

Uniform Costing Model User's Guide

VERSION 2.0

Prepared for the Texas
Water Development
Board

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Prepared by



The Uniform Costing Model (UCM) for Regional Water Planning is not intended to be used in lieu of professional engineering design or cost estimation procedures for water supply facilities. Results of all applications of the UCM, including those for technical evaluation of water management strategies in the regional water planning process, should be carefully reviewed by professional engineers and other knowledgeable professionals prior to use and publication. This tool was developed for the purpose of preparing regional water planning level cost estimates only. Any use of the UCM and results obtained there from will be at the User's sole risk and without liability or legal exposure to the Texas Water Development Board, HDR Engineering, Inc., and/or Freese and Nichols, Inc.

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Executive Summary

Regional water planning requires the evaluation and comparison of Water Management Strategies, including estimating costs to construct the required infrastructure. Additionally, cost estimating procedures are needed for non-infrastructure related water supply projects, such as conservation and drought management.

The Texas Water Development Board (TWDB) compiles cost estimates from all 16 planning regions and uses the information to develop the State Water Plan. Without a standardized costing method (including cost curves for infrastructure elements and assumptions), cost estimates varied across the state, region by region. The Uniform Costing Model (UCM) developed for the 2016 Regional Plans brought a level of consistency between cost estimates developed for the 16 Regional Water Planning Groups and their consultants. The UCM has been revised for the 2021 Regional Plans.

The UCM, along with this user's guide, is intended to assist regional water planning groups and their consultants in developing consistent cost estimates across the State of Texas, so when these 16 regional plans come together to form the State Water Plan, TWDB can be assured that each water management strategy is evaluated on an even playing field with respect to cost estimates. The UCM was designed to be relatively intuitive, with individual component modules, some of which are optional, that when possible, automatically feed information to a line item costing form. The UCM has been enhanced with new features to streamline the process, reduce space and maintain data integrity. Within the model, there are 11 costing modules along with some supporting data. Those modules include:

1. Quick Reference Guide
2. Project Information and Assumptions
3. Simplified Hydraulics
4. Advanced Hydraulics
5. Well Field
6. Embankment Calculations
7. Land Acquisition
8. Costing Form
9. Cost Summary
10. Conservation
11. Drought Management

The modules, described herein, assist the user in developing cost estimates for the most common types of water management strategies in regional water planning. Certainly, there are projects or components of projects with unique characteristics beyond the scope of what these modules are designed to evaluate, and in such cases,

the user should perform an external cost estimate that may be incorporated into the UCM, where applicable. Using these procedures and methods will provide reliable and consistent preliminary configurations and cost estimates; however, results should always be reviewed and refined with application of professional judgment and experience.

0 Introduction and General Overview

A large volume of regional planning work consists of studying alternatives for delivering water from new water sources to demand locations and evaluating ways to optimize management of existing water supplies. Investigating these types of scenarios typically includes performing a preliminary engineering analysis of needed facilities and estimating costs to construct the required infrastructure. Other tasks may involve updating construction cost estimates of alternatives that have previously been examined. Additionally, cost estimating procedures are needed for non-infrastructure related water supply projects, such as conservation and drought management.

The Texas Water Development Board (TWDB) compiles cost estimates from all 16 planning regions and uses the information to develop the State Water Plan. Without a standardized costing method (including cost curves for infrastructure elements and assumptions), cost estimates varied across the state, region by region. With the Uniform Costing Model (UCM) project, TWDB seeks to gain a level of consistency between cost estimates developed for the 16 Regional Water Planning Groups and their consultants. This, in turn, assures that cost estimates in the State Water Plan are consistent and on equal footing. The UCM allows users to size and estimate costs for water infrastructure facilities (pump stations, water treatment plants, and transmission pipelines) to meet future water needs. It contains tools for modeling hydraulics, pumping energy and costs, and sizing a well field.

The purpose of this user's guide is to present the UCM for the 2021 Regional Water Plans, which is to be used for planning-level cost estimates. Using these procedures and methods will provide reliable and consistent preliminary configurations and cost estimates; however, results should always be reviewed and refined with application of professional judgment and experience. The UCM provides overrides to cost estimates if detailed cost estimate based on an engineering studies are available. Additionally, unique situations and facilities not addressed in the procedures should be evaluated on an individual basis.

The UCM contains a series of modules to aid the user in developing a cost estimate for a water management strategy under consideration in regional water plan development. Those modules, discussed in the following sections, include:

1. Quick Reference Guide
2. Project Information and Assumptions
3. Simplified Hydraulics

4. Advanced Hydraulics
5. Well Field
6. Embankment Calculations
7. Land Acquisition
8. Costing Form
9. Cost Summary
10. Conservation
11. Drought Management

Each module has been designed to accommodate the most common types of water management strategies in regional water planning. Certainly, there are projects or components of projects with unique characteristics beyond the scope of what these modules are designed to evaluate, and in such cases, the user should perform an external cost estimate that may be incorporated into the UCM, where applicable.

1.0 Quick Reference Guide

The Quick Reference Guide module (“Quick Reference Guide” tab) of the UCM shows a flow chart to walk the user through the tool and is included in Figure 1.

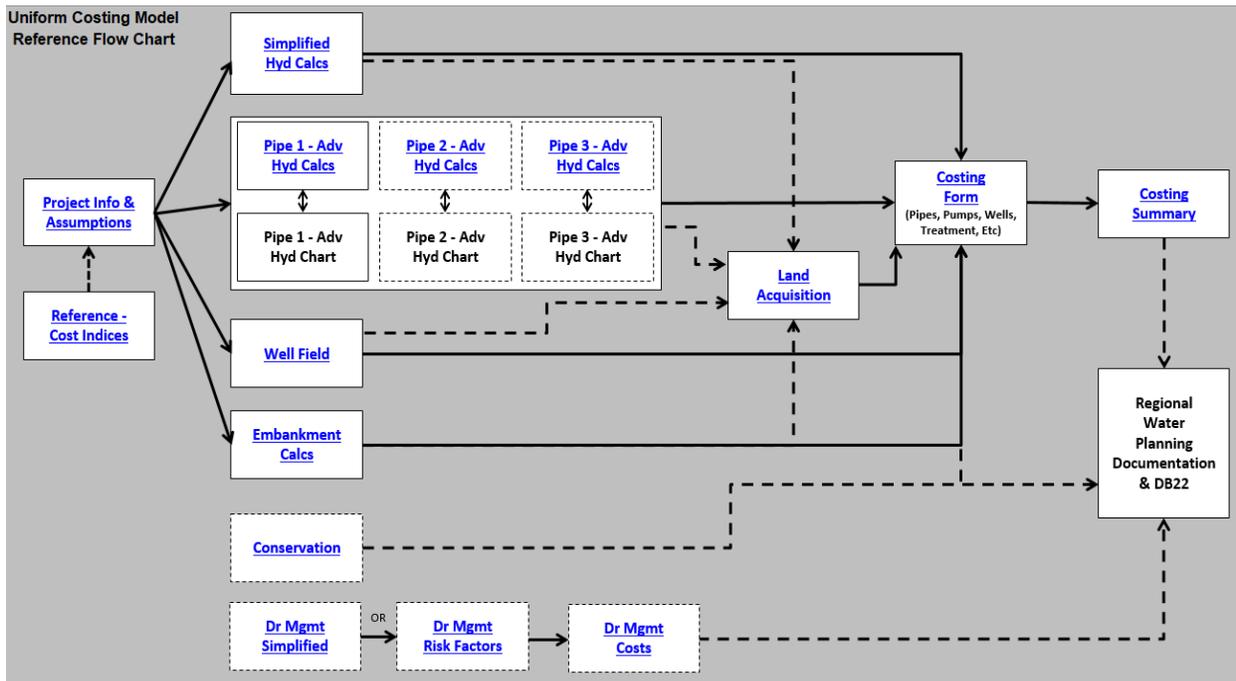


Figure 1. Quick Reference Flow Chart

For a typical Water Management Strategy (WMS) that requires the construction of infrastructure, the user begins with the Project Info and Assumptions to enter details about the project. Next, the user enters data regarding the transmission of water via

pipelines in one or more of the hydraulic calculations modules. If the project includes a well field or a dam, there are optional modules to assist the user in defining them. The user then enters information regarding land acquisition. The main hub of the UCM is the costing form, where data from all infrastructure-related components are either accumulated automatically or defined. This is where the cost estimate is pulled together line-item by line-item. Finally, the user can view a summary of the cost estimate in the Costing Summary, which has been designed to be easily copied and pasted into the Regional Water Plan report.

For non-infrastructure based WMSs, the UCM contains modules to assist the user in determining potential water savings and costs. The UCM includes one module for water conservation. A simplified approach for Drought Management has been added to complement the existing Drought management modules. Discussion of drought management is included in Section 11.

Significant updates from the 2016 version of the UCM are documented in the Change Log and include the following.

1. Correction of minor programming bugs identified by TWDB and other consultants
2. Update of cost curves for water supply infrastructure where appropriate
3. Inclusion of cost estimations for advanced water treatment facilities required for direct potable reuse strategies
4. Enhanced capability to select various pipe pressure class along a pipeline route
5. Quality control capability enhancement
6. Addition of Simplified Drought Management module
7. Reduction of file size

A full list is included in the UCM and a copy is located in Appendix A.

2.0 Project Information and Assumptions

2.1 Basic Information

The Project Information and Assumptions module (“Project Info & Assumptions” tab) (Figure 2) of the UCM is where basic project data and the general assumptions used throughout the costing model are entered. There are three sections in the Project Information and Assumptions module.

The first portion (Basic Info) allows the user to enter the name of the project, the Water User Group (WUG) or Wholesale Water Provider (WWP) associated with the

project, the name of the persons performing and checking the cost estimate, and the date the cost estimation is created. Additionally, the user enters the month and year that will be the cost basis for the WMS for the ENR Construction Cost Index Time Period and the Producer Price Index Time Period. The Producer Price Index¹ (PPI - used for pipelines) and the Engineering News Record Construction Cost Index² (CCI - used for all other facilities) values are used to establish the time basis for which the cost estimate is to be made. Historical cost indices are included in the UCM on the “Reference - Cost Indices” tab. Base cost data in the UCM are set to September 2018 dollars, per the TWDB guidance for regional water planning for the 2021 Regional Water Plans. Finally, the user enters the project supply in acre-feet per year (acft/yr). Associated peaking factor for upsizing of facilities is addressed within each module.

¹ PPI values can be found at <https://download.bls.gov/pub/time.series/pc/pc.data.18.FabricatedMetalProduct>

² ENR indices can be found at <http://enr.construction.com/economics>

Basic Info	Project Name:		
	WUG/WWP:		
	Cost Estimator:		
	Date for Estimation:		
	Checked By:		
	ENR Construction Cost Index Time Period:	February 2018	CCI Factor: 10889
	Producer Price Index Time Period:	February 2018	PPI Factor 194.5
	Available Project Yield	4,000	acft/yr
	Conservation or Drought Management WMS?	No	
	Simplified or Advanced Hydraulics?	Simplified and Advanced	
Number of Pipelines	3		
Does the project include a wellfield?	No		
TWDB General Guidelines	Interest During Construction	3.00%	
	Rate of Return on Investments	0.50%	
	Construction Period	1.0	years
	Engineering, Legal, & Contingencies (Pipes)	30%	
	Engineering, Legal, & Contingencies (All Other Facilities)	35%	
	Debt Service (Non-Reservoirs) Period	20	years
	Debt Service (Reservoirs) Period	40	years
	Annual Interest Rate (Non-Reservoirs)	3.50%	
	Annual Interest Rate (Reservoirs)	3.50%	
	Operations & Maintenance (Pipelines)	1.00%	% of Capital Costs
Operations & Maintenance (Pump Stations)	2.50%	% of Capital Costs	
Operations & Maintenance (Dams)	1.50%	% of Capital Costs	
Power Costs	\$0.08	/kilowatt-hour	
Pumps & Xings	Power Connection Costs - Pump Stations	\$150	/HP
	Recommended Crossing Length (2-Lane Roads)	115	LF
	Recommended Crossing Length (4-Lane Divided Highway)	210	LF
	Recommended Crossing Length (6-Lane Divided Highway)	240	LF
	Recommended Crossing Length (Railways)	100	LF

Figure 2. Project Information and Assumptions Module

The UCM is designed for many different types and sizes of projects and not all modules may be necessary for a WMS. The UCM has been enhanced to simplify the model's structure based on the type of WMS. New rows have been added to the Basic Info section that allows the user to define the project and the layout of the spreadsheet. Table 1 summarizes the functions of these fields.

Table 1. Selections for Project Layout in UCM

Question	Selections	Comments
Conservation or Drought Management WMS?	Yes / No	For WMS only relating to conservation or drought management. Selecting "Yes" hides all non-relevant modules and infrastructure rows in the Costing Form tab. Selecting "No" hides the Conservation and Drought Management Modules.

Simplified or Advanced Hydraulics?	Simplified	Does not require profile for the pipeline for calculating hydraulics. Hides Advanced Hydraulic modules and related infrastructure rows in Costing Form tab
	Advanced	Requires a ground profile and user can choose up to three pipelines.
	Simplified and Advanced	Uses both modules and can still select number of pipelines
Number of Pipelines?	1, 2 or 3	Used only in Advanced Hydraulics. Hides unrelated Advanced Calc modules and infrastructure rows in Costing Form
Does the project include a well field?	Yes / No	If no well field is associated with the WMS, hides or shows Well Field module and related infrastructure rows in the Costing Form

The user first determines how the hydraulics will be calculated. Options include “Simplified” which does not require a profile (see Section 3), “Advanced” which utilizes a ground profile (see Section 4), or “Simplified and Advanced”. Selecting “Simplified” will hide the three advanced hydraulic calculation modules, three advanced hydraulic chart modules, and the corresponding rows on the “Costing Form” tab. If selecting “Advanced”, the user will need to choose between 1 and 3 pipelines. Pipelines can also be evaluated in segments (up to 5) along a pipeline route (see Section 4.4). Once set, the user can always come back and make changes to their selection if necessary.

2.2 TWDB General Guidelines

The second section of the Project Information and Assumptions module allows users to enter the assumptions consistent with the TWDB guidance for regional water planning. These values have been pre-populated with the assumptions used in the 2021 regional planning cycle. Power costs and construction periods will be variable based on location and scale of project. Table 2 includes the list of project assumptions and TWDB general guidance.

Table 2. TWDB General Guidelines for 2021 Regional Water Plans

Item	TWDB Guidance	Comment
Interest During Construction	3%	Interest on the borrowed funds during the construction period. See Section 8.2.5
Rate of Return on Investment	0.5%	Return on invested funds during construction period. See Section 8.2.5
Construction Period	1 year	Use engineering judgment to provide appropriate length of construction based on the WMS
Engineering, Legal, Contingencies (Pipes)	30%	See Section 8.2.1

Engineering, Legal, Contingencies (all other facilities)	35%	See Section 8.2.1
Debt Service (non-reservoirs) period	20 years	Finance period for all infrastructure not related to a reservoir.
Debt Service (reservoirs) period	40 years	Finance period for all infrastructure not related to a reservoir.
Annual Interest Rate (non-reservoirs)	3.5%	Project finance rate on funds borrowed for non – reservoir infrastructure
Annual Interest Rate (reservoirs)	3.5%	Project finance rate on funds borrowed for reservoir infrastructure
Operations & Maintenance (Pipelines)	1% of Capital Costs	Used to determine annual cost to maintain pipeline, tank, and well infrastructure. See Section 8.3.2
Operations & Maintenance (Pump Stations)	2.5% of Capital Costs	Used to determine annual cost to maintain pump station infrastructure. See Section 8.3.2
Operations & Maintenance (Dams)	1.5% of Capital Costs	Used to determine annual cost to maintain reservoir infrastructure. See Section 8.3.2
Power Costs	\$0.08/kilowatt-hr	Cost of electricity. May vary across regions.

2.3 Pumps and Crossings

The third section of the Project Information and Assumptions module is where the user can enter assumptions pertaining to power connections and pipeline crossings. Standard values for power connections and pipeline crossings have been pre-populated. Crossing costs are determined in the Costing Form module and user's must identify the number and types of crossings to calculate costs. The power connection costs are calculated on the Costing Form once pump station or well field hydraulics have been determined. Minimum costs assumed for connecting power to a pump station or well field is \$50,000 which the user can override if necessary.

It should be noted that cells requiring user input are white in color with a blue-colored font, while default values are light green in color with blue-colored font. Default values are editable, and up to the user's discretion. A key is found on the Project Info & Assumptions Module (Figure 3).

Key (Throughout Model):	
1.5	<-- User Input
1.0	<-- Default Values Set, User May Adjust
8.9	<-- Other colored cells are either informational or calculated values

Figure 3. UCM Formatting Key

3.0 Simplified Hydraulics Calculations

There are two methods of performing pipeline hydraulics calculations available in the UCM. These methods are used to determine pipeline diameter(s), pump and booster sizes, and pumping energy required. The first is a simplified method presented in this section, and the other is a detailed method in which the user defines a pipeline route and uses an elevation profile (presented in Section 4.0).

The simplified method in the Simplified Hydraulics module (Figure 4) allows the user to quickly determine pipeline diameter(s), pump and booster sizes, and pumping energy given a few basic pieces of information. The user inputs the beginning and ending elevations, pipeline length, water delivery amount, peaking factor, and other basic assumptions.

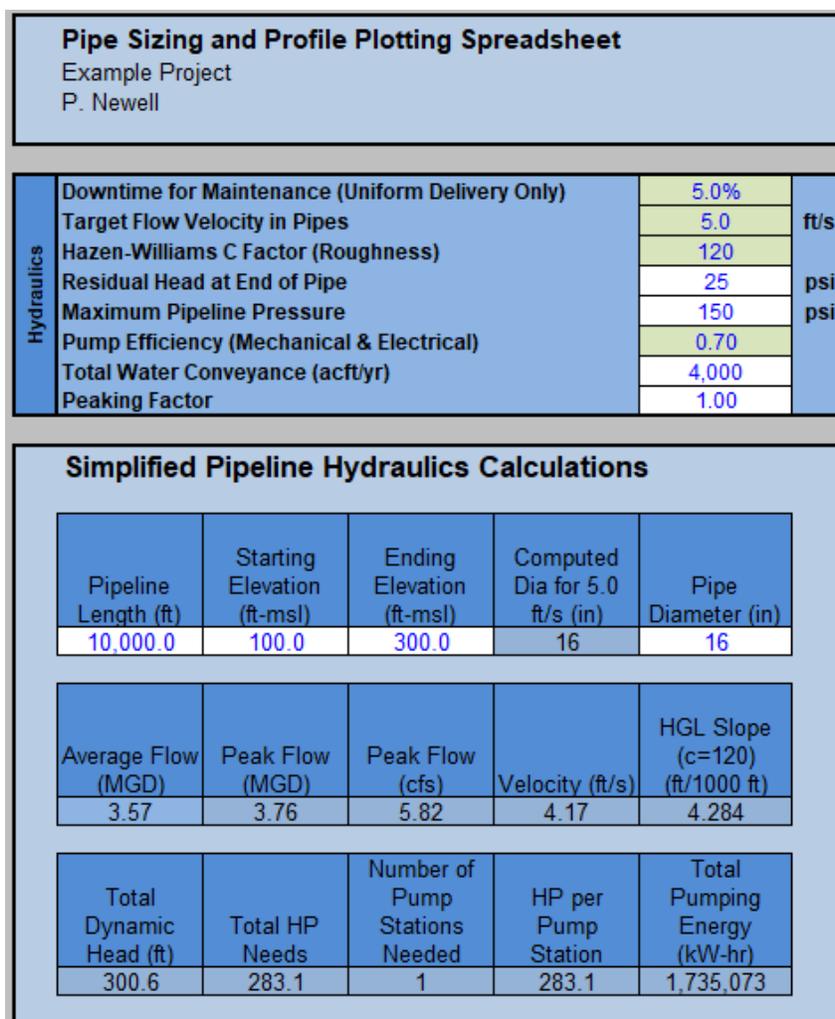


Figure 4. Simplified Hydraulics Module

3.1 Hydraulics Assumptions

The “Hydraulics” section of the Simplified Hydraulics module allows the user to input basic hydraulics information, including:

1. **Residual head at end of pipe.** The user enters the residual head at end of pipe which is often the minimum pressure along the pipeline. For treated water systems a minimum pressure of 25 psi is recommended and 15 psi for raw water delivery.
2. **Maximum pipeline pressure.** The user chooses a pressure class for the pipe (ranging from 100 psi to 350 psi). Pipeline costs are adjusted based on the pressure class chosen.
3. **Total Water Conveyance.** This is the total volume to be delivered every year in acre feet.
4. **Peaking Factor.** Water may be delivered at an average (uniform) rate over the entire year (i.e., the same volume of water would be pumped each day), or the rate may vary from month to month or day to day. The factor is the ratio of the maximum rate to the average rate. Facilities should be sized on peak rates of delivery.

User can review and revise the default values for pump station downtime for maintenance activities, roughness factor, target flow velocities, and pump efficiency, if necessary.

