Evenly Distributed:) = (Salary of driver)*($(1+i)^n$) *(percent of job driver spends on water hauling)*(0.01) / (Number of communities)

where i= inflation rate,
n = number of years into debt pay-off

[B22 = IF(Inputs!B23=1,((Inputs!B21*((1+ Inputs!E21)^Inputs!E22)) *(E6/(SUMIF($E6:$E13,">0",$E6:$E13)))*(Inputs!B22*0.01)), ((Inputs!B21*((1+ Inputs!E21)^ Inputs!E22))*(Inputs!B22*0.01)/ Inputs!B7))]

10. Waterline Repairs per year

[B25 = Inputs!E72]

11. Tank Repairs per year

[B26 = Inputs!D72]

12. Miscellaneous repairs per year

[B27 = Inputs!C72]

13. Water Cost ($ per day per community) =(Cost of Treated Water per gallon)* (Daily Water Usage per Community (gpd))

[B30 = B6*Inputs!B26]

14. Total Operational Cost per Community per Year ($/yr.) = ((Water Cost (per day per community))*(365 days)) + Truck Insurance per year + Truck Fuel per year + Truck Maintenance per year + Truck Driver Salary per year + Waterline Repairs per year + Tank Repairs per year + Miscellaneous Repairs per year

[B33 = SUM(B17:B27)+(B30*365)]

15. Total Operational Cost per Community per Month ($/month) = Total Operational Cost per Community per Year/ (12 months per year)

[C33 = B33/12]

16. Total Operational Cost per Household per Month ($/month)= (Total Operational Cost per Community per Month ($/month))/(Number of Households per Community)

[D33 = C33/Inputs!B10]

Initial Costs

Initial Costs for All Communities (items that are not depreciated)

1. Total Cost of water meters installed = (cost of one water meter)*(total number of households in all communities)

[E46 = (SUMIF(Inputs!B10: Inputs!B17, ">0", Inputs!B10: Inputs!B17)) *Inputs!C52]

2. Total Cost of Gate Valves = (cost of gate valve)*(number of valves for all communities)

[E47 = Inputs!C53*(SUMIF(Inputs!B72:Inputs!B79, >0",Inputs!B72:Inputs!B79))]

3. Miscellaneous cost (35% of Construction Costs) = (0.35)*[(Cost of site survey and deed preparation + cost of fence and gravel + cost of design, easements, permits and bidding + cost of miscellaneous fittings) + (Total cost of water meters installed) + (Total cost of gate valves)]

**[E49 = 0.35*((SUMIF(Inputs!B62:Inputs!B69, >0",Inputs!B62:Inputs!B69))
+(SUMIF(Inputs!C62:Inputs!C69,">0",Inputs!C62:Inputs!C69))
+(SUMIF(Inputs!D62:Inputs!D69,">0",Inputs!D62:Inputs!D69))
+(SUMIF(Inputs!E62:Inputs!E69,">0",Inputs!E62:Inputs!E69))+E46+E47)]**

4. Total Cost per Year (not depreciated) = [(Miscellaneous cost/ 0.35)+ (Miscellaneous cost)]/(number of years expected to pay off debt of system)

[E51 = ((E49/0.35)+E49)/Inputs! E23]

Initial Costs per community (Items that are depreciated)

$$\text{Straight line depreciation} = \frac{\textit{Purchase Value} - \textit{Salvage Value}}{\textit{Useful Life}}$$

(for waterlines, tank, and truck)

5. Depreciation per Year for Waterline ($) = [((cost of one foot of waterline)* (number of feet of installed waterlines for each community)) – (Salvage Value of Waterline)]/ (Useful Life of Waterline)

[B58 = ((Inputs!C54*Inputs!F72)-Inputs!C55)/Inputs!C56]

6. Depreciation per Year for Truck($) = [(Total Cost of Truck or Modifying Existing Truck Equipment) - (Salvage Value of Truck)]/ [(Useful Life of Truck) * (Number of Communities)]

[C58 = (Inputs! D29-Inputs!B32)/(Inputs!D32 *Inputs!B7)]