To determine pipeline diameter and size the pump station, the user enters the pipeline length and starting and ending elevations. Based on the provided information, the Simplified Hydraulics module aids the user in choosing a pipeline diameter and generates the number of pump stations required, along with their sizes and required pumping energy.

4.0 Advanced Hydraulics Calculations

The second method of performing pipeline hydraulics calculations available in the UCM, and used to determine pipeline diameter(s), pump and booster sizes, and pumping energy required, is through use of the Advanced Hydraulics module (“Pipe X - Adv Hyd Calcs” tab) (Figure 5). The user supplies a pipeline profile (based on externally-selected route), including station, elevation, ground type (rock or soil), and level of development (rural or urban) along the pipeline route. The Advanced Hydraulic module allows the user to consider the pressure in the pipeline along the entire route to verify if maximum and minimum pressure parameters are met throughout the pipeline route. Additionally, the user may specify delivery amounts and points along the pipeline route, thereby facilitating adjustment of the pipe diameter for varying flow rates, as well as pressure classes along the pipeline.

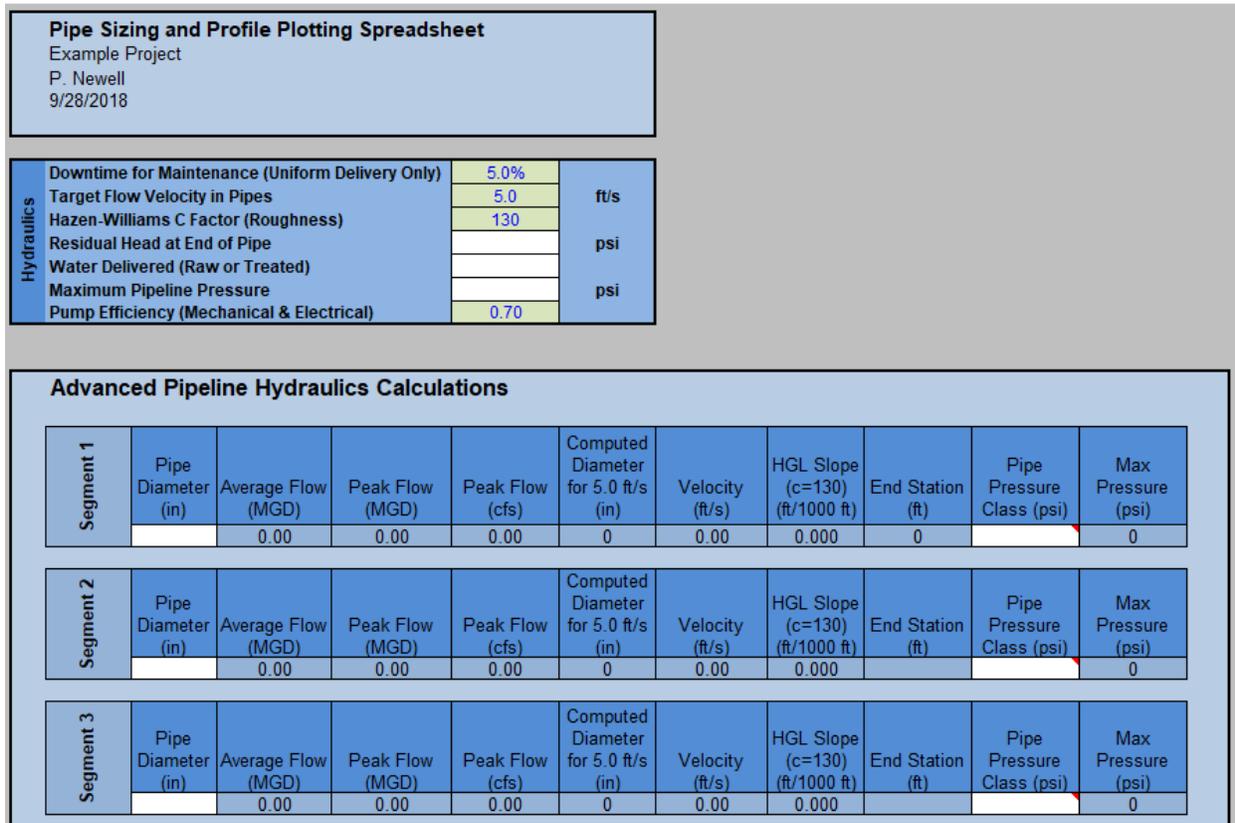


Figure 5. Advanced Hydraulics Module

The user may choose up to five delivery locations or five unique segments along the pipeline route to deliver portions of the total water to be conveyed by the transmission system.

The user can also choose locations of booster stations and allocate a portion of the Total Dynamic Head (TDH) to each of the booster stations. Additionally, the user may specify up to five pump/booster stations to gain the necessary lift from the beginning of the pipeline to the end delivery point.

The Advanced Hydraulics tab is linked to a chart (Pipe X – Adv Hyd Chart) that includes the pipeline ground elevation and the hydraulic grade line (HGL) based on selected flow rates and diameters. Finally, because water management strategies often include more than one pipeline route (for example, there may be a high-capacity diversion from a river to an off-channel reservoir and a uniform delivery of firm yield from the off-channel reservoir to a WTP), the UCM has included three (3) Advanced Hydraulics modules to allow up to three separate pipelines (transmission sub-systems) to be evaluated for one water management strategy.

4.1 Hydraulics Assumptions

The “Hydraulics” section of the Advanced Hydraulics module allows the user to input basic hydraulics information, including roughness factor, target flow velocities, type of water being transported (raw or treated water), etc. The user chooses a pressure class for the pipe (ranging from 100 psi to 350 psi). Base pipeline costs are adjusted based on the pressure class chosen. The UCM allows the user to select unique pressure class pipe for each of the segments. Pressure classes range between 100 and 350 psi and are set in a dropdown list. Segments can be specified by the station along the profile. To aid the user in selection of pressure class pipe, the maximum pressure in the segment is identified.

The type of water to be transported is a consideration that may have an impact on the engineering analysis. Raw water and treated water comprise the categories that are expected to be encountered in technical evaluation of water management strategies. Treated water is water that has been treated for some purpose; generally this would be potable water from a water treatment plant. Raw water is usually thought of as untreated, non-potable surface water that comes from a stream or reservoir. Groundwater may potentially be categorized as potable (classified as treated in the UCM) or non-potable (classified as untreated in the UCM) water depending on resident levels of certain substances found in the water. It is important to be aware of the water type because minimum pipeline pressure requirements vary depending on the type and use. In the UCM, the Advanced Hydraulics module assumes a 15-psi minimum pressure for raw water and a 25-psi minimum pressure for treated water.

4.2 Water Delivery Locations

The user specifies the total water conveyance, peaking factor, delivery quantities, and locations in the “Deliveries” portion of the Advanced Hydraulics module (Figure 6). Some amount of water must be delivered to the end of the pipeline. The locations of the delivery points are needed in order to chart a pipeline route. Possible delivery locations include rivers, reservoirs, water treatment plants, storage tanks, and municipal distribution systems.

Deliveries	Total Water Conveyance (acft/yr)		
	Peaking Factor		
	Delivery Amount #1 (acft/yr)		Station (ft):
	Delivery Amount #2 (acft/yr)		Station (ft):
	Delivery Amount #3 (acft/yr)		Station (ft):
	Delivery Amount #4 (acft/yr)		Station (ft):
	Delivery Amount #5 (acft/yr)		Station (ft):

Figure 6. Deliveries Table in Advance Hydraulics Module

Delivery amounts are subtracted from the user input field “Total Water Conveyance (acft/yr)”. So in order to maintain full delivery amount but provide two or more pressure classes, the user would enter “0” for delivery amount and select an end station to differentiate the segment.

4.3 Pipeline Route Selection and Profile

Generally, the first step in the Advanced Hydraulics module pipeline analysis is to determine a route. The goal is to connect the source with the destination by the most direct and logical route possible. Once a path has been selected, a two-dimensional pipeline profile can be generated from a set of points distributed along the route (Section 4.3.1). Each point represents a station (horizontal dimension), and a corresponding ground elevation (vertical dimension). The number of points and the distances between these locations needed to represent the profile adequately will vary depending on the topography along the route. The goal is to capture the general topographic features or trends while showing points of significant elevation changes (i.e., minimum and maximum points along a route segment). These data, along with the ground type (rock or soil), and level of development (rural or urban) along the pipeline route, are entered into the Pipeline Profile Data portion of the Advanced Hydraulics module (Figure 7). Ground type and level of development are specified as these attributes affect project costs. Pipeline unit costs include factors for ground type and level of development.

Pipeline Profile Data										
Station (ft)	Ground Elevation (ft-msl)	Soil or Rock	Urban or Rural	Pressure: 100 psi (ft-msl)	HGL (ft-msl)	Hydraulic Calcs (psi)	Soil, Urban	Soil, Rural	Rock, Urban	Rock, Rural
0	5	soil	rural	235.55	109.88	45.60				
50	5	soil	rural	235.55	109.83	45.58	0.00	50.00	0.00	0.00
100	5	soil	rural	235.55	109.79	45.56	0.00	100.00	0.00	0.00
150	5	soil	rural	235.55	109.74	45.54	0.00	150.00	0.00	0.00
200	5	soil	rural	235.55	109.69	45.52	0.00	200.00	0.00	0.00
250	5	soil	rural	235.55	109.65	45.50	0.00	250.00	0.00	0.00
300	5	soil	rural	235.55	109.60	45.48	0.00	300.00	0.00	0.00
350	5	soil	rural	235.55	109.55	45.46	0.00	350.00	0.00	0.00

Figure 7. Pipeline Profile Data Example

4.3.1 Route Selection and Profile Generation Guidelines and Tasks

Pipeline routes are identified and generated using external mapping resources available. Selecting a route to be used in technical evaluation of a water management strategy is typically an exercise in professional judgment based on experience. The

following guidelines and tasks should, however, be considered in any strategy evaluation:

4.3.2 Route Selection Guidelines

1. Select the most direct route paralleling existing right-of-ways to the extent possible. Existing right-of-ways include roadways (preferred), pipelines, power transmission lines, and railways (least preferred).
2. Limit pipeline routing across open land to the extent possible. Property division is less desirable than paralleling a boundary, except when following an existing right-of-way. In the design phase, it may be more feasible to cross open land along selected sections of a route if, during the design evaluation, the benefits outweigh the costs.
3. Bypass large water bodies.
4. Bypass cemeteries and sites known to be culturally significant or environmentally sensitive. An environmental and archaeological review may or may not be performed at the regional planning level, but readily available information should be used to help avoid known sensitive areas.
5. Bypass urban centers to the extent possible. Though it may result in a longer route, traversing around a city will likely result in lower construction costs.
6. Avoid rough terrain, if possible; especially bypass hills that could be higher than the hydraulic grade line of the pipeline.
7. Avoid heavily forested areas to the extent possible.
8. Avoid crossing a highway at a major interchange.
9. Avoid areas that require rock excavation if practical. Since soil conditions are usually consistent within some range, moving the pipeline is generally not expected to significantly change the ground conditions encountered. In the event that evidence shows the ground conditions would change significantly by shifting the pipeline route, the route that would result in lower construction costs should be selected.

It is recommended that when generating a pipeline route and pipeline profile, the user use GIS technologies. Profile generation guidance can be found in Appendix B.

4.4 Pipeline Hydraulics Calculations

The user selects pipeline diameters for the transmission pipeline segments, along with pump/booster station locations and associated lift in the Advanced Pipeline Hydraulics Calculations portion of the Advanced Hydraulics module. The following sub-sections (4.4.1 through 4.4.4) briefly explain the theory behind the calculations

used in the Advanced Pipeline Hydraulics Calculations portion of the UCM that guide the user in making these selections.

4.4.1 Pipe Size, Velocity, and Head Loss

The Advanced Pipeline Hydraulics Calculations portion of the Advanced Hydraulics module is used to size pipes and generate the hydraulic grade line (HGL). Using total water conveyance and the peaking factor, the peak delivery rate is established and the process of selecting the size, velocity and head loss is as follows:

1. Estimate a pipe diameter for a corresponding velocity. A target velocity is used at this stage to help establish an appropriate size range. Equation 1 calculates the exact diameter in inches, as follows:

$$D(in) = \sqrt{\frac{Q(cfs)}{V(fps) \left(\frac{\pi}{4} \right) \left(\frac{1ft}{12in} \right)^2}} \quad (1)$$

2. The user then picks a standard pipe diameter based on the diameter resulting from Equation 1. Standard pipe sizes are set in a dropdown list.
3. With the standard diameter set, the pipe velocity corresponding to the chosen pipe diameter is calculated using Equation 2. An important guideline to remember is to select pipeline diameter to maintain velocity within the 3.5-7 fps range. This range is a general guideline intended to prevent solids deposition in the pipe and to minimize energy requirements associated with friction losses experienced at high velocities.

$$V(fps) = \frac{Q(cfs)}{\left(\frac{\pi}{4} \right) \left(\frac{D(in)}{12in/ft} \right)^2} \quad (2)$$

4. Using the Hazen-Williams equation (Equation 3), the head loss in the pipe is calculated (hydraulic grade line or HGL slope) with the diameter selected in step 2 and the velocity found in step 3. The HGL will be plotted on the same graph (Figure 8) in Advanced Hydraulic Chart (“Pipe X - Adv Hyd Chart” tab) as the ground profile using the calculated slope.

$$S \left(\frac{ft}{ft} \right) = \left(\frac{V(fps)}{1.32C \left(\frac{D(in)}{4} \cdot \frac{1ft}{12in} \right)^{0.63}} \right)^{\left(\frac{1}{0.54} \right)} \quad (3)$$

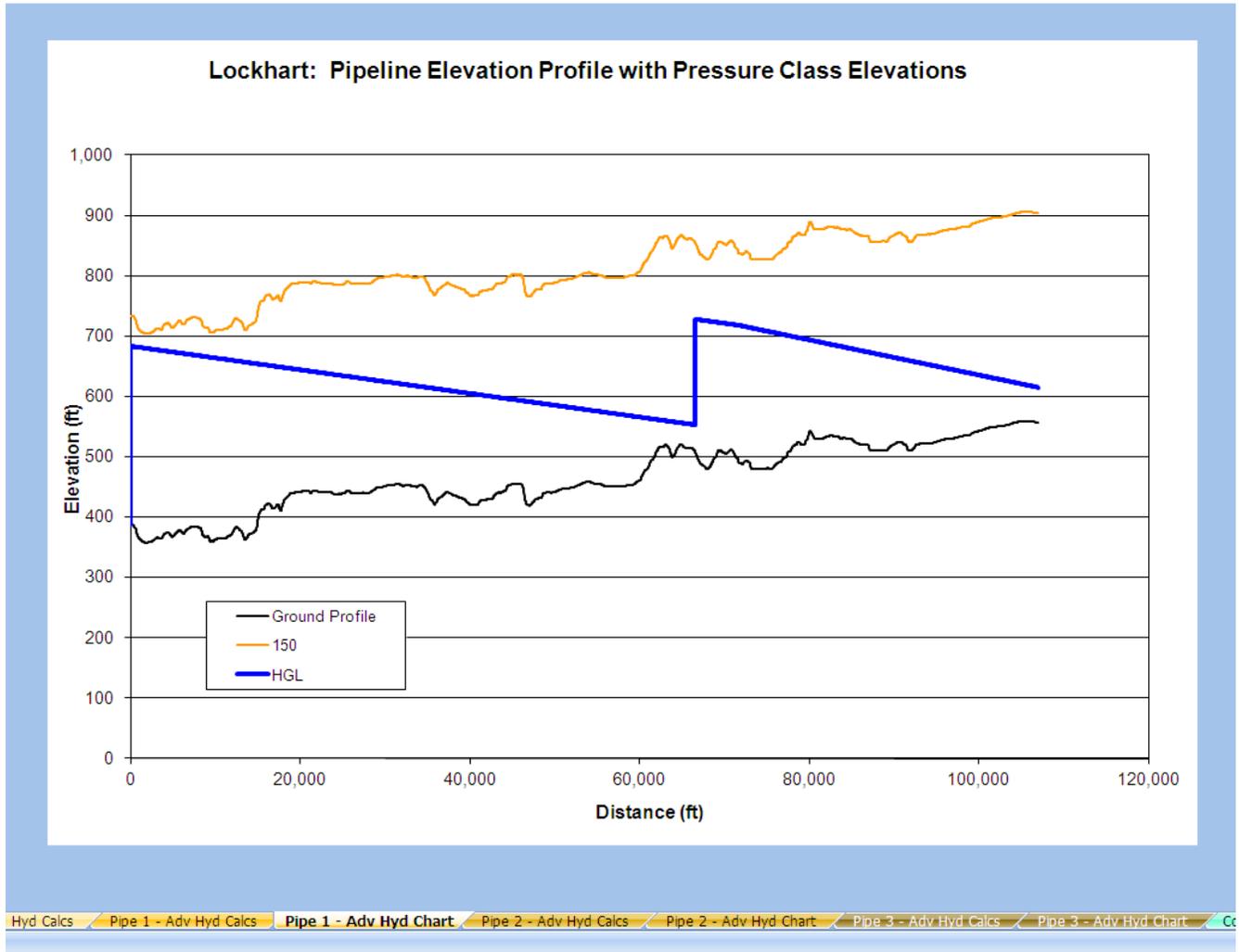


Figure 8. Advanced Hydraulic Pipeline HGL Chart

4.4.2 Pipe Pressure

When pumps impart energy to water, or “lift” it, a pressure will be generated within the pipe. This pressure is one component of the total head. Assuming that velocity head is negligible, the pressure head can be estimated using Equation 4.

$$\text{Pressure Head} = \text{Hydraulic Grade Line Elevation} - \text{Profile Elevation.} \quad (4)$$

Pressure head can easily be converted to pressure by Equation 5. This equation can also be used to find the pressure head for a given pressure. Using a plot of the hydraulic grade line, it is possible to determine the pressure within the pipe at any point along the length.

$$\text{Pressure}(psi) = \text{Pressure Head}(ft) \left(\frac{62.4lb / ft^3 \text{ for water}}{144in^2 / ft^2} \right) \quad (5)$$

Pipes are manufactured by pressure class providing a factor of safety within certain pressure ranges. A convenient tool for determining the pressure ranges in a pipeline is to plot pressure heads for various pipe pressure classes over the entire length of the pipeline profile, then inspect the grade line to see what lengths of pipe fall within a particular pressure head range.

Another guideline to keep in mind is that the HGL must clear all high profile points along the route in order to prevent formation of a vacuum within the pipeline and reduce the potential for column separation and water hammer within the pipe. It is desired to clear these points by a minimum water pressure at all times. The minimum line pressures that should be met or exceeded are 15 psi for raw water and 25 psi for treated water. This requirement should be met within all anticipated flow ranges.

4.4.3 Pump and Booster Station Locations and Total Dynamic Head

Pump/Booster station locations and sizes are dependent on the flow rate, pipe size, and corresponding head loss. A change in flow rate resulting in a change of pipe size can dramatically impact the number and sizes of pumping stations needed to convey water to the destination. Therefore the pipeline and pumping requirements must be evaluated together. Several iterations involving different combinations of pipe sizes and pumping station arrangements may be required to obtain an appropriate selection. The combination of pumping stations and pipe size selected must conform to engineering principles, comply with guidelines, and make sense economically. Determining the size of a pump or booster station entails estimating the amount of energy, or head, needed to lift water to a sufficient level for driving water to a particular destination. This amount of head developed by the pump is called the total dynamic head, or TDH, and is made up of the following:

1. **Static Head** – The total change in elevation of the liquid from the suction level to discharge level, plus the pressure difference between suction and discharge reservoirs if different from atmospheric.
2. **Pipe Friction** – The friction head loss in the suction and discharge line, elbows, and valves, and the suction pipe entrance loss.
3. **Velocity Head** – the head at the end of the discharge pipe.

For study purposes, the TDH will be calculated as the difference between the calculated elevations of the HGL at the pumps and the suction source plus station losses (Equation 6).

$$\text{TDH (ft)} = \text{Final HGL Elevation at Pumping Station (ft)} - \text{Water Surface Elevation (ft)} + \text{Pumping Station Losses (ft)} \quad (6)$$

The simple approach used in the UCM for determining the TDH for sizing a pump station is one that involves starting at the destination at a predetermined elevation, creating a HGL based on the peak flow, and evaluating a number of factors back toward the source. Once a transmission system arrangement is selected for peak flows, the same factors will be evaluated to ensure that the system will function adequately for the lowest anticipated flows.

4.4.4 Pump Station Horsepower (size) and Power Requirements

Pump station sizing and power requirements involve assessment of station power needs for different operating conditions. Power is the time rate of energy transfer, with the TDH for a particular flow rate being the amount of energy to be transferred. Horsepower is the unit of power that is used in the UCM and can be calculated with Equation 7. The efficiency of the pumping station is represented by “*e*”. It is actually a “combined efficiency” that accounts for the efficiencies of the pumps and pump motors. **For regional water planning purposes, assume a combined efficiency of 0.7.** The pump station size, which is based on the greatest amount of horsepower needed, is derived using the peak flow rate and its resulting TDH.

$$HP = \frac{Q(cfs) \cdot TDH(ft)}{8.8 \cdot e} \quad (7)$$

Power consumption for estimating pumping energy costs is based on average flow rate and the headloss associated with the average flow rate. Electric energy is typically billed by the kilowatt-hour (kWh or KW-HR). “Watt” is the International System (SI) unit for power and is related to horsepower by Equation 8.

$$\begin{aligned} 1HP &= 746W \\ 1HP &= 0.746KW \\ \# \text{ of } KW &= \text{Horsepower} * \frac{0.746KW}{1HP} \end{aligned} \quad (8)$$

The estimated energy consumed in pumping is calculated by converting power back to energy for the pumping duration, based on average flow rate and the headloss associated with the average flow rate. Equation 9 illustrates this calculation.

$$\text{Annual KW - HR} = KW \cdot \text{total hours of pumping operation per year} \quad (9)$$

The number of hours of pumping operation is the total number of hours out of the year needed to deliver the annual water volume at a flow rate which is to be expected the majority of the time when pumping. Annual pumping energy cost is based on the annual energy consumed.

5.0 Well Fields

Wells must be constructed to extract water from below the land surface and pump it into a water delivery system. Each well can be considered an individual, or stand alone, pump station for sizing purposes and for pumping energy calculations. Size/horsepower requirements, like pump stations, are based on the flow and the total dynamic head. Total dynamic head for a well pump is the elevation difference between the hydraulic grade line and the estimated groundwater (i.e. piezometric) surface at the well during pumping conditions, plus station losses and friction losses in the casing pipe.

The user lays out a well field, for example like Figure 9, and then determines the connectivity of the wells, collection pipes, and main trunk line(s). This information is then fed into the Well Field module, at which time, the flow, pipe sizes, and pumping energy is calculated.

The Well Field module (“Well Field” tab) (Figure 10) allows the user to layout the facilities in order to determine costs for the well field. To begin, the user provides:

1. the static water elevation (ft msl),
2. expected drawdown during pumping,
3. the water production for the total well field in acft/yr,
4. the peak factor used for the wells,
5. and the average flow per well

With this information, the model will estimate the required number of active production wells to meet the production goal per year, and an estimate of backup wells required (about 15% of the # of active wells). Taking the number of active and backup wells, the user assigns a well ID and provides the peak flow rate based on the user determined peaking factor. The model provides a suggested pipe diameter for velocities at 5 fps but the user must select a pipe diameter from the dropdown menu.

Next the user provides a pipe length to the next downstream node for the collection system or to another well ID. Elevation data for well IDs or other junction points are entered in cells M43:O73. The model will read this data and calculate head losses in the pipe due to changes in elevation and friction. Note that if no downstream node is entered, the model will use the value entered in D10 (Elevation of the Delivery Point) as the downstream node elevation. If the downstream node is another well ID, the user must include the well’s pump rate plus the rate from the upstream well to

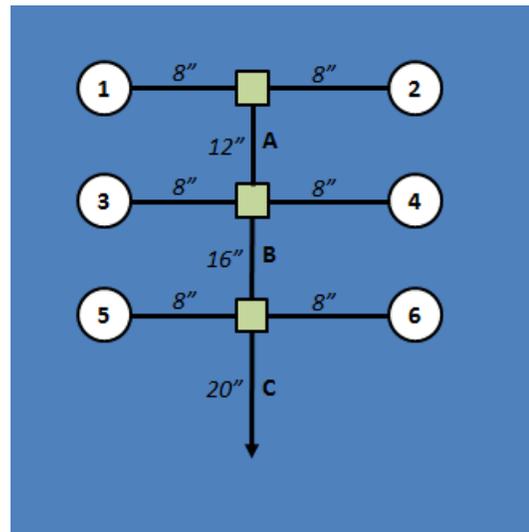


Figure 9. Example Well Field Layout

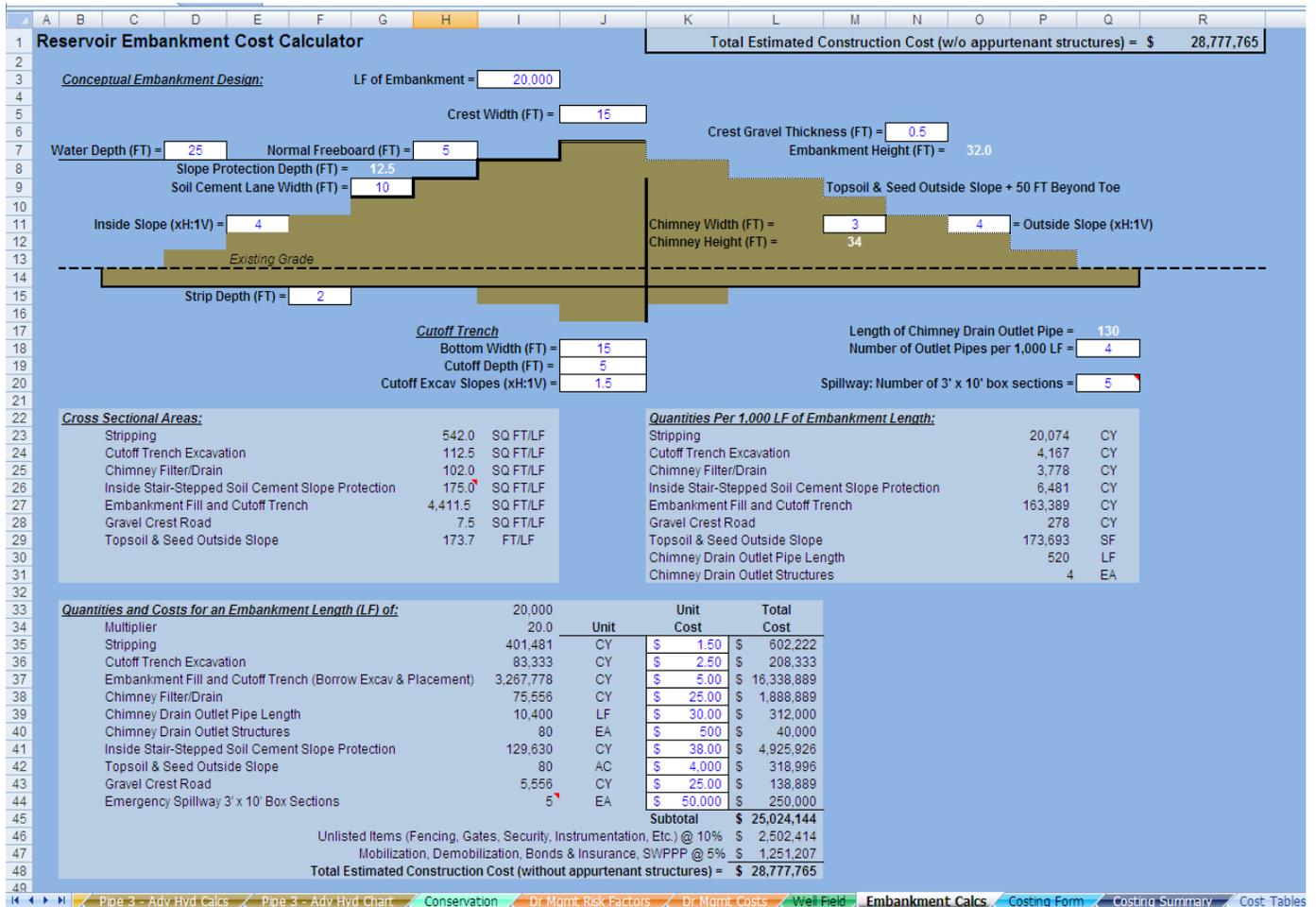


Figure 11. Dam Embankment Module

This information is not linked to the Costing Form and must be entered manually into one of the external cost cells for a ring dike reservoir or terminal storage. The user must also manually enter the storage capacity and area in the Costing Form in order for the UCM to calculate the land, environmental and surveying costs.

7.0 Land Acquisition

The Land Acquisition module (“Land Acquisition” tab – Figure 12) of the UCM is where the user can define land costs values (per acre) for each of the infrastructure components. Land cost vary significantly with location and economic factors. Land costs in Texas can be estimated using Rural Land Values in the Southwest published

biannually by the Real Estate Center at Texas A&M University³. Land values are estimated by county and land type. The user should use the Nominal Median Price per Acre when using the Real Estate Center's land values. A link to the Real Estate Center at Texas A&M University is embedded in the Land Acquisition module of the UCM.

Other sources of land values, such as county appraisal district records, may be available for use. Some judgment in the use of suggested land costs is required. For example, the land cost estimate developed from a resource may be appropriate for general land prices but may not be appropriate for prime locations in the same area. In such a situation, the prime land value could be significantly higher than that of the surrounding lands.

Pipeline right-of-way (ROW) may be calculated by two methods: Simplified and Advanced. The simplified method simply allows the user to input a total unit cost per acre for ROW land costs. The advanced method allows the user to specify the raw land unit cost, an assumption for the number parcels crossed per mile, permanent ROW width, and information regarding administrative costs, condemnation hearings, and trials. If "Advanced" methodology is selected, flags will appear to indicate where data must be entered to accurately calculate costs. The UCM assumes that 80 percent of the parcels will be acquired without condemnation, 10 percent acquired via a condemnation hearing, and 10 percent will go to trial.

³ <https://www.recenter.tamu.edu/data/rural-land/>

Pipeline Right-Of-Way Costs			
Right-Of-Way Costing Method	Advanced		
Unit Land Cost		/acre	
Assumed Parcels per Mile	4	parcels/mile	<----Must add value here
Permanent ROW Width	50	ft	
ROW Base Administrative Cost (80% of Parcels)	\$14,000	/parcel	<----Must add value here
Condemnation Hearing Cost (10% of Parcels)	\$26,500	/parcel	<----Must add value here
Trial Cost (10% of Parcels)	\$35,500	/parcel	<----Must add value here
Wellfield			

Land Costs for Other Facilities	County	Land Value (\$/acre)
Water Treatment Plant #1		
Water Treatment Plant #2		
Storage Tank		
Storage Tank		
Storage Tank		
Initial Pump Station		
Booster Station		
Booster Station		
Booster Station		
Booster Station		
Booster Station		
Booster Station		
Booster Station		
Booster Station		
Booster Station		
Booster Station		
Booster Station		
Booster Station		
Well Field		
Traditional Reservoir		
Off-Channel Reservoir		
Terminal Storage		

Figure 12. Land Acquisition Module

8.0 Cost Estimating Form

A studies level cost estimate includes three major cost categories: construction costs, other project costs, and annual costs. Construction costs are the direct costs, such as those for materials, labor, and equipment, incurred in constructing facilities. These are the costs that are generally submitted by a contractor bidding on a project. “Other project costs” include additional expenses not directly associated with construction activities such as costs for engineering, legal, land acquisition (including surveying for land acquisition), contingencies, environmental/archaeological/cultural resources studies, and interest during construction. Capital costs and other project costs comprise the Total Project Cost. Operation and maintenance (O&M), energy costs, and debt service payments are examples of annual costs. Major components that may be part of a preliminary cost estimate are listed in Table 3.

The Costing Form module (“Costing Form” sheet) of the UCM is the primary module for creating the cost estimate. The Costing Form module pulls information calculated in the other modules together, and allows the user to input additional data to step through the cost estimation, as summarized in Table 3. Warning Flags were

developed to provide the user with a check on areas where mistakes often occur. A few warning flags may appear on the Costing Form if certain information is missing or is inconsistent with another module. Flags will remain until resolved and will also be identified on the Costing Summary module. Flags include:

1. Well Field selected to be included on Project Info & Assumptions, but data from Well Field Module not entered.
 - a. To resolve this flag, the user needs to add data to the Well Field module and copy that into the Costing Form, or
 - b. If costs for a well field are not necessary for the WMS, select “No” on the Project Info & Assumptions module in row 19
2. Unit Land Cost on Land Acquisition sheet is zero
 - a. Without a land cost, easement or right of way costs may not be calculated. To resolve this flag, add land costs on the Land Acquisition module.

The following sub-sections briefly describe each of the elements included in creating a cost estimate in the Costing Form module.

The Costing Form contains subsections to assemble costs for pump station, pipelines, crossings, water treatment plants, dams and reservoirs, storage tanks, and well fields including wells and piping, along with project related costs such as engineering, legal, contingencies, land acquisition, environmental, archaeology studies, mitigation, and interest during construction. Note, if sections are hidden that are necessary for costing of the strategy, proceed to the Project Info & Assumptions module to select the appropriate methodology for hydraulic calculations, number of pipelines, and /or the well field (D17:19).

Table 3. Major Project Cost Categories

Cost Elements	
Capital Costs (Structural Costs)	Other Project Costs (Non-Structural Costs)
1. Pump Stations 2. Pipelines 3. Water Treatment Plants & Advanced Water Treatment Facilities 4. Dams and Reservoirs 5. Off-Channel Reservoirs 6. Water Storage Tanks 7. Well Fields a. Public	1. Engineering (Feasibility Studies, Design, Bidding and Construction Phase Services, Geotechnical, Legal Assistance, Financing, Bond Counsel, and Contingencies) 2. Environmental and Archaeological Studies and Mitigation 3. Land Acquisition and Surveying 4. Interest During Construction
	Annual Project Costs

<ul style="list-style-type: none"> b. Irrigation c. ASR Wells 8. Relocations, Integration and Other Facilities 	<ul style="list-style-type: none"> 1. Debt Service 2. Operation and Maintenance (excluding pumping energy) 3. Pumping Energy Costs 4. Purchase Water Cost (if applicable)
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8.1 Capital Costs

Cost tables have been updated for the 2021 Regional Water Plans and are discussed in the technical memorandum in Appendix C. The cost for a project element can be determined by applying a unit cost from the cost tables to a specific unit quantity. For example, pipeline costs can be determined by pipe diameter and linear feet of line. Cost estimates are approximate, therefore reporting costs to the dollar is not necessary. Estimates reported to the thousands of dollars are acceptable.

Throughout the Costing Form, the user has the option to override a calculated cost estimate for an element with an external cost estimate by simply filling in a value into the “External Cost Estimate” space on each line item. A recommended practice would be to add user notes in Column J for the source of alternate costs overriding the UCM generated costs.

The cost tables report “all-inclusive” costs to construct a particular facility. For example, the pump station cost table values include building, pump, materials, labor, and installation costs. Interpolation between the table values is done automatically by the UCM in order to arrive at the appropriate cost estimate. Each cost table has a reference time period for which the cost data is current. The user can adjust the time period by adjusting the CCI and PPI values on the Project Information and Assumptions module.

8.1.1 Pumping Stations

Anticipated primary pump and booster station costs vary according to the discharge and pumping head requirements, and structural requirements for housing the equipment and providing proper flow conditions at the pump suction intake. For planning level cost estimates, the cost tables provided are based on the station size, or horsepower, for the peak flow rate. The costs include those for pumps, housing, motors, site work, and all materials needed. Electrical connection costs are based on horsepower and may need to be adjusted based on engineering judgment. If a strategy includes upgrading a pump station where there is sufficient space in the building, the user can override the interpolated cost based on HP by adding a quote from the vendor (indexed to the correct date) in the External Cost Est section on the Costing Form.

The Costing Form has a section for each of the pipelines that use the Advanced Hydraulic Calculations module, each of which has a primary pump station and up to four booster stations. The primary pump station is broken into pump station cost and intake cost. The user may also wish to add a channel dam, if necessary, to this cost estimate. The UCM does not include cost curves for channel dams at this time, and if required, a construction cost estimate must be provided by the user. If the primary pump station is associated with something other than a diversion that requires an intake structure (such as a high service pump station (HSPS)), the user can set the intake cost to zero by entering “0” in the “External Cost Estimate” column on the appropriate row, thereby overriding the cost estimate. Additionally, the user enters the average flow rate associated with each booster station to establish the cost estimate for the storage tanks associated with the booster stations. The tank size is calculated using 10 percent of the daily average flow.

8.1.2 Pipeline

Pipeline construction costs are influenced by pipe materials, bedding requirements, geologic conditions, urbanization, terrain, and special crossings. Additionally, the pressure class of the pipe can affect the cost. For a planning level cost estimate, pipeline costs will be determined from unit costs based on the pipe diameter, ground type, and level of urban development. The unit costs include installation cost of the pipeline and appurtenances, such as markers, valves, thrust restraint systems, corrosion monitoring and control equipment, air and vacuum valves, blow-off valves, erosion control, revegetation of rights-of-way, fencing and gates.

Based on choices the user made on one or more of the hydraulics spreadsheets, the UCM calculates the cost associated with each pipeline segment based on the pipe diameter, soil / urbanization condition, pipeline length, and pressure class. Base pipeline costs are adjusted based on the pressure class chosen. The factors for cost adjustment based on pressure class are based on data received from a pipe distributor in March 2013⁴.

Additionally, the user can input crossing information to account for various types of pipeline crossings along the route.

8.1.3 Water Treatment Plants

Construction costs for water treatment facilities are based on plant capacity for six different levels of water treatment. It is not the intent of the cost estimating methodology to establish an exact treatment process but rather to estimate the cost of a general process appropriate for bringing the source water quality to the required

⁴ Email from Ronny Huffstickler – American Ductile Iron Pipe Company, March 8, 2013.

standard of the receiving system. The process options presented include disinfection, advanced groundwater treatment, simple filtration, conventional treatment, advanced brackish water treatment, and advanced seawater desalination. Table 4 gives a description of the processes involved in each treatment option. The water treatment plant unit costs include costs for all processes required, site work, buildings, storage tanks, sludge handling and disposal, clearwell, pumps and equipment. The costs assume pumping through and out of the plant as follows: Levels 2 through 5 treatment plants include raw water pumping into the plant for a total pumping head of 100 feet, and finished water pumping for 300 feet of total head. Levels 0 and 1 treatment includes finished water pumping only at 300 feet of head. **Note: include the costs of a HSPS (using the Simplified or Advanced Hydraulic modules) if the WTP is not delivering directly to a distribution system.**

When selecting a size for the WTP for the project, cost tables are based on rated capacity. If a project needs additional peaking at the plant the user will need to modify the WTP size on the Costing Form accordingly. Annual operation and maintenance (O&M) costs are based on the plant size.

Table 4. Water Treatment Level Descriptions

Level 0:	Disinfection Only - This treatment process will be used for groundwater with no contaminants that exceed the regulatory limits. Assumes groundwater does not require treatment for taste and odor reduction and groundwater is stable and requires no treatment for corrosion stabilization. With this treatment, the ground water is suitable for public water system distribution, aquifer injection, and delivery to the recharge zone.
Level 1:	Ground Water Treatment - This treatment process will be used for groundwater to lower the iron and manganese content and to disinfect. The process includes application of an oxidant and addition of phosphate to sequester iron and manganese. Chlorine disinfection as the final treatment. With this treatment, the ground water is suitable for public water system distribution, aquifer injection, and delivery to the recharge zone.
Level 2:	Direct Filtration Treatment - This treatment process will be used for treating ground water from sources where iron, manganese, or other constituent concentrations exceed the regulatory limit and require filtration for solids removal. Assumes turbidity and taste and odor levels are low. In the direct filtration process, low doses of coagulant and polymer are used and settling basins are not required as all suspended solids are removed by filters. The process includes alum and polymer addition, rapid mix, flocculation, filtration, and disinfection. Water treatment with this process is suitable for aquifer injection or for delivery to the recharge zone.
Level 3:	Surface Water Treatment – (new or expansion) This treatment process will be used for treating all surface water sources to be delivered to a potable water

	distribution system. The process includes coagulant and polymer addition, rapid mix, flocculation, settling, filtration, and disinfection with chlorine. This treatment process also applies for difficult to treat groundwater containing high concentrations of iron (greater than 3 mg/l) and manganese requiring settling before filtration.
Level 4:	Brackish Groundwater Desalination ⁵ - Note: This treatment cost includes pretreatment for solids removal prior to RO membranes. This treatment process will be used for treatment of groundwater with total dissolved solids (TDS) exceeding the regulatory limit of 1,000 mg/l. Base costs are based on reverse osmosis (RO) membrane desalination of groundwater with 3,000 mg/l of TDS to lower the treated water TDS below the regulatory limit. However, the user enters the TDS associated with the brackish water source (1,000 mg/L to 35,000 mg/L), and costs are adjusted based on the TDS. The desalination concept includes minimal pretreatment (cartridge filtration, antiscalent addition, and acid addition), reverse osmosis membrane system, and disinfection with chlorine. Costs assume desalination concentrate will be discharged to surface water adjacent to treatment plant. With this treatment, the ground water is suitable for public water system distribution, aquifer injection, and delivery to the recharge zone. WTP size is based on finished water from the plant.
Level 5:	Seawater Desalination - Note: This treatment cost includes pretreatment for solids removal prior to RO membranes. This treatment process will be used for treatment of seawater with total dissolved solids (TDS) exceeding the regulatory limit of 1,000 mg/l. Costs are based on reverse osmosis (RO) membrane desalination of a water with 32,000 mg/l of TDS to lower the treated water TDS below the regulatory limit. The desalination concept includes minimal pretreatment (cartridge filtration, antiscalent addition, and acid addition), reverse osmosis membrane system, and disinfection with chlorine. Costs assume desalination concentrate will be discharged to surface water adjacent to treatment plant. With this treatment, the ground water is suitable for public water system distribution, aquifer injection, and delivery to the recharge zone. WTP size is based on finished water from the plant.