7. Depreciation per Year for Tank ($) = [(Total Cost of Tank) – (Salvage Value of Tank)]/ (Useful Life of Tank)

[D58 = (Inputs! C57-Inputs!C58)/(Inputs!C59)]

8. Total Depreciation per year ($) = (Depreciation per Year of Waterlines) + (Depreciation per Year of Tank) + (Depreciation per Year of Truck)

[E58 = SUM(B58:D58)]

Total initial costs

9. Total Initial Cost Paid Yearly ($/yr.) = ((Total Cost per year (no depreciation)/ (Number of Communities)) + (Total Depreciation per year)

[B69 = (($E$51/Inputs!B7)+E58)]

10. Total Initial Cost per Household per Year ($/yr.) = (Total Initial Cost Paid Yearly)/(Number of Households per Community)

[C69 = B69/Inputs!B10]

11. Total Initial Costs per Household per Month ($/month) = (Total initial cost per household per year)/(12 months/year)

[D69 = C69/12]

Total Costs for Alternative 1

Total Cost Paid Monthly per Household ($/month)= (Total Operational Cost Per Household Per Month) + (Total Initial Costs per Household per Month)

[D80 = B80 + C80]

II. ALTERNATIVE 2:

Community Tank, initial costs **not included** in monthly customer bill

The following are the assumptions and equations used to estimate the operational costs of the water hauling system that uses a community tank. The operational costs are the only costs paid by the households; initial costs are assumed to be paid from some supplemental source.

All calculations are for sheet '**Alternative 2**'. Within the Excel equations, if a sheet name does not precede the cell location, then the cell is located in the '**Alternative 2**' sheet.

Assumptions:

1. A two day water supply must be stored in the community tank at all times.
2. One 20,000-gallon tank is used per community.

Equations:

Operational Costs

The equations for calculating operational costs for Alternative 2 are the same as the equations used to calculate operational costs for Alternative 1. Refer to the previous section.

Total Costs for Alternative 2

Total Cost Paid Monthly per Household ($/month)= (Total Operational Cost Per Household Per Month)

[E33 = D33]

III. COMMUNITY TANK INITIAL COSTS

This sheet shows a separate calculation for the initial costs when a community tank is used.

***Initial Costs*:**

Initial Costs for All Communities (items that are not depreciated)

1. Total Cost of water meters installed = (cost of one water meter)* (total number of households in all communities)

[E7 = (SUMIF(Inputs!B10: Inputs!B17, ">0", Inputs!B10: Inputs!B17))*Inputs!C52]

2. Total Cost of Gate Valves = (cost of gate valve)* (number of valves for all communities)

[E8 = Inputs!C53*(SUMIF(Inputs!B72:Inputs!B79, >0",Inputs!B72:Inputs!B79))]

3. Miscellaneous cost (35% of Construction Costs) = (0.35)*[(Cost of site survey and deed preparation + cost of fence and gravel + cost of design, easements, permits and bidding + cost of miscellaneous fittings) + (Total cost of water meters installed) + (Total cost of gate valves)]

**[E10 = 0.35*((SUMIF(Inputs!B62:Inputs!B69, >0",Inputs!B62:Inputs!B69))
+(SUMIF(Inputs!C62:Inputs!C69,">0",Inputs!C62:Inputs!C69))
+(SUMIF(Inputs!D62:Inputs!D69,">0",Inputs!D62:Inputs!D69))
+(SUMIF(Inputs!E62:Inputs!E69,">0",Inputs!E62:Inputs!E69))+E46+E47)]**

4. Total Cost per Year (not depreciated) = [(Miscellaneous cost/ 0.35)+ (Miscellaneous cost)]/(number of years expected to pay off debt of system)

[E12 = ((E10/0.35)+E10)/Inputs! E23]

Initial Costs (items that are depreciated)

$$\text{Straight line depreciation} = \frac{\textit{Purchase Value} - \textit{Salvage Value}}{\textit{Useful Life}}$$

(for waterlines, tank, and truck)

5. Depreciation per Year for Waterline ($) = [((cost of one foot of waterline)* (number of feet of installed waterlines for each community)) - (Salvage Value of Waterline)]/ (Useful Life of Waterline))