8.1.4 Advanced Water Treatment Facilities

More WUGs are considering direct potable reuse (DPR) using advanced water treatment facilities (AWTF) to purify wastewater to the level such that it can be

⁵ “Graves, M., and Choffel, K., 2004, Economic siting factors for seawater desalination projects using reverse-osmosis processes, in Texas Water Development Board Report 363, Technical Papers, Case Studies and Desalination Technology Resources.”

blended with other sources and delivered back to the water treatment plant for additional treatment and distribution. Referencing data⁶ provided in the April 2015 TWDB Direct Potable Reuse Resource Document, the UCM includes capital cost and operation and maintenance cost curves for advanced water treatment facilities based on two treatment approaches. These schemes have proven effectiveness based on limited direct or indirect potable reuse projects; however, any treatment scheme should be based on site specific data and limitations.

DPR treatment strategies include a combination of infrastructure and treatment approaches to address regulated and unregulated water quality constituents and to provide redundancy for health and safety. Table 5 includes a list of treatment processes for DPR

Table 5 – A WTF Processes and Purposes (adapted from TWDB DPR Resource Document Table 5-1)

Process	Purpose
Microfiltration (MF) or Ultrafiltration (UF)	Typically functions as pretreatment for membranes to prevent fouling and removes suspended solids
Membrane Bioreactors (MBR)	Combines WWTP biological treatment with MF or UF in one unit process. Removes BOD, ammonia, turbidity, and pathogens
Reverse Osmosis (RO)	Pressure driven membrane process that separates and removes dissolved solids, bulk organics, nitrate, pesticides, CECs and pathogens. Requires additional disposal of concentrate.
Chlorine	Disinfectant for inactivation of pathogens
Ultraviolet Irradiation (UV) Disinfection	Inactivation of pathogens. Effectiveness based on water quality, exposure time and UV intensity
Advanced Oxidation Processes (AOP)	Chemical process to oxidize organic compounds and CECs
Ozone	Strong disinfectant and oxidant of organics
Ozone / Biological Activated Carbon (BAC)	Strong disinfectant and oxidant of organics. BAC helps remove chemical by products of ozonation
Stabilization	Chemical stabilization via decarbonation and dosing with alkaline source to address corrosivity of RO water.

⁶ In addition, 10% for contractor overhead and profit were included with the cost curves for consistency with other facility costs.

The AWTF approaches below assume secondary or tertiary treated wastewater as the influent. The two AWTF schemes are below and listed from highest to least cost alternatives:

1. MF/UF+RO+UV/AOP + Stabilization
2. Ozone + BAC + MF/UF + UV + Chlorine

A major difference between these two treatment schemes is the use of RO which is included in Scheme 1 but not in Scheme 2. In order to utilize Scheme 2, nitrogen must be removed at the WWTP. Scheme 1 is closely associated with the direct reuse project in Big Springs, TX and Wichita Falls, TX.

To add AWTF costs, the user must select treatment scheme 1 or 2 and provide the treatment capacity. Scheme 1 assumes adequate MF / UF components to handle larger flow to provide adequate feed water for the RO process since the RO recovery rate is typically 75 – 80%. For example, a 1 MGD AWTF using Scheme 1 is actually sized for 1.2 mgd in order to provide 1 mgd of product water and resulting 0.2 mgd of concentrate. Please note that UCM costs for AWTF do not include transmission pipelines, concentrate disposal, engineered storage, or upgrades to WWTP to meet influent criteria for the AWTF. As with other facilities, if the user has more specific costs for a DPR strategy, estimates can be provided in the appropriate external cost cells.

8.1.5 Reservoirs, Off-Channel Reservoirs, and Terminal Storage

Reservoir cost estimates in the UCM cost tables are not intended to develop detailed and complete costs, but may be considered to provide context for site specific data and calculations. Standard cost tables for construction costs for on channel reservoirs, off-channel reservoirs, and terminal storage are based on reservoir capacity. The user enters the reservoir's conservation capacity, area and the quantity and the UCM generates a cost estimate using cost curves based on bid data and engineering estimates. The standard cost curves are available to the user when there are no specific details about a surface storage facility available, outside of a storage capacity. Alternatively, the user may use the Embankment Calculations module to develop a more detailed cost estimate, when there is a specific reservoir site with specific details available. To bring in costs developed in the Embankment Calcs tab, the user needs to link or enter the costs to the External Cost Est. column for the appropriate row.

8.1.6 Stilling Basins

If an alternative involves discharging into a water body or perhaps into a recharge structure, it may require that excess energy in the water be dissipated so that scouring and erosion do not become a problem. Energy will be dissipated with the use of stilling basins. The user enters the discharge flow in cfs, and the UCM calculates a stilling basin cost based on a cost of \$3,025 per unit flow (cfs).

8.1.7 Storage Tanks

Ground storage tanks may be used for stand-alone storage, as part of a distribution system, or as part of a pumping station. The costs for storage tanks are based on cost per million gallons of capacity. The user specifies the type of storage tank to be used (ground storage with roof, ground storage without roof, or elevated storage) and the capacity of the storage tank.

Elevated storage tanks are rarely used in water transmission systems and are typically utilized in distribution systems within a water service area. However, the UCM includes the option to include an elevated storage tank, if necessary.

8.1.8 Well Fields

Working with the Well Field module, a user may estimate total lengths and diameters of the collection system which will need to be manually added to the Well Field Piping section on the Costing Form. Collection piping uses the same cost curves as the transmission piping and the user will need to add the ground type to generate a unit cost. The power connection costs assume a HP based on the depth, pump rate and number of wells. The Well Field module if completed will generate a better estimate of total HP for the wells which includes necessary power to convey through the collection system and can be manually entered into the External Cost Est column. Note: If there is data in the Well Field module, a warning flag will appear on the Costing Form to alert the user to enter this data. The flag reads:

1. Well Field selected to be included on Project Info & Assumptions, but data from Well Field Module not entered.
 - a. To resolve this flag, the user needs to add data to the Well Field module and copy that into the Costing Form, or
 - b. If costs for a Well Field are not necessary for the WMS, select “No” on the Project Info & Assumptions module in row 19

The UCM contains four types of wells: public supply, irrigation, aquifer storage and recovery (ASR), and injection wells. Public supply wells are wells used by municipalities and other water suppliers to supply groundwater for consumption. Irrigation wells provide water for irrigation purposes but may also be used in scenarios involving surface and groundwater exchange. ASR is the concept of using wells to inject water into an aquifer for temporary storage and then extracting the water later when needed. ASR wells include injection wells, recovery wells, and wells that can be used for both injection and recovery. Additionally, there are injection wells for injecting reject water from various types of projects.

Well costs have been generated for the different types of wells for pumping water from various static water level ranges and pumpage rates. The costs include complete

installation of the well and pump to include drilling services, materials, pump and control equipment, valves, testing, security fencing, and a small access road. The costs do not include those for a building, surface piping connecting to a transmission/collector pipeline, or power connection costs.

8.1.9 Conservation

Conservation strategies are often program based with annual costs. However, some conservation WMS include replacing leaking pipe, meter replacements or other infrastructure improvements in order to reduce system losses. The UCM includes capital costs for conservation WMS. Pipeline costs reference the cost tables for the transmission pipe and the user will need to identify the length, diameter, ground type and pressure class of pipe. Unique costs can be added into the External Cost Est column.

8.1.10 Relocations

Large-scale projects, such as reservoirs, may require the use of lands that contain existing improvements or facilities such as homes, businesses, utilities, and roads. If the benefits outweigh the costs, the new project element may be constructed, but with the requirement that selected affected improvements or facilities be relocated. An example of a relocation is the rerouting of a highway out of the inundation area of a new reservoir. Because the type of improvements and facilities that may be candidates for relocation can vary significantly, estimating the costs for other relocation items should be handled on an individual basis.

8.1.11 Integration

The introduction of treated water to a city, or other entity, may require improvements to connect to the entity's water distribution system. A detailed analysis of a distribution system is needed to determine the system improvements required to handle the introduction of additional water supplies. The analysis would incorporate the development of a model of the entity's distribution system using a program, such as KYPIPE or EPANET, to determine what improvements are needed. This level of work is usually beyond the scope of a regional water planning analysis.

Cost estimates for distribution system improvements should be handled on an individual basis because the magnitude of improvements will vary significantly with each system. Some systems may actually require very little improvements, while others may require large-scale advancements.

In accordance with 31 TAC §357.34(e)(3)(A) the cost of distribution system improvements within a service area should not be part of the cost for a WMS unless it is associated with water savings in a conservation strategy⁷.

8.1.12 Other Capital Cost Items

Alternatives may involve elements that are not adequately addressed by the cost tables and guidelines within this section. These additional items will require research on an individual basis to obtain appropriate cost estimates.

8.2 Associated Project Costs

As previously mentioned, “Associated Project Costs” are costs incurred in a project that are not directly associated with construction activities. These include costs for engineering, legal, financing, contingencies, program management, land, easements, surveying, environmental services, and interest during construction.

8.2.1 Engineering, Legal, Financing, and Contingencies

Some “Associated Project” costs can be estimated by applying a percentage to the total capital cost. For studies level cost estimates we will use a percentage to calculate a combined cost that accounts for engineering, financial, and legal services, and contingencies. The contingency allowance accounts for unforeseen circumstances and for variances in design and construction. The percentages to be used are 30 percent of the total construction costs for pipelines and 35 percent for all other facilities.

For large scale projects involving multiple design and construction contracts, a WUG may hire a program manager to keep the project running smoothly. If appropriate to use a program manager, the UCM applies a certain percentage of the total construction cost. The percentage should be based on the size of the project.

8.2.2 Land Acquisition

Land related costs for a project can typically be divided into two categories, land purchase costs and easement costs. Land purchase costs are those costs incurred for direct purchase of land areas not currently in the project owner’s possession. Survey and legal service costs for land transactions will be added to land and easement costs to get the total land acquisition costs. Suggested land areas for various facility types are listed in Table 6.

⁷ TWDB, Exhibit C, “General Guidelines for Fifth Cycle of Regional Water Plan Development”, Second Amended, April 2018

Pipelines may be built on lands that are, or are not, possessed by the project owner. Typically, a pipeline will start on land in the possession of the project owner that was purchased and/or dedicated for use with a specific facility, such as a pump station or water treatment plant, and then traverse cross-country. Rather than purchase land along the pipeline route, easements are usually acquired. The general definition of an easement is a right granted by the owner of a parcel of land to another party. The rights are for use of the land for a specified purpose. There are a number of easement types and methods in which they can be created. For pipelines, the process is usually similar to land purchase, with a price being paid for construction of the pipeline on the landowner's property and for future entry rights for maintenance activities. Payment for easements may be less than land purchase price since the original owner maintains title, and the land is usually restored after construction by the contractor, and used by the landowner.

Table 6. Suggested Land Area for Various Facilities

Facility	Suggested Land Area (acres)
Pump Station	5
Water Treatment Plant	0.5/MGD
Water Storage Tanks	2
Reservoirs	Inundation Area ¹
Well Fields ²	0.5 per well minimum
¹ Larger land areas may be required in order to account for flood pool, freeboard, etc. ² Larger land areas may be required in order to obtain a certain quantity of water rights.	

Two types of easements are usually acquired for pipeline construction: temporary and permanent. Permanent easements are those, in which the pipeline will reside once constructed, and provide room for future maintenance and protect the line from other parallel underground utilities. Temporary easements provide extra working space during construction for equipment movement, material storage, and related construction activities. Once the pipeline has been installed, the grounds are restored to pre-construction conditions, and the temporary easement ceases to exist. The owner of the property may resume activities over the easements, with the right granted to the project owner allowing entry to the permanent easement for inspection, maintenance, and repair activities. The total construction easement width shown is the sum of the permanent and temporary easements. The width of the easement identified

on Land Acquisition module should represent the permanent easement width. However, the costs for easements should assume both permanent and temporary.

For more information regarding land acquisition, please see Section 7.0.

8.2.3 Surveying

Surveying and legal services are required with most land transactions. The UCM defaults to ten percent (10 percent) of the land cost as a portion of surveying, except for reservoirs. The surveying cost for reservoirs is estimated as \$50 per acre of inundation. These default values can be revised provided there is more precise alternative costs to utilize.

8.2.4 Environmental and Archaeology Studies, Permitting, and Mitigation

In general, most construction projects will require some type of approval by governmental agencies. Environmental permits may be required by local, state, and/or the federal agencies for projects that affect land and water resources, or generate air pollution. Of particular importance, studies for projects will be performed to determine if environmentally sensitive areas, wetlands, threatened or endangered species, and valuable archaeological/cultural resources exist on or near properties where project facilities are proposed for construction. In addition, such conditions may result in restrictions or modifications in construction, may require mitigation, and in some cases could prevent construction altogether. As related to construction projects, mitigation refers to actions taken to achieve equitable compensation given for environmental impacts relative to construction and/or operation of the project. This could include purchase of land, enhancement of wildlife habitat and/or money compensation.

Environmental and archaeological studies are usually performed during the design phase of a project, though some investigations may occur during the preliminary engineering phase. In the studies level analysis of a project, it is difficult at best to determine what permits may be required and the costs for environmental studies. There will be some base fee for the initial environmental studies that will be performed on a project. More detailed environmental analysis may be required if any environmental issues are discovered, which could result in increased environmental studies and permitting costs, and perhaps mitigation. Mitigation, if required, can vary significantly, as would the related value/cost. Costs for environmental studies, permitting, and mitigation are project dependent and should be estimated on an individual basis using information available and the judgment of qualified professionals. For all project components except pipelines, the UCM assumes the Environmental/Mitigation Costs are 100 percent of land costs. This assumption can be adjusted by the user as appropriate. The recommended value for environmental studies and mitigation costs for pipelines is \$25,000/mile of pipeline.

8.2.5 Interest during Construction

An entity generally funds construction projects by securing loans or selling bonds of some type. Typically, the entity receives the funds at the start of the construction project and pays the contractor from the funds over the duration of the construction period. Interest on the borrowed funds will be charged during the construction period as well. It is desired by the entity not to make payments on the borrowed funds or the interest until the project is complete and is generating revenue. As such, the interest during construction (IDC) is determined and treated as a cost item to be included as part of the total project cost and made part of the loan. In addition, the entity may invest part of the borrowed funds during the construction period and any gains made on the investments can be used to offset interest payments (i.e. reduce the net interest during construction).

IDC is calculated as the cost of interest on the borrowed amount less the return on the proportion of borrowed money invested.

IDC is calculated by applying the net interest rate over the construction period of the project to the average project cost (Equation 10). The net interest rate is the interest rate on borrowed funds less the return interest rate from the investment on unspent borrowed funds. The average project cost is equal to the sum of the capital costs, and all other project costs, excluding IDC, divided by two.

$$\text{IDC} = [\text{Amount Borrowed} \times \text{Annual Rate of Loan} \times \text{Construction Period (years)}] - [\text{One-Half Amount Borrowed} \times \text{Annual Rate of Return} \times \text{Construction Period (years)}] \quad (10)$$

The final total project cost is equal to all costs plus the interest during construction. The UCM provides for unique IDC for Reservoir and non-reservoir construction.

8.3 Annual Costs

The annual costs in a cost estimate are the estimated annual costs that the project owner can expect if the project is implemented. These costs include the costs for repayment of borrowed funds (debt service), operation and maintenance costs of the project facilities, pumping power costs, and possibly water purchase costs.

8.3.1 Debt Service

Debt service is the estimated annual payment that can be expected for repayment of borrowed funds based on the total project cost (present worth), the project finance rate, and the finance period in years. The UCM contains the necessary calculations to estimate annual payments based on financing period and interest rates. The financing period and interest rates are entered on the Project Information and Assumptions module.

8.3.2 Operation and Maintenance

Operation and maintenance costs for dams, pump stations, pipelines and well fields (excluding pumping power costs) include labor and materials required to maintain the project, regular repair and/or replacement of equipment. Operation and maintenance costs (O&M) are calculated as a percent of the total estimated construction cost for various types of facilities.

1. Pipeline, Tank, Distribution, and Well
2. Dams and Reservoirs
3. Intake and Pump Stations

These percentage rates are entered on the Project Information and Assumptions module by the user.

8.3.3 Pumping Energy Costs

Power costs are calculated on an annual basis using the appropriate calculated power load and a power rate. The power rate is entered on the Project Information and Assumptions module by the user. For peaking projects, the UCM calculates the annual power not the peaking power. Note that energy costs for WTP and AWTF are included in the O&M estimates.

8.3.4 Purchase of Water

The purchase cost, if applicable, should be shown if the alternative involves purchase of raw or treated water from an entity. This cost may include other fees on the water such as groundwater district fees, wheeling fees or others and will vary by source.

9.0 Cost Summary

The Cost Summary module (“Cost Summary” sheet – Figure 13) pulls together common costing elements from the Costing Form module and summarizes them and their costs in a simple tabular format capable of being placed directly into a water management strategy write-up. All the fields within the module are populated automatically. The user may “condense” the summary table to eliminate elements that are not part of the current cost estimate by clicking the “Create Cost Estimate Summary for Report” button. Clicking this button will produce a summary table that only contains line items for elements that contain a cost for the cost estimate. To reset the table, the user can click the “Reset Summary” button. Any warning flags remaining on the Costing Form module will be identified as a warning flag on the Costing Summary.

Cost Estimate Summary Water Supply Project Option February 2018 Prices Missing, TX - Example Project	
Cost based on ENR CCI 10889.17 for February 2018 and a PPI of 194.5 for February 2018	
<i>Item</i>	<i>Estimated Costs for Facilities</i>
Dam and Reservoir (Conservation Pool 40000 acft, 500 acres)	\$14,250,000
Primary Pump Station (0 MGD)	\$7,189,000
Water Treatment Plant (4 MGD)	\$2,319,000
TOTAL COST OF FACILITIES	\$23,758,000
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	\$8,791,000
Environmental & Archaeology Studies and Mitigation	\$47,000
Land Acquisition and Surveying (518 acres)	\$25,000
Interest During Construction (4% for 1 years with a 1% ROI)	<u>\$1,126,000</u>
TOTAL COST OF PROJECT	\$33,747,000
ANNUAL COST	
Debt Service (5 percent, 30 years)	\$867,000
Reservoir Debt Service (5 percent, 30 years)	\$1,297,000
Operation and Maintenance	
Intakes and Pump Stations (2.5% of Cost of Facilities)	\$180,000
Dam and Reservoir (1.5% of Cost of Facilities)	\$214,000
Water Treatment Plant	\$765,000
Advanced Water Treatment Facility	\$0
Pumping Energy Costs (1735073 kW-hr @ 0.12 \$/kW-hr)	\$208,000
Purchase of Water (acft/yr @ \$/acft)	<u>\$0</u>
TOTAL ANNUAL COST	\$3,531,000
Available Project Yield (acft/yr)	4,000
Annual Cost of Water (\$ per acft), based on PF=1	\$883
Annual Cost of Water After Debt Service (\$ per acft), based on PF=1	\$342
Annual Cost of Water (\$ per 1,000 gallons), based on PF=1	\$2.71
Annual Cost of Water After Debt Service (\$ per 1,000 gallons), based on PF=1	\$1.05
<i>P. Newell</i>	<i>7/25/2018</i>

Figure 13. Costing Summary Module

10.0 Water Conservation

The Conservation module (“Conservation” tab – Figure 14) of the UCM provides the user a simplified method of calculating advanced municipal water conservation savings and associated costs. Advanced water conservation is conservation above and beyond that of the water efficiency savings that are included in the TWDB water demand projections. Note: The TWDB is creating a new tool for Conservation which will be useful, but not required, for regional planning. Completion is estimated to be in late 2018, and the TWDB will inform planning groups of its availability. There are two approaches to calculating the water conservation quantities and costs in the Conservation module: Simple Approach and Detailed Approach.

decrease after the goal has been reached. If no additional conservation is to be included after the goal is met, the “Rate Once Goal Is Achieved” can be set to zero.

Finally, the user sets the unit cost of conservation by specifying the urban/suburban/rural setting of the WUG/WWP. Default unit costs of municipal water conservation were obtained from the “Quantifying the Effectiveness of Various Water Conservation Techniques in Texas”⁸ study conducted for TWDB. The user may deviate from these default unit costs if more specific cost information is available.

10.2 Detailed Approach

In the Detailed Approach, the user has the option to add conservation goals for seven categories: Public & School Education, Water Audits, Water Conservation Pricing, Landscape Design Conversion, Passive Clothes Washers, Plumbing Retrofits, and Other. Guidance is given within the UCM as comments. Additional information regarding potential savings and associated cost ranges can be found in the “Water Conservation Best Management Practices Guide⁹,” (http://www.twdb.state.tx.us/publications/reports/numbered_reports/doc/R362_BMP_Guide.pdf).

The user can specify the savings rate, the effectiveness, and the costs associated with each conservation measure. The Conservation module then computes the advanced water conservation savings and the associated annual and unit cost of the strategy.

Any conservation strategies that will include capital costs will need to be estimated on the Costing Form module as mentioned in Section 8.1.9. A note in the Conservation module redirects the user to the Costing Form for these types of strategies.

⁸ GDS Associates, “Quantifying the Effectiveness of Various Water Conservation Techniques in Texas; Appendix VI, Region L,” Texas Water Development Board, Austin, Texas, July 2003.

⁹ Water Conservation Implementation Task Force, “Water Conservation Best Management Practices Guide,” November 2004.

11.0 Drought Management Risk Factor and Cost

11.1 Simplified Approach

Financial impacts due to water shortages on demands can be significant and can have far ranging socioeconomic impacts. In past planning cycles, the TWDB has estimated the socioeconomic impacts using an economic modeling software package, the IMPLAN model, and made the report available to the planning regions. Impacts include tax losses, utility revenue losses, income and job losses, population and school enrollment losses.

The TWDB plans to provide the socioeconomic report to be included in the 2021 Initially Prepared Plans in late 2019. In Fall 2019, prior to the release of the report, TWDB will also provide a drought management impact estimating tool for the RWPGs using the same model for estimating socioeconomic impacts for the 2021 Regional Water Plan. WUG specific unit cost will be provided that will be consistent with the socioeconomic impact reports.

11.2 Detailed Approach

The detailed approach for Drought Management includes two modules “Dr Mgmt Risk Factors” and “Dr Mgmt Costs” which are used to develop estimates of municipal drought management water savings (i.e. failure to meet projected water needs) and associated costs (i.e. economic impacts of failure to meet projected water needs) for WUGs/WWPs. The calculations are rather complex, and are described in detail Appendix D, an excerpt from the 2016 South Central Texas Regional Water Plan¹⁰. For the UCM, an automated process has been included for quantifying drought management savings and estimating economic impacts which are converted to unit costs for direct comparison to other water management strategies.

¹⁰ South Central Texas Regional Water Planning Group, 2016 Regional Water Plan, Volume II, Technical Evaluations of Water Management Strategies, December 2015.

Drought Management - Step 1: Determination of Risk Factors																	
WUG / WWP:		Lockhart															
Reference Year:		2000															
Year		1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Hist. Ann. Use (gpcd)		101	105	100	114												
5-Yr Moving Avg Use (gpcd)						104	105	107	113	114	116	121	121	118	121	130	130
% Above (+) or Below (-) 5-year Mov. Avg.						-2.3	-0.2	5.1	15.5	6.8	-4.3	7.4	-6.8	-4.8	16.1	17.9	1.4
Rank						17	20	26	34	27	12	28	6	11	35	36	22
Percentile						45.9%	54.1%	70.3%	91.9%	73.0%	32.4%	75.7%	16.2%	29.7%	94.6%	97.3%	59.5%
% Above (+) or Below (-) Year 2000 from 5-year Mov. Avg.						9.2	11.5	17.4	29.0	19.4	6.9	20.1	4.2	6.4	29.8	31.7	13.3

Ranked Deviation from 5-Year Moving Average ---->														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	2.70	5.41	8.11	10.81	13.51	16.22	18.92	21.62	24.32	27.03	29.73	32.43	35.14	37.84
	-9.012	0.000	0.622	1.581	1.767	4.179	4.452	4.651	5.068	6.125	6.418	6.923	7.136	7.411
	0.0	0.0	0.8	3.0	4.5	8.0	11.7	12.2	13.0	15.1	17.0	18.0	19.0	19.7
	-0.5	0.0	2.2	4.3	5.9	9.4	13.0	13.5	14.4	16.5	18.3	19.4	20.4	21.0
	-1.0	0.1	3.5	5.7	7.2	10.7	14.4	14.9	15.7	17.8	19.7	20.7	21.7	22.4
	-1.5	0.3	4.9	7.0	8.6	12.1	15.7	16.2	17.1	19.2	21.0	22.1	23.1	23.7
	-2.0	0.6	6.2	8.4	9.9	13.4	17.1	17.6	18.4	20.5	22.4	23.4	24.4	25.1
	-2.5	0.9	7.6	9.7	11.3	14.8	18.4	18.9	19.8	21.9	23.7	24.8	25.8	26.4
	-3.0	1.3	8.9	11.1	12.6	16.1	19.8	20.3	21.1	23.2	25.1	26.1	27.1	27.8
	-3.5	1.8	10.3	12.4	14.0	17.5	21.1	21.6	22.5	24.6	26.4	27.5	28.5	29.1
	-4.0	2.4	11.7	13.8	15.3	18.8	22.5	23.0	23.8	25.9	27.8	28.8	29.8	30.5
	-4.5	3.0	13.0	15.1	16.7	20.2	23.8	24.3	25.2	27.3	29.1	30.2	31.2	31.8
	-5.0	3.7	14.4	16.5	18.0	21.5	25.2	25.7	26.5	28.6	30.5	31.5	32.5	33.2
	-5.5	4.5	15.7	17.8	19.4	22.9	26.5	27.0	27.9	30.0	31.8	32.9	33.9	34.5
	-6.0	5.4	17.1	19.2	20.7	24.3	27.9	28.4	29.2	31.3	33.2	34.2	35.2	35.9
	-6.5	6.3	18.4	20.5	22.1	25.6	29.2	29.7	30.6	32.7	34.5	35.6	36.6	37.2
	-7.0	7.3	19.8	21.9	23.4	27.0	30.6	31.1	31.9	34.0	35.9	36.9	37.9	38.6
	-7.5	8.4	21.1	23.2	24.8	28.3	31.9	32.4	33.3	35.4	37.2	38.3	39.3	39.9
	-8.0	9.6	22.5	24.6	26.1	29.7	33.3	33.8	34.6	36.7	38.6	39.7	40.6	41.3
	-8.5	10.8	23.8	25.9	27.5	31.0	34.6	35.1	36.0	38.1	39.9	41.0	42.0	42.6
	-9.0	12.1	25.2	27.3	28.8	32.4	36.0	36.5	37.3	39.4	41.3	42.4	43.3	44.0
	-9.5	13.5	26.5	28.7	30.2	33.7	37.3	37.8	38.7	40.8	42.6	43.7	44.7	45.3

Note: The table to the right is used to calculate the incremental risk factor between each ranked deviation from 5-year moving average for each potential drought management reductions, via trapezoidal integration. On the far right of the table (Column AZ) sums the incremental risk factors to a total risk factor for each potential drought management reductions.

Figure 15. Advanced Drought Management Risk Factors Module

The user starts with the Drought Management Risk Factor module (Figure 15) and enters the historical per capita water use data for each WUG/WWP and a reference year. This module calculates the risk associated with making drought management reductions at various levels. The results of this module feed the Drought Management Costs module (Figure 16). It should be noted that drought management water management strategies that are evaluated should take into account any previous implementation of drought management that may be embedded in historical GPCD data to avoid under-estimating impacts of annual unit costs of failure to meet projected water need (aka drought management).

The Drought Management Costs module takes results from the Drought Management Risk Factor module and calculates the amount of water saved for 5, 10, 15, and 20 percent reductions, and their associated costs. The user enters the water demand for the municipal WUG/WWP and planning year for which drought management is being considered. Additionally, the user enters the water use sector distribution (domestic/residential, commercial, and manufacturing) for the municipal WUG/WWP and the unit cost of reduction for the various sectors. Information required for this tool is not available from the TWDB and the user will need to use its own data.

	A	B	C	D	E	F	G	H	I	J
1										
2		Drought Management - Step 2: Cost Calculation								
3										
4		<i>Water User Group:</i>	Lockhart							
5		<i>Water Demand (acft/yr):</i>	2,451							
6		<i>Planning Year:</i>	2020							
7										
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41										
42										

	Demand Reduction	Unit Cost
RESIDENTIAL	5%	\$ 920
	10%	\$ 1,030
	20%	\$ 1,290
	30%	\$ 2,130
	40%	\$ 5,780
	50%	\$ 7,040
	60%	\$ 8,950
	70%	\$ 12,120
	80%	\$ 18,460
	>90%	\$ 24,070
	Commercial	\$ 35,230
	Industry	\$ -

Figure 16. Advanced Drought Management Cost Module

The Drought Management Costs module processes the inputs and the resulting risk factors from the Drought Management Risk Factor module to determine the amount of water saved due to drought management and the associated economic impact of not meeting water needs.

12.0 Project Phasing

The UCM is designed to estimate total project costs for developing water management strategies in order to meet projected water needs through the regional planning period. The UCM has not been designed for the complexities of project phasing and the evaluation of costs at various times during the life of a project. However, if there is a need to demonstrate expansions of WTP or pump stations, or the paralleling of a transmission pipeline, a few items of guidance have been developed below. This is not a comprehensive list but a few examples of how the UCM can be used for project phasing.

The UCM allows for an expansion of existing WTP but only for conventional treatment or Level 3. The user selects the treatment level as “3 (Expansion)” from the drop down menu on the Costing Form. The capacity field represents the incremental capacity for the expansion. For example, if a plant was to expand from a 5 mgd to a 10 mgd plant, the user would enter “5 mgd” for capacity.

A conservative approach for expanding a pump station would require estimating the cost for the current versus the proposed pump station and then adding that difference to the External Cost Est column. Alternatively, if most of the electrical and structural elements will not be revised, replacing pumps and motors may represent up to 35% of the cost of the pump station.

To estimate the hydraulics of a future parallel pipeline, the user will need to determine the correct balance of flow rate and losses in each pipeline. If the diameters and C-factor are identical in the pipelines, the flow rate will be the same. However, for pipelines originating from the same pump station the hydraulics will be such that the losses in the pipe are identical but the flow rates may be different. The user could approach this using two Advanced Hydraulic Calculation modules to determine the correct flow rates and pumping energy and then revise the Costing Form to account for the necessary infrastructure.

This is not a comprehensive list but provides examples of how the UCM can be used for project phasing.

13.0 References

South Central Texas Regional Water Planning Group, 2016 Regional Water Plan, Volume II, Technical Evaluations of Water Management Strategies, December 2015.

GDS Associates, “Quantifying the Effectiveness of Various Water Conservation Techniques in Texas; Appendix VI, Region L,” Texas Water Development Board, Austin, Texas, July 2003.

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APPENDIX A
UCM Change Log

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Scope	Description of Change	Changed Cells	Scope Item
Costing Form	Performed manual QC check on all costs - did not find any errors.	N/A	B
Pipe X - Adv Hyd Calcs (3 sheets)	Drop down menus for soil type and urban/rural for pipeline profiles	S:T	B1
Simplified Hyd Calcs	Changed Diameter data validation to point to named range	G19	B1
Well Field	Modified list of diameters to mirror "pipeline_diameters" named range used throughout rest of UCM	I43:J69	B1
Well Field	Changed "Selected Diameter" data validation to point to named range "pipeline_diameters"	G15:G33	B1
Pipe X - Adv Hyd Calcs (3 sheets)	Eliminated energy being produced (due to negative TDH) by using max(0, TDH)	D35	B2
Well Field	Energy calcs include lift at individual well level.	Q15:Q33	B3
Costing Summary	Performed manual QC check on all costs pulled from Costing Form - no errors found.	N/A	B4
Cost Tables	Corrected bad date formats in numerous locations	D2, E2, F37, C70, etc...	B5
Costing Form	Corrected bad date format	C5	B5
Costing Summary	Fixed bad date formats	B1, B3, B4	B5
Cost Tables	Added Baseline Cost 1 or 2 to calculate both index whether the curves were updated or not.	L1:O1	C
Cost Tables	Updated unit costs based on new bid data	Various	C1
Costing Form	Added "Annual Cost of Water Without Debt Service (\$/1000 gal)"	I271	C10
Costing Summary	Added "Annual Cost of Water After Debt Service (\$/1000 gal)"	C41	C10
Reference - Cost Indices	Updated CCI and PPI values to current	Various	C2
Project Info & Assumptions	Revised assumptions regarding interest rates in accordance with agency guidance	E22:34	C3
Cost Tables	Added shallow well costs to table and updated formula on "Costing Form" to capture the new range	B194:D194	C4
Cost Tables	Unit costs for ASR wells were reviewed and were escalated based on ENR CCI	B219:G225	C5
Cost Tables	Added DPR facility costs and O&M costs.	A239:G254	C6
Costing Form	Added rows for Advanced Water Treatment Facility & O&M	Row 145, 238	C6
Costing Summary	Added rows for Advanced Water Treatment Facility & O&M	Row 16	C6
Costing Form	The current methodology for determining reservoir land acquisition costs were reviewed and determined	N/A	C7

Scope	Description of Change	Changed Cells	Scope Item
	adequate based on current market trends. No changes are recommended		
Cost Tables	Unit costs for WTP O&M were updated for Level 2, 3 and 5	B139:I148	C8
Dr Mngt Costs	Evaluated costing capabilities for drought management. No recommended changes to the Risk Factors or Advanced Drought Methodology	N/A	C9
Dr Mngt_Simplified	Evaluated alternative approaches to simplify costing Drought Management strategies using TWDB Socioeconomic Analysis which TWDB will provide in late 2019. TWDB plans to provide a drought management impact estimating tool using same model for estimating socioeconomic impacts for the 2021 RWP.	N/A	C9
Costing Form	Added default if no pressure class added to field. Costs will not calculate without it.	G68:G127	D
Costing Form	Modified formulas to eliminate errors when Simplified Hyd Calcs sheet is blanked.	Row 59:65	D
Costing Form	Fixed reservoir unit cost calculation on costing form tab	E221	D
Costing Form	Included wellfield lines in survey costs	F233	D
Costing Form	Added option to cost Pump Station by MGD rather than HP	Row 65	D
Costing Form	Revised max diameter for directional drill to 60 IN	D141	D
Land Acquisition	Added wellfield option as part of lease, simplified or advanced ROW calcs	C12	D
Land Acquisition	Updated the TAMU link	C2	D
Project Info & Assumptions	Added lookup formula to pull in cost indices based on ENR date	F9:10	D
Simplified Hyd Calcs	Modified formulas so that velocity, head, and HP would be zero if there was not a selected diameter	Row 25	D
Well Field	Added % Time Operating at individual well level.	P15:P33	D
Well Field	Rows 36 to 39 no longer needed. Hid rows in case of need to revert back to this approach.	Row 36:39	D
Well Field	Removed "% Operating Time for x wells:" field, and moved "Minimum Pipeline Pressure (psi):" field up one row	I10:I11	D
Well Field	Changed cell name to Peak Flow (gpm)	D14	D
Well Field	Removed additional 15 psi calc on all trunk lines and use it for one segment	N27:N33	D
Conservation	Reviewed the methodology and did not revise considering the new TWDB Conservation tool to be released in late 2018. Added capital costs for Conservation strategies on Costing Form (see note on	N/A	D1

Scope	Description of Change	Changed Cells	Scope Item
	Costing Form).		
Costing Form	Added rows for conservation capital costs	Row 196:203	D1
Costing Summary	Added line for Conservation Capital Costs	Row 17	D1
Embankment Calcs	Provided description of costing on channel and off channel type reservoirs in User's Guide and applicability of the Embankment Calcs estimate and those developed on the Costing Form utilizing cost curves.	N/A	D2
Well Field	Provided figure and directions in User's Guide for using the Well Field module	N/A	D3
Pipe X - Adv Hyd Calcs (3 sheets)	Added pressure class options by segment	L:M	D4
Costing Form	Added comment field for Intake	H9	D5
Costing Summary	Changed label to allow for "Intake Pump Station" or "Primary Pump Station"	B10	D5
Workbook level	Considered how phasing of pipelines could be incorporated into the hydraulics modules but did not incorporate as it would have created some confusion. Instead opted to add discussion in User's Guide on phasing of project components (pipelines, pump stations, WTP) using the UCM.	N/A	D6
Costing Form	Show/Hide Simplified Hyd, Advanced Hyd, Well Field sections based on choices in Project Info & Assumptions	Various	D7
Costing Form	Added warning if sum of WTP capacities is under/over the project's peak flow (yield*PF)	J143	D7
Costing Form	Added warning if well field piping lengths, by diameter, do not match what's in the Well Field sheet.	J159	D7
Costing Form	Added warning if Simplified Hydraulics chosen, but there are costs in the Advanced Hyd sections	J201	D7
Costing Form	Added warning if Well Field was not indicated in Project Info & Assumptions sheet, but there are costs in the well field section	J202	D7
Costing Form	Added comment field that is unlocked to for user to provide additional detail / assumptions	Column J	D7
Costing Summary	Added warning if there are any warnings on Costing Form sheet.	D23	D7
Costing Summary	Peak Factor references maximum factor found in the hydraulics tabs	B40:43	D7
Project Info & Assumptions	Added "Simplified or Advanced Hydraulics" dropdown list. Choices are "Advanced", "Simplified", and "Simplified and Advanced". On changed selection, appropriate sheets and sections in Costing Form are	D17	D7

Scope	Description of Change	Changed Cells	Scope Item
	hidden/displayed.		
Project Info & Assumptions	Added "Number of Pipelines" dropdown list. Choices are 1, 2, 3 Only displays if "Advanced" or "Simplified and Advanced" selected in D17. Shows/hides sheets and sections in Costing Form when changed.	D18	D7
Project Info & Assumptions	Added "Does the project include a wellfield?" dropdown list. Choices are "Yes" and "No". Shows/hides Well Field sheet, and wellfield section in Costing Form.	D19	D7
Project Info & Assumptions	Added new field for date of cost estimate was prepared	D7	D7
Project Info & Assumptions	Removed Peak Factor, Average flow rate fields to minimize error	N/A	D7
Well Field	Add warning if % Time Operating for any well exceeds 100%	L5	D7
Costing Form	Used columns P:U to indicate, e.g., whether O&M was categorized as [PL, Tank, Distribution, Well], [Dam/Res], or [Intake & PS]. Based on these booleans, simplified formulas that add up costs based on categories. Old formulas hard-coded a lengthy list of cell addresses, and are tough to modify or QC.	F205:F207 F243:F245	D8
Pipe X - Adv Hyd Calcs (3 sheets)	Changed Maximum Pipeline Pressure data validation to point to named range	G13	D8
Pipe X - Adv Hyd Calcs (3 sheets)	Changed Diameter data validations to point to named ranges	D20, D23, D26, D29, D32	D8
Pipe X - Adv Hyd Calcs (3 sheets)	Implemented UDFs for computed diameter, HGL, Velocity, Energy, HP	Various	D8
Project Info & Assumptions	Changed flow conversion formulas to point to User Defined Function (UDF)	D12:D13	D8
Simplified Hyd Calcs	Implemented UDFs for units conversion, HP, computed diameter, HGL, velocity	Various	D8
Well Field	Implemented UDFs for units conversion, HP, computed diameter, HGL, velocity	Various	D8
Workbook level	Added User Defined Functions (UDFs) for units conversion, hydraulics, and energy calculations	N/A	D8
Workbook level	Changed interpolation subroutine b/c the old one didn't extrapolate and used goto's	N/A	D8
Workbook level	Reduced UCM file size	N/A	D9

APPENDIX B
Pipeline Route and Profile Generation Procedures

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Using the pipeline route selection guidelines, a route can be defined, and then a corresponding profile generated. These tasks have typically been accomplished by manual methods in the past. The manual process entails drawing a route on a topographic map, setting points that define the ground profile, and measuring the stations and recording the corresponding ground elevations. Performing these tasks, especially recording the profile data, can be very tedious and time consuming. Advancements in computer technology and the growth of Geographic Information Systems (GIS) have resulted in mapping tools that can accelerate this process significantly. The definition of GIS is as follows:

Geographic Information Systems (GIS) – an organized collection of computer hardware, software, geographic data, and personnel, designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced data.

For study planning purposes, the definition may be summarized as follows:

Geographic Information Systems (GIS) – a system for utilizing data that is linked spatially to a geographic reference.

GIS should be used to the greatest extent practical as the means for laying out a pipeline route and “capturing” the profile information because it offers increased efficiency and speed in performing these tasks. An appropriate set of tools useful in determining pipeline routes and profiles consists of the following:

ArcGIS – This is a mapping and GIS software package created by Esri¹¹. It has capabilities for creating maps, adding features (such as pipeline routes) to existing maps, and for readily integrating multiple geographically referenced databases.

Digital Elevation Model (DEM) – DEMs are files that have ground elevation data located at regularly spaced intervals in a geographic area. These files provide elevation data only.

United States Geological Survey (USGS) Topographic Maps - USGS topographic maps are available in electronic format locally through the Texas Natural Resources Information System (TNRIS).

Topologically Integrated Geographic Encoding and Referencing (TIGER) Maps - These are mapping files prepared by the United States Census Bureau. TIGER maps show many of the items that are shown on USGS topographic maps, such as rivers, lakes, roadways, railroads, and urban centers. It does not, however, provide information on ground elevation data and vegetation conditions. Data such as population counts and political boundaries may be spatially linked to the map. Though void of ground elevation data, these maps can be very useful for determining a pipeline alignment.

¹¹ <http://www.esri.com/>

Texas Department of Transportation (TxDOT) Highway Maps - County highway maps are available in electronic format.

Model Builder Profile Tool –This is a custom built tool within the ArcGIS software to extract the station, elevation, and crossing data (streams and rivers major roads, railways, etc.) along a specified route and save it to an exportable data file.

Aerial Photography – Current aerial photography, that can be accessed online or via various agencies, that are useful to determine urban development along the specified route.