[B19 = ((Inputs!C54*Inputs!F72)-Inputs!C55)/Inputs!C56]

6. Depreciation per Year for Truck($) = [(Total Cost of Truck or Modifying Existing Truck Equipment) - (Salvage Value of Truck)]/ [(Useful Life of Truck) * (Number of Communities)]

[C19 = (Inputs! D29-Inputs!B32)/(Inputs!D32 *Inputs!B7)]

7. Depreciation per Year for Tank ($) = [(Total Cost of Tank) – (Salvage Value of Tank)]/ [(Useful Life of Tank)]

[D19 = (Inputs! C57-Inputs!C58)/(Inputs!C59)]

8. Total Depreciation per year ($) = (Depreciation per Year of Waterlines) + (Depreciation per Year of Tank) + (Depreciation per Year of Truck)

[E19 = SUM(B19:D19)]

Total initial costs

9. Total Initial Cost Paid Yearly ($/yr.) = ((Total Cost per year (not depreciated)/ (Number of Households per Community)) + (Total Depreciation per year)

[B30 = (($E$51/Inputs!B7)+E19)]

10. Total Initial Cost per Household per Year = (Total Initial Cost Paid Yearly)/ (Number of Households per Community)

[C30 = B30/Inputs!B10]

11. Total Initial Costs per Household per Month = (Total initial cost per household per year)/(12 months/year)

[D30 = C30/12]

IV. ALTERNATIVE 3:

Individual Household Tanks, initial costs **included** in monthly customer bill

The following are the assumptions and equations used to estimate the total costs of the water hauling system that uses individual household tanks. The total monthly cost to the customer includes both operational and initial costs.

All calculations are for sheet '**Alternative 3**'. Within the Excel equations, if a sheet name does not precede the cell location, then the cell is located in the '**Alternative 3**' sheet.

Assumptions:

1. A two-day water supply must be stored in the community tank at all times.
2. Straight-line depreciation is used.

Equations:

Operational Costs

Many of the calculations for operational costs in Alternative 3 are the same as those for Alternative 1. When the calculations are the same, the reader is referred to Section I.

1. Daily Water Usage per Community: refer to Section I

2. Number of Days to Deplete Water Supply (days), x,
= [((Average Capacity of Tanks)*(Number of Households per Community))
-((Daily Water Usage per Community)*(2 days))/Daily Water Usage per Community]

[C6 = ((Inputs!B37*Inputs!B10)-(B6*2))/B6]

3. Number of Trips per Refill Day, T: refer to Section I

4. Number of Miles per Year to Service (miles): refer to Section I

5. Driver time required per week: refer to Section I

6. Truck Insurance: refer to Section I

7. Cost of Truck Fuel per year: refer to Section I

8. Cost of Truck Maintenance per year: refer to Section I

9. Truck Driver: refer to Section I

10. Tank and Distribution System Repairs per year

[B25 = Inputs!G37]

11. Water Cost per community per day ($) =(Cost of Treated Water per gallon)* (Daily Water Usage per Community (gpd))

[B28 = B6*Inputs!B26]

Total Operational Costs

12. Total Operational Costs per Community per Year ($/year) = ((Water Cost per community per day)*(365 days)) + Truck Insurance per year + Truck Fuel per year + Truck Maintenance per year + Truck Driver Salary per year + Tank and Distribution System Repairs per year

[B31 = SUM(B17:B25)+(B28*365)]

13. Total Operational Cost per Community per Month ($/month) = Total Operational Cost per Community per Year/ (12 months per year)

[C31 = B31/12]

14. Total Operational Cost per Household per Month ($/month) = (Total Cost per Community per Month ($/month))/ (Number of Households per Community)

[D31 = C31/Inputs!B10]

Initial Costs

Initial Costs (items that are depreciated):

$$\text{Straight line depreciation} = \frac{Purchase\ \ Value\ -\ Salvage\ \ Value}{Useful\ \ Life}$$

(for tank and distribution system and truck)