Google Earth – Routes can also be delineated using Google Earth and exporting the alignment as a KML/KMZ file that can be imported into GIS software.

Note: Alternative higher resolution datasets can and should be used if readily available.

Because of the time reduction that GIS can offer in route selection and profile generation, using GIS is clearly the preferred method for technical evaluation of water management strategies considered in the regional water planning process. If there is a reason that GIS cannot be used, the manual approach previously summarized should be followed. The steps for laying out a pipeline and profile generation using GIS are as follows:

1. Consult with a GIS specialist.
2. Using the ArcGIS software, lay out a pipeline route on a topographic, current aerial photography, TIGER, or highway map that is overlaid on a corresponding DEM. Define and draw a route on the map following the route selection guidelines. If a TIGER or TxDOT map is used to layout a route, it is a good idea to check the pipeline alignment on a USGS topographic map and current aerial photography to identify potentially undesirable land features along the pipeline. For example, make sure that the route is not traversing extremely rough terrain or that it is not going over a high peak when there is relatively flat ground close by. Additionally, USGS maps may provide more details regarding features that need to be accounted for such as stream crossings along the pipeline route. Once created, the pipeline route can easily be placed on different types of map files, with the location on each being determined using latitude and longitude coordinates (i.e. geo-referenced).
3. Extract profile data using the alignment generated in step 2 and an available elevation dataset. You can use tools within the ArcGIS software to create a listing of stations with X, Y and Z data. Crossing data can then be attributed to these stations based on underlying datasets. Soil types and whether the alignment falls within developed/undeveloped areas can be associated to the stations. The station interval distance between these points should be such that the general land features are recorded while capturing points of significant elevation changes. Begin stationing at the water source for consistency. Save the profile data to an electronic file.
4. Generate a plot of the ground profile using a spreadsheet. The data saved in step three will probably have to be “delimited” so that it can be read directly into columns of a spreadsheet. The plot will have elevations on the vertical axis and stations on the horizontal axis (see Figure 1). Treat the ground profile as if it were the pipeline profile for regional planning purposes, therefore, no adjustments to the elevation data will need

to be made for pipe burial. In an actual pipeline design project the ground profile would be plotted along with a profile of the pipeline beneath the ground surface by a specified amount of ground cover.

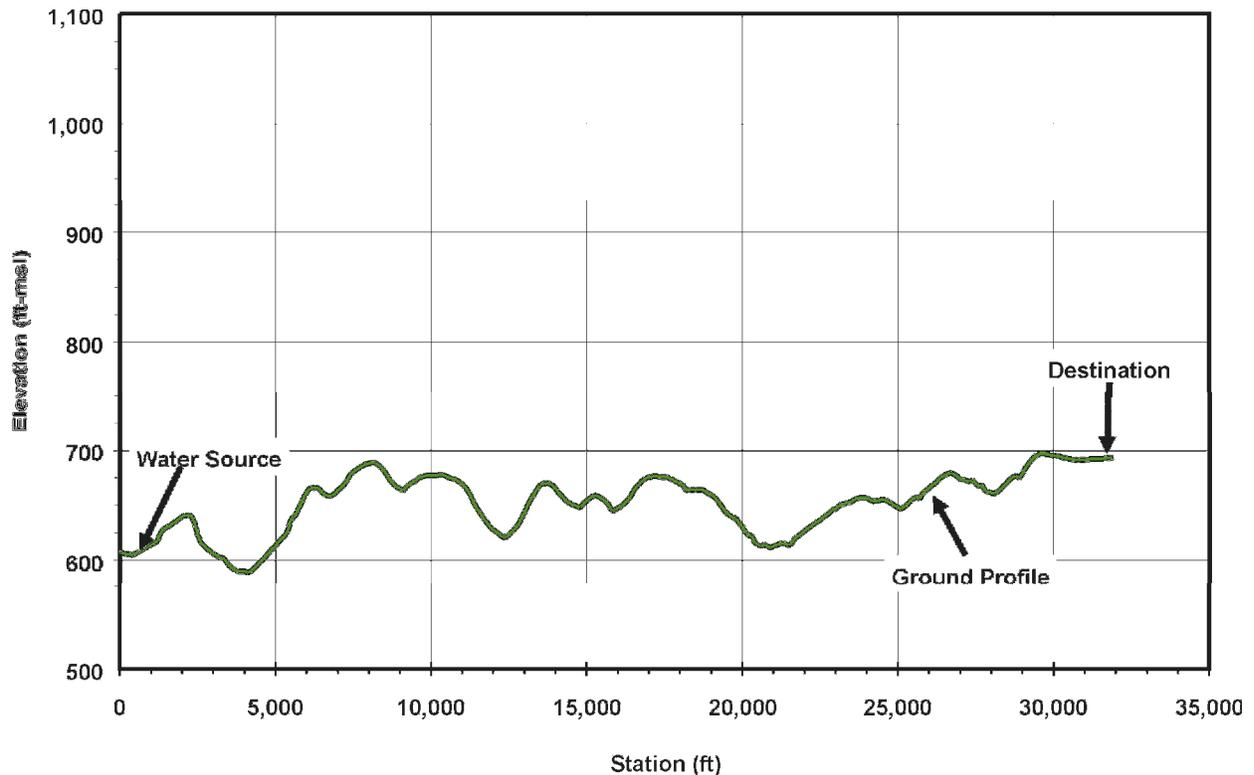


Figure 1. Typical Ground Profile Plot

Once the profile has been generated, the crossing data can be used to determine if any special installations utilizing trenchless technology construction techniques are required. Such crossings may include streams, roads, railways, and major rivers. In addition, urban/rural, land use soil conditions impacts along the route can be easily categorized. This information is needed in order to prepare the construction cost estimate and can be generated quickly for multiple routes for easy analysis.

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APPENDIX C
Unit Cost Table Development Technical Memorandum

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TO: Peter Newell, P.E.
CC: Simone Kiel, P.E.
FROM: Keeley Kirksey, P.E.
SUBJECT: Texas Water Development Board Unified Costing Model Update
DATE: May 29, 2018
PROJECT: HDR18263



INTRODUCTION

HDR Inc. and Freese and Nichols, Inc. (FNI) were retained by the Texas Water Development Board (TWDB) to update the Unified Costing Model (UCM) that was originally developed for the 2016 Regional Water Plans. The previously developed unit costs for pipelines, booster pump stations, intake pump stations, water storage tanks, water treatment plants, terminal storage reservoirs, earthen dams, ring-dikes, and groundwater wells and well fields were reevaluated by FNI based on construction costs for recent projects. The proposed new unit costs based on that review will be used by the regional water planning groups and their consultants in developing the 2021 regional water plans.

METHODOLOGY

Unit costs were indexed to December 2017 dollars and updated in Microsoft Excel using new (post 2012) historical bid tab information from HDR and FNI. The existing UCM cost curves were also adjusted to December 2017 dollars for a direct comparison with the new bid data. The new cost points were compared to the previous cost curves and the cost curves were revised as needed to create a better fit with the new data points. All unit costs include the contractors' mobilization, overhead, and profit. The unit costs do not include engineering, contingency, financial and legal services, costs for land and rights-of-way, permits, environmental and archeological studies, or mitigation. The costs for these items are determined separately in the cost tables. All of the existing UCM and proposed UCM unit costs will need to be indexed to the appropriate date as stated in the 2021 Regional Water Planning Guidelines.

Indexing Unit Costs

During the original development of the cost curves it was determined that the booster pump stations, intake pump stations, water storage tanks, water treatment plants, terminal storage reservoirs, and groundwater wells and well fields should be adjusted for changing construction prices using Engineering News-Record's (ENR) Construction Cost Index (CCI). The pipeline bid tabs were adjusted using the U.S. Bureau of Labor Statistics Producer Price Index (PPI). It was determined a separate index should be used for pipeline projects because pipeline projects are particularly dependent upon the cost of steel for steel pipe and the price of oil for plastic pipe, and the PPI seems to better reflect the changes in steel and oil prices. The use of a particular index for a specific construction type was not reevaluated as part of this update.

SPECIFIC CONSIDERATIONS FOR UNIT COST UPDATES

Pipeline Unit Costs

Cost data was available for seven new urban pipeline projects since the development of the cost curves in 2012. The new bid data was higher than previous data. Because of this, the cost curves were increased between 10 percent and 50 percent. The only original UCM cost curves increased by 50 percent were the urban, rock pipeline costs for smaller diameter pipes. The large increase for this category was because much of the new bid data was for urban, rock pipelines. Without specific bid data for the other categories, input from industry experts was used to estimate reasonable increases from the original UCM cost curves. Most of the cost curve data points for non-urban, rock pipelines were increased by between 10 and 30 percent. The current and proposed cost curves for rural pipelines is shown in **Figure 1**. No new bid data was available for rural pipelines. However, because of the large increases to urban pipeline bid data, it was assumed that rural pipeline costs have also increased since the development of the original UCM. The new bid data for urban pipelines is plotted against the current UCM unit costs and the proposed revised unit costs in **Figure 2**. The inflection point shown in Figures 1 and 2 at the 78-inch diameter point is based on historical experience and input from experts at FNI.

Figure 1. Bid Data and Cost Curves for Rural Pipelines (December 2017 Dollars)

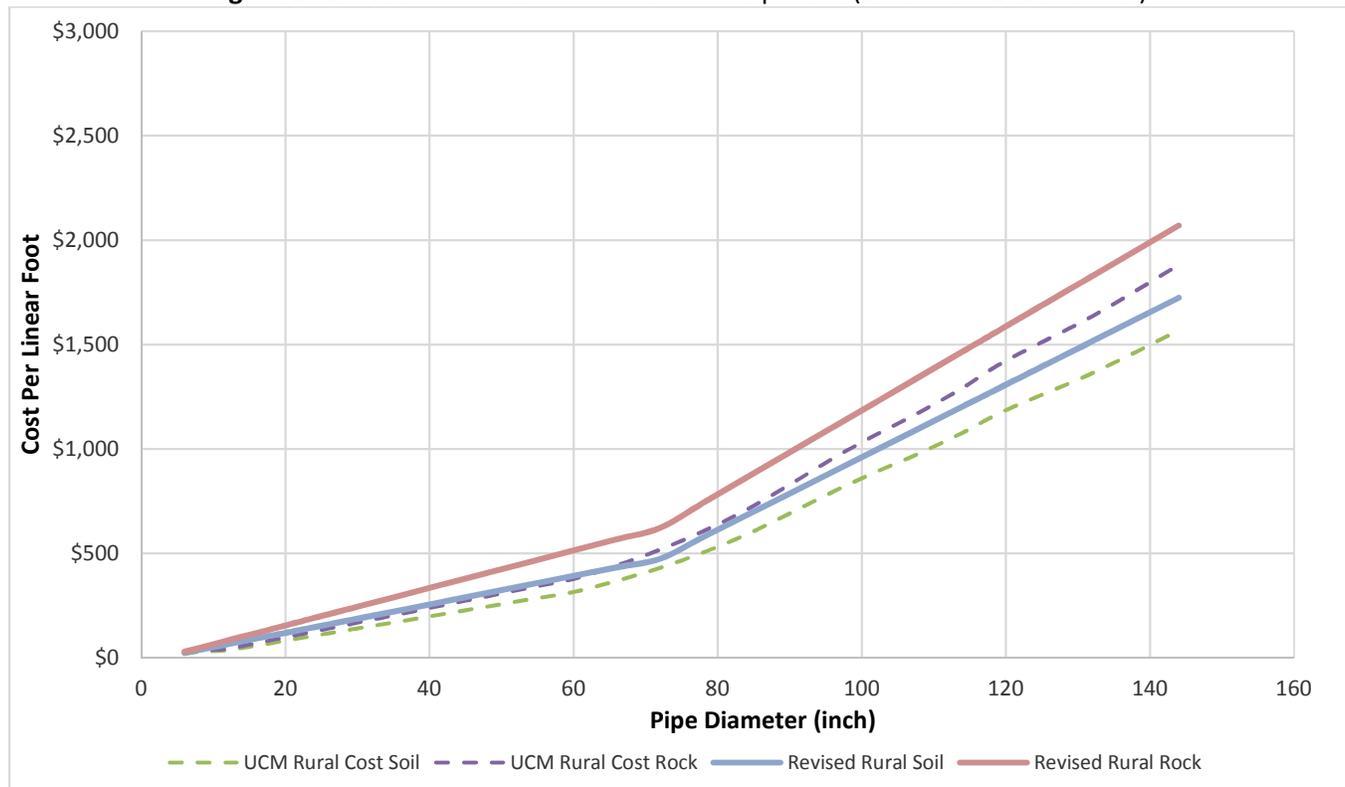


Figure 2. Bid Data and Cost Curves for Urban Pipelines (December 2017 Dollars)

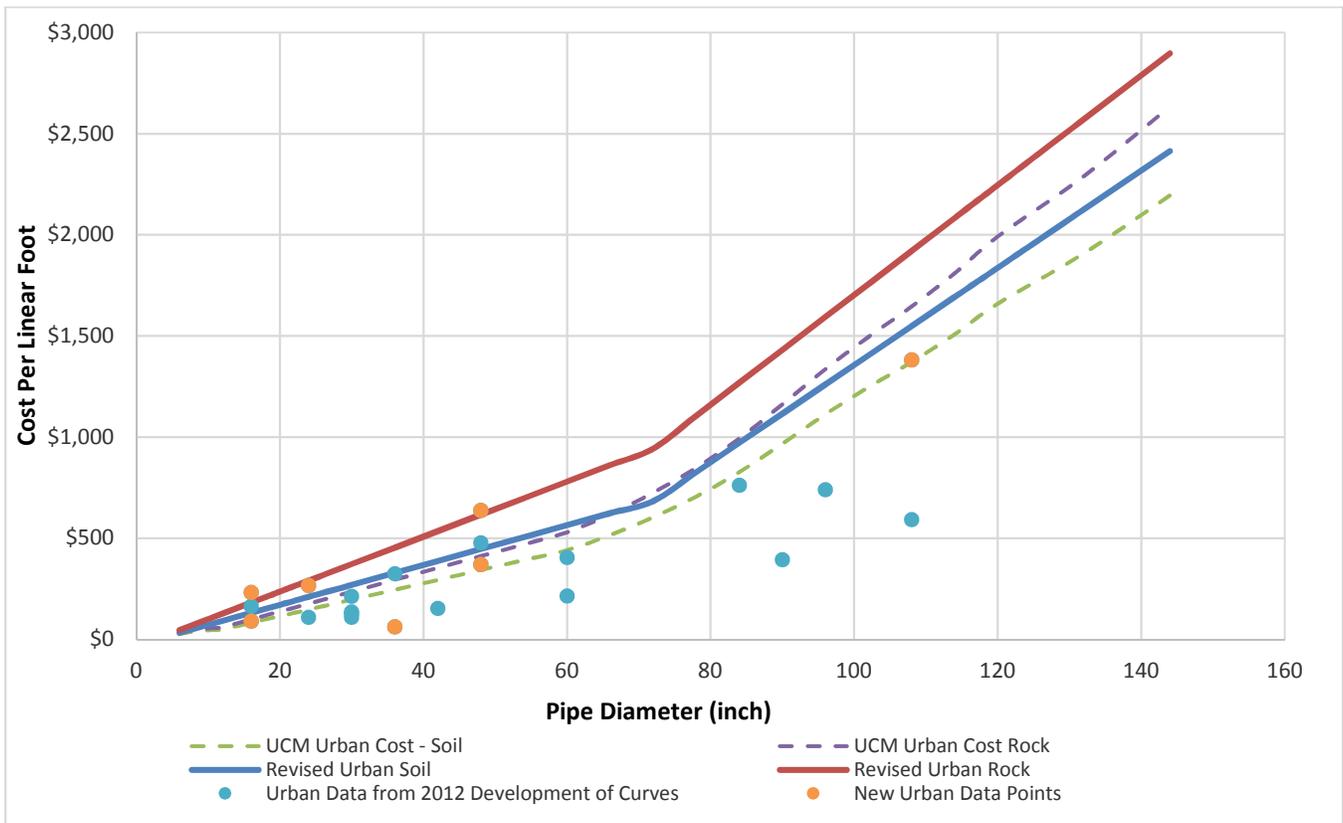


Table 1. Proposed Unit Costs for Pipelines (Does not include right-of-way)

Diameter	Rural Cost with Appurtenances - Soil	Rural Cost with Appurtenances - Rock	Urban Cost with Appurtenances - Soil	Urban Cost with Appurtenances - Rock
(inches)	(\$/Foot)	(\$/Foot)	(\$/Foot)	(\$/Foot)
6	\$24	\$30	\$34	\$47
8	\$38	\$48	\$53	\$74
10	\$52	\$66	\$73	\$101
12	\$65	\$83	\$93	\$128
14	\$79	\$101	\$112	\$155
16	\$92	\$119	\$132	\$183
18	\$106	\$137	\$152	\$210
20	\$120	\$155	\$172	\$237
24	\$147	\$191	\$211	\$291
30	\$188	\$245	\$270	\$373
36	\$229	\$299	\$329	\$454
42	\$270	\$353	\$388	\$536
48	\$311	\$407	\$447	\$617
54	\$352	\$460	\$506	\$699
60	\$393	\$514	\$565	\$780
66	\$433	\$568	\$625	\$862
72	\$474	\$622	\$684	\$943
78	\$579	\$743	\$828	\$1,106
84	\$683	\$863	\$972	\$1,269
90	\$787	\$984	\$1,116	\$1,432
96	\$891	\$1,105	\$1,260	\$1,595
102	\$995	\$1,225	\$1,405	\$1,758
108	\$1,099	\$1,346	\$1,549	\$1,920
114	\$1,203	\$1,467	\$1,693	\$2,083
120	\$1,308	\$1,587	\$1,837	\$2,246
132	\$1,516	\$1,828	\$2,126	\$2,572
144	\$1,724	\$2,070	\$2,414	\$2,898

Pump Station Unit Costs

In the original UCM intake and booster pump station costs were developed based on horsepower. It is now recommended that the costs for pump stations based on both horsepower and capacity should be included in the costing tool. A second table has been developed based on capacity and cost and it is recommended that the UCM be updated to use the higher cost from either the capacity table or the horsepower table for the corresponding capacity and horsepower associated with a pump station.

The intake pump station costs listed in can be used for reservoir or river intake pump station costs. These costs for intake pump stations include the intake structure (a unique structure that reaches out into the water) and the pump station facilities. Booster pump stations/high service pump stations are those located along a water transmission system. Costs for booster pump stations include only the pump station facilities. There were 11 new (post 2012) intake and booster pump station bids available for the updates to costs as a function of horsepower. Because capacity had not been considered previously, all available bid data was used for the development of the cost curves as a function of pump station capacity. For the development of the capacity-based cost curves, 39 bids were available for booster pump stations and 13 bids were available for intake pump stations.

Table 2. Unit Costs for Booster and Reservoir Intake Pump Stations Based on Horsepower

Horsepower	Booster Pump Station Costs (Millions)	Intake Pump Station Costs (Millions)
5	\$0.71	\$2.68
10	\$0.78	\$2.76
20	\$0.82	\$2.92
25	\$0.86	\$3.00
50	\$0.90	\$3.40
100	\$0.94	\$4.20
200	\$1.25	\$5.80
300	\$1.85	\$7.40
400	\$2.44	\$9.00
500	\$3.04	\$10.60
600	\$3.62	\$12.20
700	\$4.21	\$13.80
800	\$4.79	\$15.40
900	\$5.36	\$17.00
1,000	\$5.94	\$18.60
2,000	\$11.44	\$34.60
3,000	\$16.54	\$36.10
4,000	\$23.14	\$37.29
5,000	\$29.75	\$38.48
6,000	\$31.07	\$40.00
7,000	\$32.07	\$41.18
8,000	\$33.22	\$42.36
9,000	\$34.38	\$43.54
10,000	\$35.54	\$44.72
20,000	\$47.12	\$56.52
30,000	\$58.69	\$68.31
40,000	\$70.27	\$80.11
50,000	\$81.85	\$91.91
60,000	\$93.42	\$103.70
70,000	\$105.00	\$115.50

Figure 3. Bid Data and Cost Curves for Booster and Intake Pump Stations

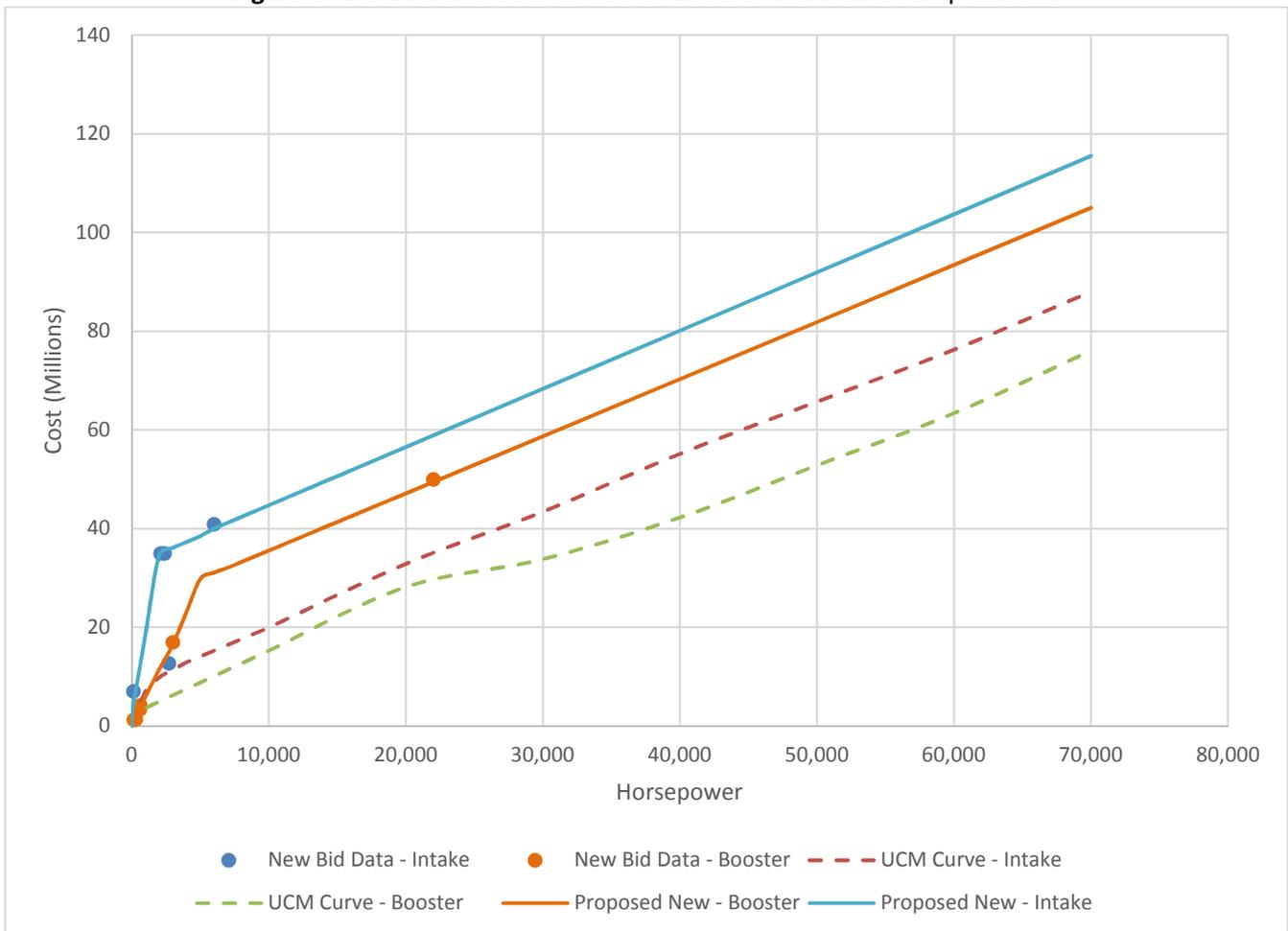
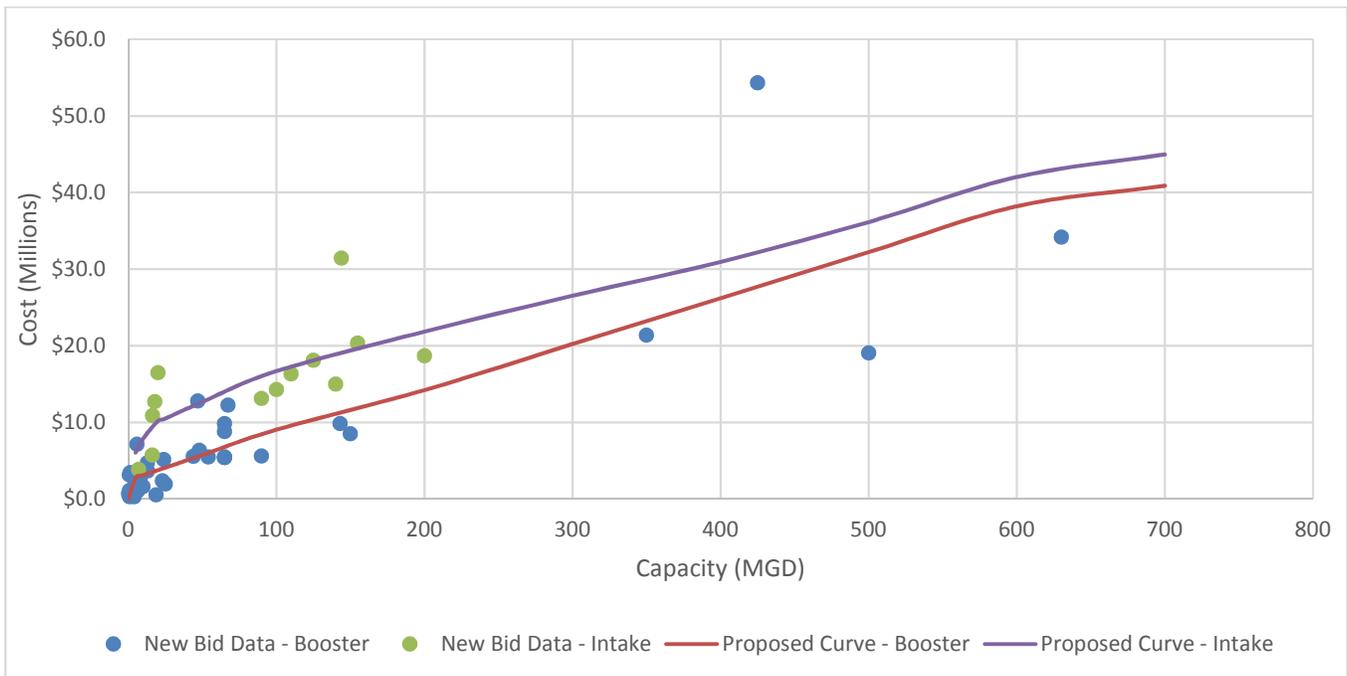


Table 3. Unit Costs for Booster and Reservoir Intake Pump Stations Based on Capacity

Capacity (MGD)	Booster Pump Station Costs (Millions)	Intake Pump Station Costs (Millions)
5	\$2.76	\$6.05
10	\$3.09	\$7.85
20	\$3.75	\$10.17
25	\$4.08	\$10.50
50	\$5.73	\$12.66
100	\$9.03	\$16.68
200	\$14.21	\$21.84
300	\$20.21	\$26.53
400	\$26.21	\$30.96
500	\$32.21	\$36.15
600	\$38.21	\$42.03
700	\$40.88	\$44.97

Figure 4. Bid Data and Cost Curves for Booster and Intake Pump Stations



Tank Unit Costs

Post 2012 bid data was available for eight elevated storage tanks and 14 ground storage tanks (one of which did not have a roof). The cost curves for the elevated and ground storage tanks were increased based on the new bid data. The current UCM costs are plotted against the new bid data and the proposed revised cost curves in **Figures 5 and 6.**

Figure 5. Cost Curve and Bid Data for Elevated Storage Tanks

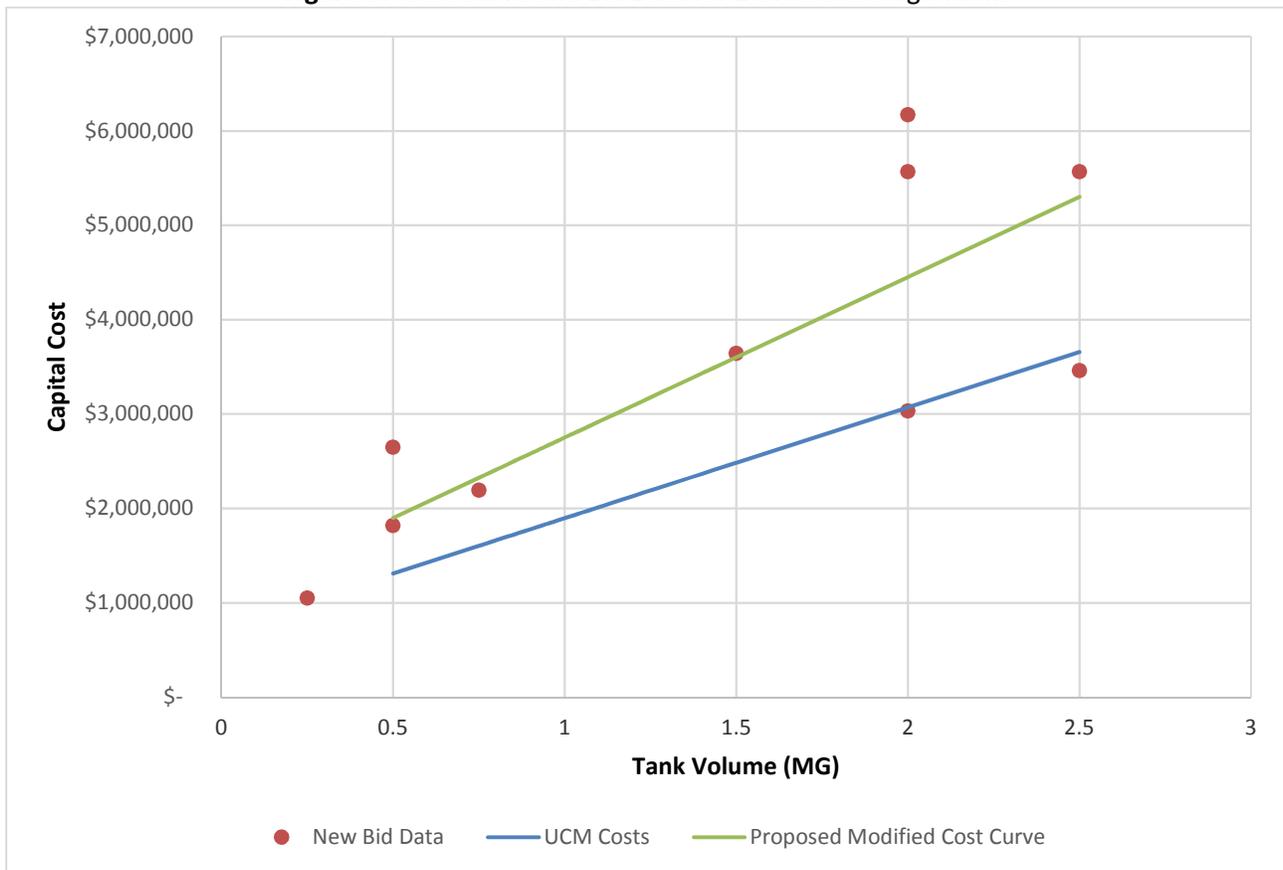


Table 4. Elevated Storage Tank Unit Costs (December 2017)

Size (MG)	Cost
0.5	\$1,900,000
0.75	\$2,325,000
1	\$2,751,000
1.5	\$3,601,000
2	\$4,452,000
2.5	\$5,302,000

Figure 6. Cost Curve and Bid Data for Ground Storage Tanks

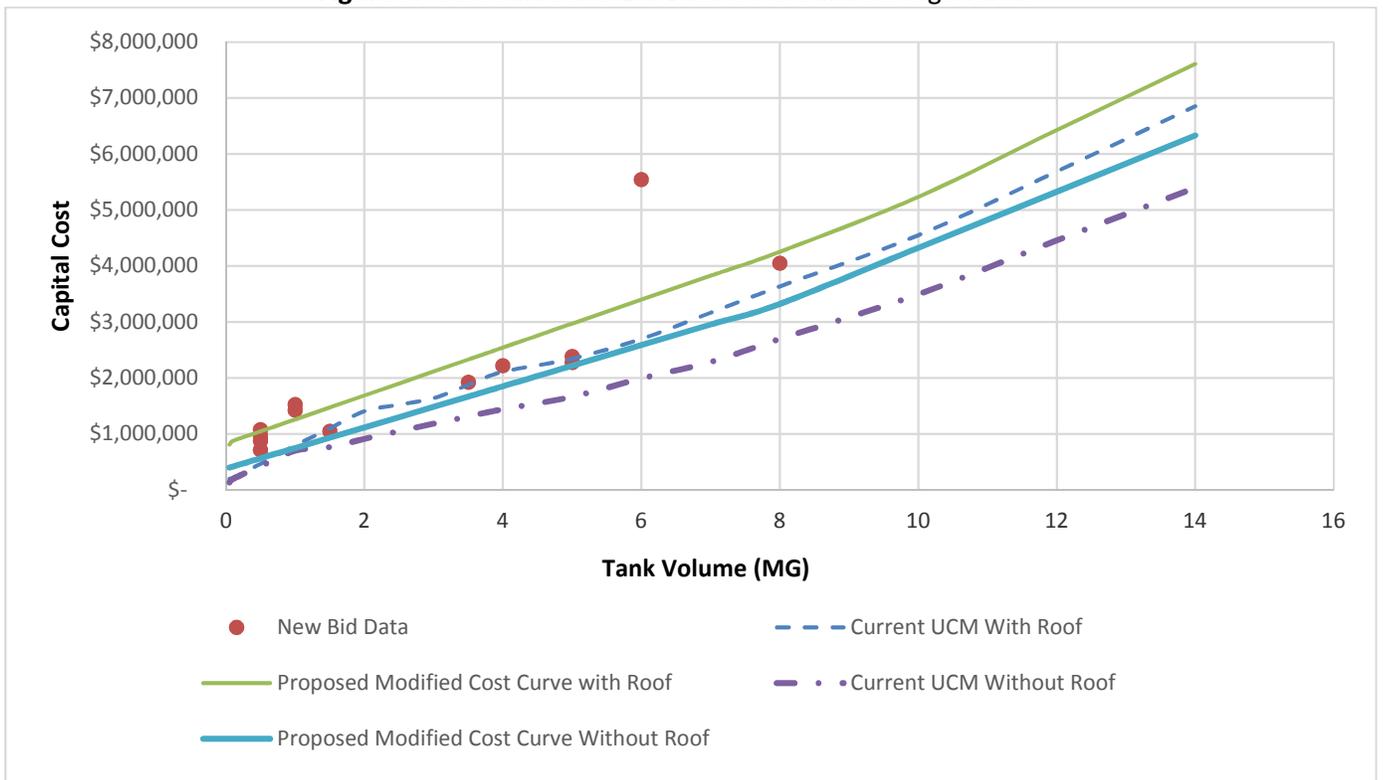


Table 5. Ground Storage Tank Unit Costs (December 2017)

Size (MG)	With Roof	Without Roof
0.05	\$811,800	\$402,400
0.1	\$877,500	\$420,800
0.5	\$1,048,600	\$567,800
1	\$1,262,300	\$751,500
1.5	\$1,476,100	\$935,200
2	\$1,689,900	\$1,119,000
2.5	\$1,903,600	\$1,302,700
3	\$2,117,400	\$1,486,500
3.5	\$2,331,200	\$1,670,200
4	\$2,544,900	\$1,853,900
5	\$2,972,500	\$2,221,400
6	\$3,400,000	\$2,588,900
7	\$3,827,600	\$2,956,400
8	\$4,255,100	\$3,323,900
10	\$5,233,400	\$4,326,300
12	\$6,427,900	\$5,328,700
14	\$7,607,600	\$6,331,200

Water Treatment Plant (WTP) Unit Costs

Based on a review by experts in the water treatment field at FNI, it is recommended that the unit costs currently in the UCM be increased by 10 percent. This is because it has been observed that treatment plant construction costs have increased faster than inflation in the last several years.

Table 6. Unit Costs (in millions) for Water Treatment Plants (December 2017 Dollars)

Capacity (MGD)	New Level 0	New Level 1	New Level 2	New Level 3	Expansion Level 3	New Level 4 ¹	New Level 5
0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
0.1	\$0.02	\$0.28	\$1.29	\$1.72	\$1.72	\$1.22	\$2.76
1	\$0.09	\$1.13	\$4.52	\$6.07	\$6.07	\$4.87	\$18.45
10	\$0.55	\$4.69	\$23.87	\$41.30	\$23.23	\$32.91	\$123
50	\$2.76	\$13.63	\$90.33	\$169.80	\$83.88	\$125	\$466
75	\$4.14	\$19.66	\$132	\$250	\$133	\$175	\$652
100	\$5.52	\$24.09	\$174	\$328	\$162	\$222	\$826
150	\$8.28	\$36.86	\$257	\$482	\$242	\$311	\$1,155
200	\$11.04	\$42.45	\$341	\$634	\$299	\$395	\$1,464

¹ The interpolate function associated with these costs as a function of the TDS of the treated water should be maintained as it is in the current UCM.

WTP Operation and Maintenance (O&M)

Several changes to the O&M costs are recommended as follows:

Level 0 and 1 – No recommended changes.

Level 2 – Recommended calculation is changed to match the same percent of construction as Level 3 (10 percent of capital costs) for plants between 0 MGD and 1 MGD. O&M for plants greater than 1 MGD is recommended as 7 percent of the capital cost. There is no reason that the Level 2 O&M costs would be higher than Level 3.

Level 3 (New) and Level 3 (Exp) – The percent for capacities of 10 MGD and greater was changed to 7 percent to reflect an economy of scale for larger plants with diminishing staffing requirements per treatment capacity and a lower equipment maintenance as a percentage of the cost for larger plants because there is more capital cost in low maintenance construction like concrete basins. The percent of O&M for plants with capacities of less than 10 MGD was left at 10 percent of the capital cost.

Level 4 – Keep the O&M at 20 percent for all capacities to reflect much of the O&M cost which is power usage that scales linearly with capacity.

Level 5 – Recommend a change to 15 percent of capital cost for all capacities to reflect much of the O&M cost which is power usage. This large change is to account for the fact that the current UCM used an inflated O&M cost for seawater desalination that does not reflect market conditions.

Well Unit Costs

Three new well bids were available. When compared to the current costs in the UCM, two of the three costs are within 10 percent of the UCM unit costs. One cost was six percent higher than the current UCM estimate and one cost was nine percent lower than the current UCM estimate. Because of this and the limited number of

new costs available, no changes are recommended to the existing unit costs for public water supply wells. Two well drillers were contacted to obtain information on unit costs for shallow wells (less than 100 feet in depth). After a phone call and follow-up email, no responses were received. Two cost data points were obtained from planning level projects. Costs were developed for wells less than 100 feet in depth based on these estimates. These costs are shown in **Table 7**.

Table 7. Public Water Supply Well Costs

Well Depth (Feet)	Well Capacity (gpm)		
	100	175	350
50	\$85,870	\$109,110	\$140,780

No new bid data for irrigation well costs were available. It is recommended that the current UCM costs continue to be used.

No new bid data was available for ASR wells since the original development of the UCM, therefore no changes are recommended to the unit costs for ASR wells.

Dam, Large Ring Dikes, and Terminal Storage Unit Costs

Based on several OPCCs and a review of the current costs by several experts at FNI, no changes are recommended to the current unit costs for dams, large ring dikes, and terminal storage reservoirs.

Drought Management Water Management Strategy (WMS) Costs

Drought Management Water Management Strategy costs depend on numerous factors and are highly Water User Group (WUG) specific. For this reason, it is not recommended that drought management costs be included in the UCM. Rather, a list of items to consider when developing Drought Management WMSs and general guidance should be developed and included in the Unified Costing Tool User's Manual. This will allow regions to develop WUG and Region-specific costs.

Reservoir Land Acquisition Costs

The current methodology in the UCM for determining reservoir land acquisition costs appears to be appropriate based on current market trends. No changes to this current methodology are recommended.

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APPENDIX D
Drought Management Methodology
(Excerpt from the 2016 South Central Texas Regional Water Plan)

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5.2.2 Drought Management

5.2.2.1 Description of Water Management Strategy

Texas Administrative Code (TAC), Chapter 357 Regional Water Planning Guidelines, states that “Regional water plan development shall include an evaluation of all water management strategies the regional water planning group determines to be potentially feasible, including drought management measures including water demand management [357.7(a)(7)(B)].” As defined here, drought management means the periodic activation of approved drought contingency plans resulting in short-term demand reduction and/or rationing. This reduction in demand is then considered a “supply” source. Using this approach, an entity may make the conscious decision not to develop firm water supplies greater than or equal to projected water demands with the understanding that demands will have to be reduced or go unmet during times of drought. Using this rationale, an economic impact of not meeting projected water demands can be estimated and compared with the costs of other potentially feasible water management strategies in terms of annual unit costs.

Figure 5.2.2-1 shows how water supply planning was done in the 2007 State Water Plan and 2006 Regional Water Plans. For each Water User Group (WUG) with an identified shortage or need during the planning period, a future water supply plan was developed consisting of one or more water management strategies. In each case, the planned future water supply was greater than the projected dry weather demand to allow for drought more severe than the drought of record, uncertainty in water demand projections, and/or available supply from recommended water management strategies. This difference between planned water supply and projected dry weather demand is called management supply in Region L.

Figure 5.2.2-2 illustrates how a drought management water management strategy (WMS) could alter the planning paradigm for WUGs with projected needs. Instead of identifying water management strategies to meet the projected need, planned water supply remains below the projected dry weather water demand. The difference between these two lines represents the drought management WMS. Under this concept, a WUG’s water demand would be reduced by activating a drought contingency plan to reduce demands, resulting in unmet needs. This strategy of demand reduction or water rationing could negate the need for water management strategies to meet the full projected need of the WUG. Basically, using this approach, the WUG is planning to manage water shortages through drought contingency plan activation or water rationing if needed. This concept is more fully illustrated in Figure 5.2.2-3, which shows that, in any given year, the actual demand may be above or below the planned supply. During times in which the demand exceeds supply, the WUG would experience shortages and incur associated economic impacts.