1. Depreciation per Year for Truck ($) = [(Total Cost of Truck or Modifying Existing Truck Equipment) - (Salvage Value of Truck)]/ [(Useful Life of Truck) * (Number of Communities)]

[B46 = (Inputs! D29-Inputs!B32)/(Inputs!D32 *Inputs!B7)]

2. Depreciation per Year for Tank and Distribution System ($)
   = [(Average Cost of Tank and Distribution System)
   – (Salvage Value of Tank)]/ [(Useful Life of Tank and System)]

[C46 = (Inputs!C37-Inputs!E37)/(Inputs!F37)]

3. Total Depreciation per year ($) = (Depreciation per Year of Truck)
   + (Depreciation per Year of Tank & Distribution System)

[D46 = SUM(B46:C46)]

Total initial costs

4. Total Initial Cost Paid Yearly ($/year) = (Total Depreciation per year)

[B57 = D46]

4. Total Initial Cost per Household per Year ($/year) =
   (Total Initial Cost Paid Yearly)/(Number of Households per Community)

[C57 = B57/Inputs!B10]

5. Total Initial Costs per Household per Month ($/month) =
   (Total initial cost per household per year)/(12 months/year)

[D57 = C57/12]

Total Costs for Alternative 3:

Total Cost Paid Monthly per Household ($/month)=
(Total Operational Cost Per Household Per Month)
+ (Total Initial Costs per Household per Month)

[D67 = B67 + C67]

V. Alternative 4:

Individual Household Tanks, initial costs **not included** in monthly customer bill

The following are the assumptions and equations used to estimate the operational costs of the water hauling system that uses individual household tanks. The operational costs are the only costs paid by the households; initial costs are assumed to be paid from some supplemental source.

All calculations are for sheet '**Alternative 4**'. Within the Excel equations, if a sheet name does not precede the cell location, then the cell is located in the **'Alternative 4'** sheet.

***Assumptions*:**

1. A two-day water supply must be stored in the individual tanks at all times.
2. Straight-line depreciation is used.

***Equations*:**

Operational Costs

The operational costs for Alternative 4 are the same as those for Alternative 3. Refer to Section IV for the equations. Only operational costs are included in this alternative.

Total Costs for Alternative 4

Total Cost Paid Monthly per Household ($/month)=
(Total Operational Cost Per Household Per Month)

[E31 = D31]

VI. INDIVIDUAL HOUSEHOLD TANK INITIAL COSTS

This sheet shows a separate calculation for the initial costs when individual household tanks are used. The following are the equations used to estimate the initial costs of the water hauling system with individual household water tanks.

Initial Costs

Initial Costs (Items that are depreciated):

$$\text{Straight line depreciation} = \frac{Purchase\ \ Value\ -\ Salvage\ \ Value}{Useful\ \ Life}$$

(for tank & distribution system and truck)

1. Depreciation per Year for Truck ($) = [(Total Cost of Truck or Modifying Existing Truck Equipment) - (Salvage Value of Truck)]/ [(Useful Life of Truck) * (Number of Communities)]

[B8 = (Inputs! D29-Inputs!B32)/(Inputs!D32 *Inputs!B7)]

2. Depreciation per Year for Tank and Distribution System ($) =
[(Average Cost of Tank and Distribution System) - (Salvage Value of Tank)]/
[(Useful Life of Tank and System)]

[C8 = (Inputs!C37-Inputs!E37)/(Inputs!F37)]

3. Total Depreciation per year ($) = (Depreciation per Year of Truck)
+ (Depreciation per Year of Tank and Distribution System)

[D8 = SUM(B8:C8)]

Total initial costs

4. Total Initial Cost Paid Yearly ($/year) = (Total Depreciation per year)

[B19 = D8]

5. Total Initial Cost per Household per Year ($/year) =
(Total Initial Cost Paid Yearly)/(Number of Households per Community)

[C19 = B19/Inputs!B10]

6. Total Initial Costs per Household per Month ($/month) =
(Total initial cost per household per year)/(12 months/year)

[D19 = C19/12]

APPENDIX B

Excel Spreadsheets
For Single and Multi-Community Model Illustrations