Figure 5.2.2-1. Typical Planning in 2011 Regional Water

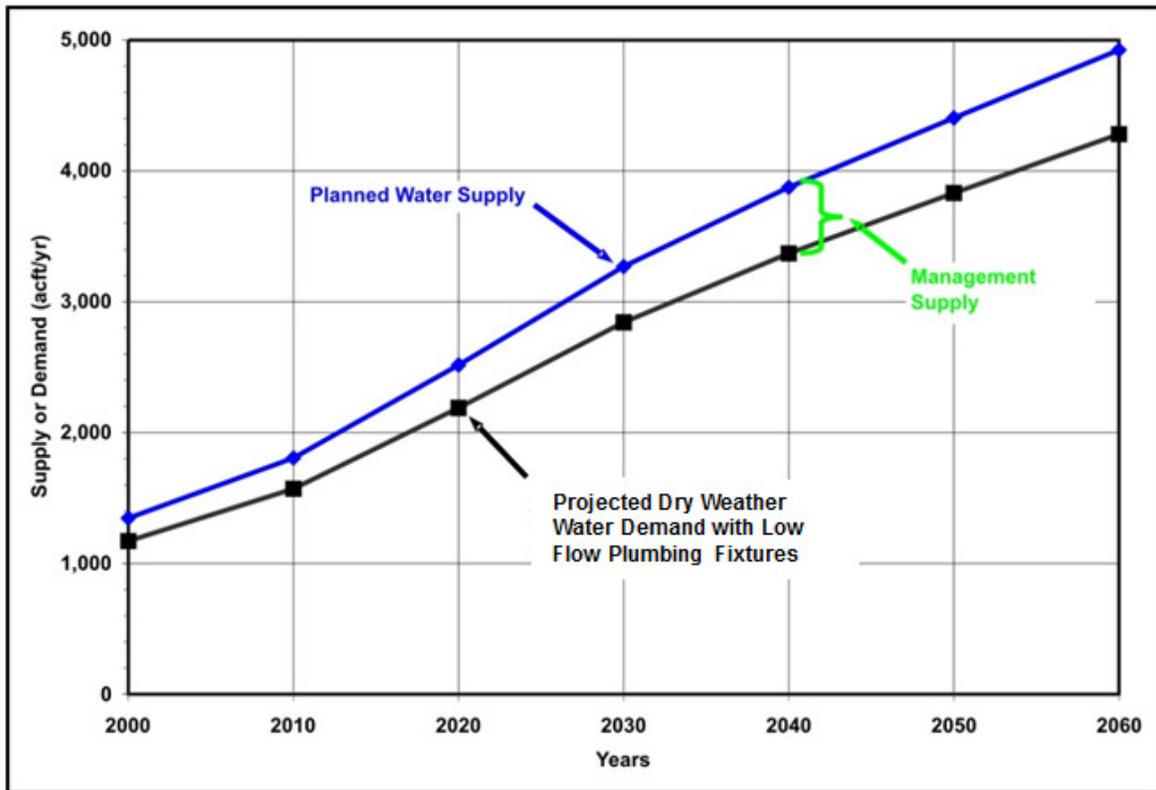


Figure 5.2.2-2. Planning with Drought Management Water Management Strategy

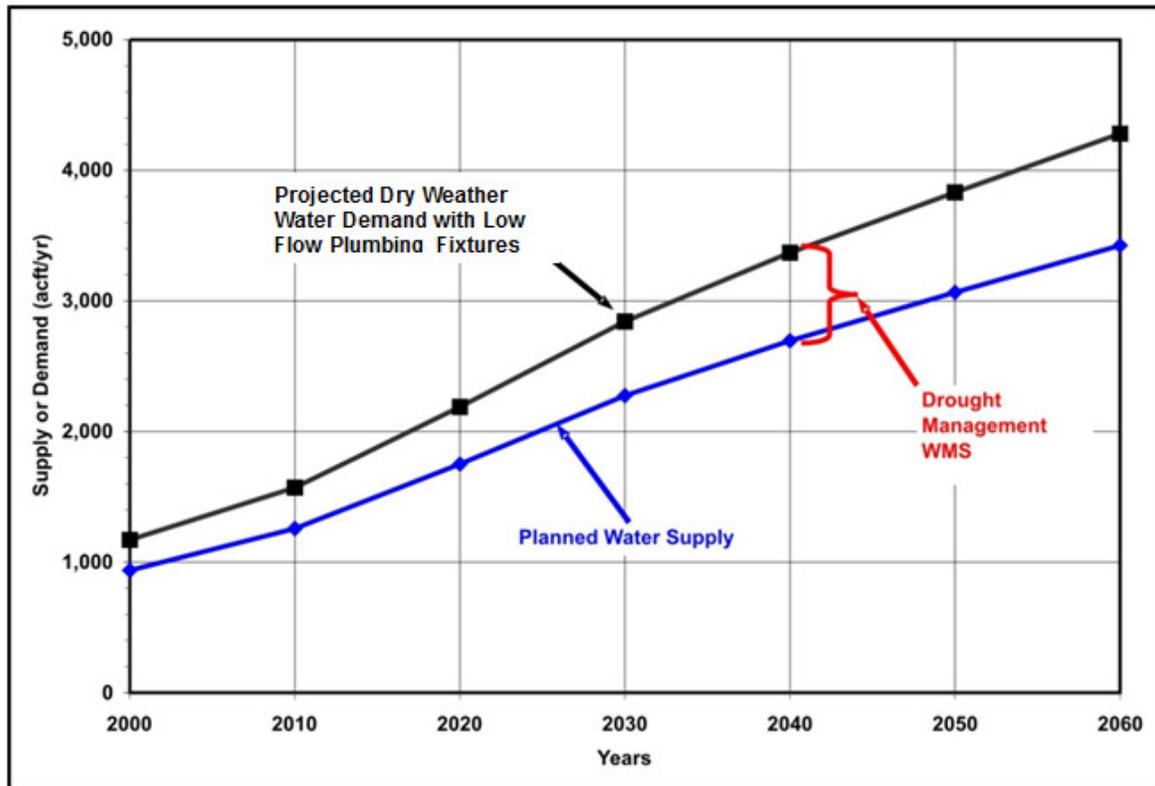
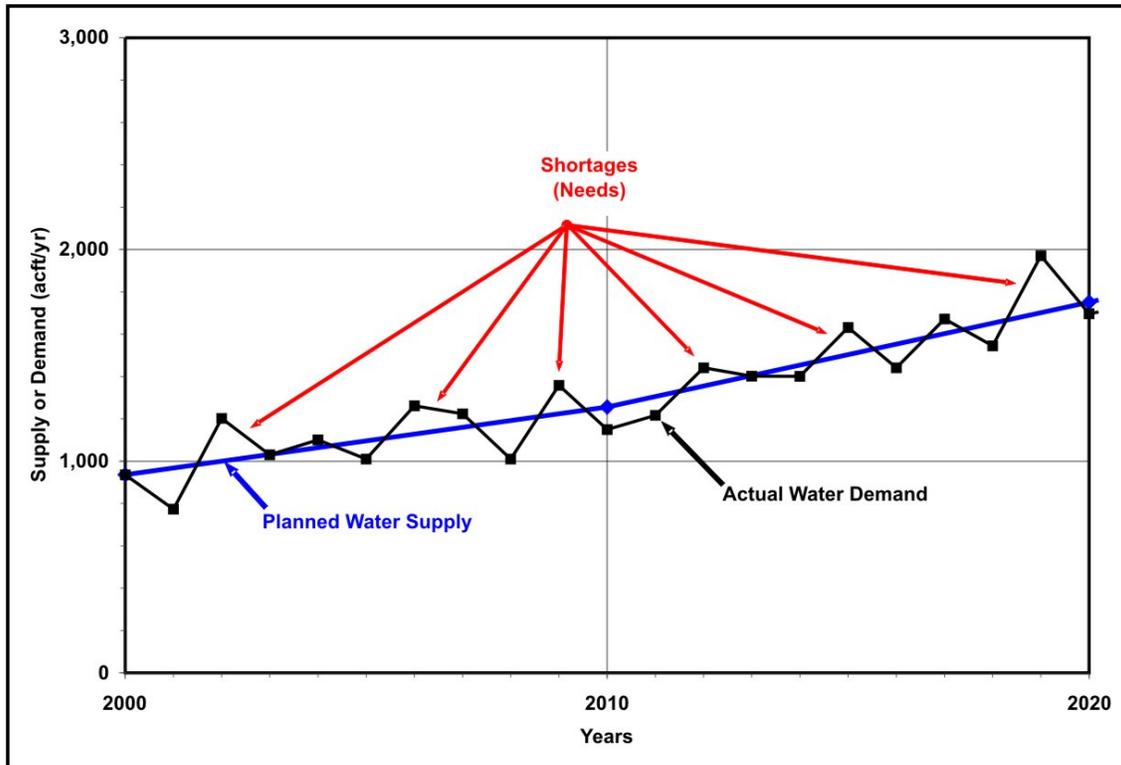


Figure 5.2.2-3. Example Drought Management Water Management Strategy



5.2.2.2 Drought Management Strategy Methodology

As shown in Figure 5.2.2-4, there are a number of incremental steps to calculating a unit cost for this strategy so that it can be compared to other strategies. The first step in the process is to calculate a risk factor for the 5% reduction, 10% reduction, 15% reduction, and 20% reduction cases. Figure 5.2.2-5 illustrates the 5% reduction scenario. The risk factor is defined as the integrated chance of occurrence of potential annual demands in excess of planned supply based on historical per capita variations for each entity. A 5% Drought Management WMS, for example, equates to planned supply that is 95% of projected demand.

The first step in determining the risk factors was to obtain historical annual per capita water use values. These data were obtained from the TWDB for the period 1964 to 2011, if available. From these data, a 5-year moving per capita water use average was calculated in order to limit the effects of trends in per capita water use rates. Next, an annual percentage above or below the 5-year moving average was calculated. These values were then ranked lowest to highest. A frequency curve was then developed using these data with the percentage above or below the 5-year moving average on the y-axis and the percentage of years less than or equal to that value on the x-axis. Finally, this curve was translated so that the year 2011 value was placed at 0 on the y-axis (Figure 5.2.2-5) because year 2011 was used by the TWDB as the basis for demand projections in the 2016 regional water plans.

Figure 5.2.2-4. Methodology Flowchart

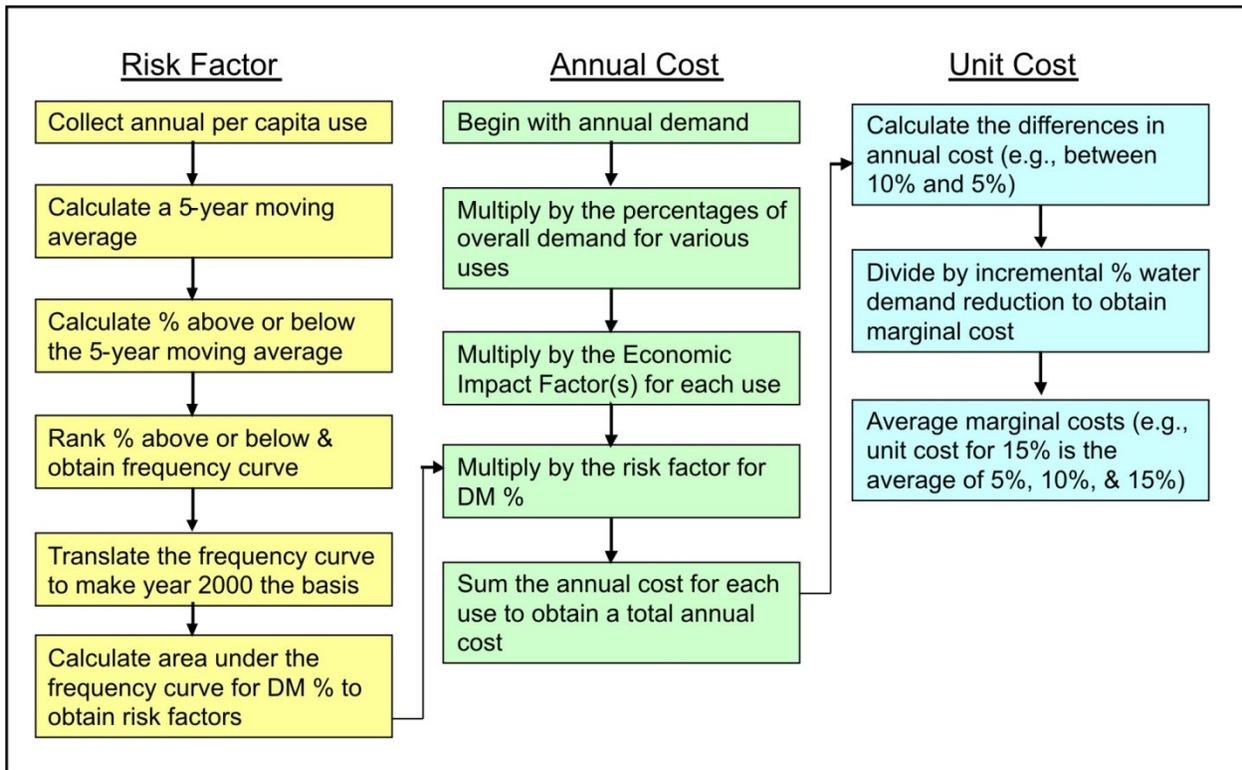
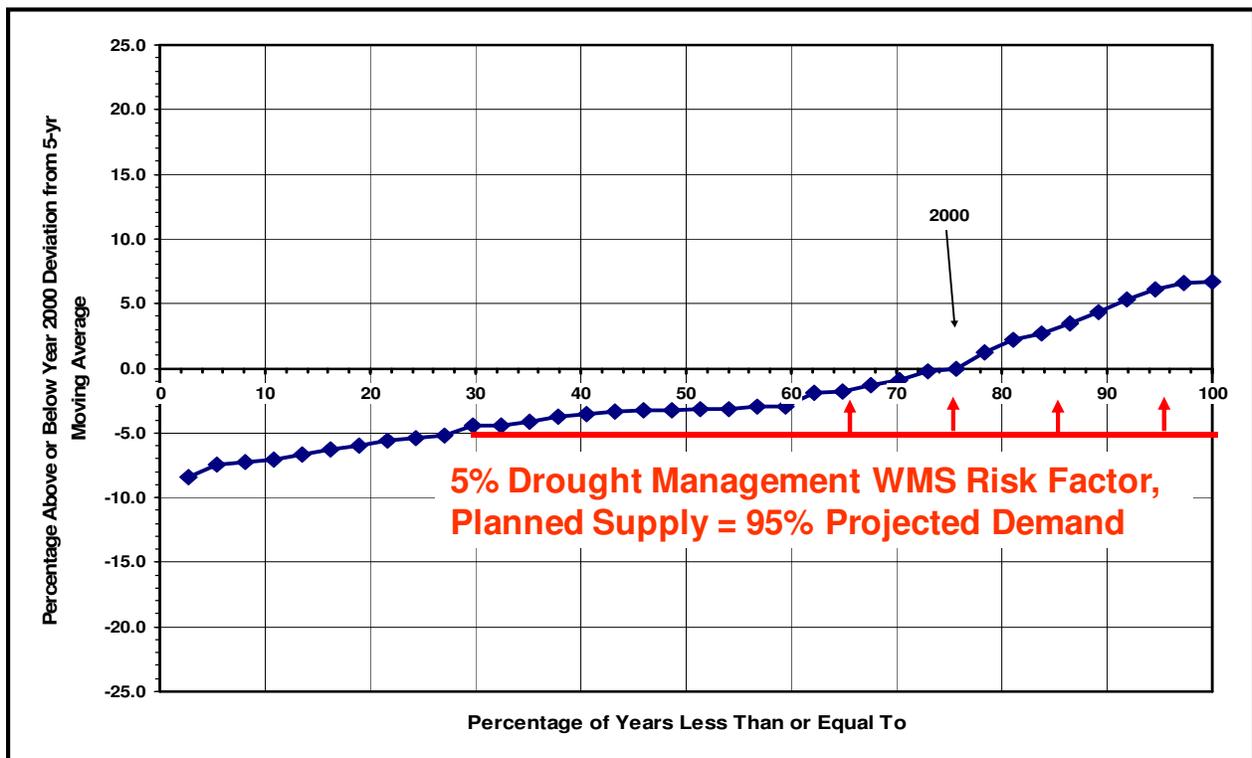


Figure 5.2.2-5. Frequency of Per Capita Water Use Variations



From a plot like Figure 5.2.2-5, the integrated area under the frequency curve was calculated as the risk factor. Using formulas developed in Excel, a chart of risk factors was developed for each WUG for each half percent reduction in water use. Using data supplied by the TWDB which shows the percent of water use for each WUG that is considered to be residential/domestic, the percent reduction in this use type was determined for each of the determined drought management levels (5%, 10%, 15%, and 20%). In other words, reductions in use were focused on residential use first. In this case, all reductions in residential use are attributed to outdoor water use and no reductions in indoor residential water use were assumed to occur. For example, a 10% reduction in overall water use for a WUG may reflect a 12% reduction in residential water use, depending on the amount of water used for other purposes.

Using the chart developed above, the risk factor associated with a 12% reduction in use (10% overall) was determined. If an overall 20% reduction in water use could be obtained without exceeding a 25% reduction in residential use, the use for other water users was not affected. If however, for certain WUGs (Lockhart, Leon Valley, Kirby, Carrizo Springs, Kennedy, Castroville, La Coste, Uvalde and Victoria) this was not the case. For these WUG, residential water use was reduced by 25% with the remaining reduction being split evenly between commercial and industrial use.

After risk factors for each scenario were calculated, an annual cost was then calculated using the following formula:

$$(\text{Demand}) \times (\% \text{Demand}) \times (\text{Risk Factor}) \times (\$ \text{ Impact Factor}) = \text{DM WMS Annual Cost}$$

where:

- Demand (acft/yr) = Projected “dry year” demand from TWDB based on year 2000 per capita use rate (projected demand in year 2010 was used);
- % Demand = Proportion of water demand associated with various use types (i.e., residential, commercial, and manufacturing);
- Risk Factor = Integrated chance of occurrence of potential annual demands in excess of planned supply based on historical per capita use variations for each entity;
- \$ Impact Factor (\$/acft) = Economic impact factors used by TWDB (see Table 5.2.2-1) to calculate economic impacts of not meeting needs. TWDB factors used include (a) lost sales for water-intensive commercial users; (b) costs to non-water-intensive commercial businesses and households; and (c) lost sales for manufacturing; and
- DM WMS Annual Cost (\$/yr) = Typical annual economic impacts of adhering to the Drought Management WMS for that water use type. The annual cost for each use type (i.e., domestic, commercial, and manufacturing) were then summed to obtain a total annual cost.

Table 5.2.2-1. Texas Water Development Board Economic Impact Factors

WUG	COUNTY	RESIDENTIAL/DOMESTIC										INDOOR			NON RESIDENTIAL			DISTRIBUTION BY CATEGORY		
		OUTDOOR					% OF TOTAL HOUSEHOLD MONTHLY USE RESTRICTED					COMMERCIAL	INDUSTRIAL (UTILITY SERVICED)	COMMERCIAL (%)	INDUSTRIAL (UTILITY SERVICED)	DOMESTIC %	COMMERCIAL (%)	INDUSTRIAL (UTILITY SERVICED)		
		5%	10%	20%	30%	40%	50%	60%	70%	80%	>90%									
ALAMO HEIGHTS	BEAR	\$994	\$1,112	\$1,393	\$2,300	\$6,242	\$7,603	\$9,666	\$13,090	\$19,937	\$25,996	\$51,494	\$0	\$0	85%	15%	0%			
ASHERTON	DIMMIT	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$24,613	\$0	\$0	79%	21%	0%			
ATASCOSA RURAL W/SC	BEAR	\$994	\$1,112	\$1,393	\$2,300	\$6,242	\$7,603	\$9,666	\$13,090	\$19,937	\$25,996	\$37,778	\$0	\$0	100%	0%	0%			
CARRIZO SPRINGS	DIMMIT	\$994	\$1,112	\$1,393	\$2,300	\$6,242	\$7,603	\$9,666	\$13,090	\$19,937	\$25,996	\$24,613	\$0	\$0	74%	26%	0%			
CASTROVILLE	MEDINA	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$36,223	\$58,320	\$0	70%	30%	0%			
CIBOLO	GUADALUPE	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$36,223	\$58,320	\$0	88%	12%	0%			
CONVERSE	BEAR	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$12,571	\$163,480	\$0	88%	10%	2%			
GARDEN RIDGE	COMAL	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$14,774	\$0	100%	0%	0%				
GREEN VALLEY SUD	GUADALUPE	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$12,571	\$163,480	\$0	91%	7%	2%			
HONDO	MEDINA	\$994	\$1,112	\$1,393	\$2,300	\$6,242	\$7,603	\$9,666	\$13,090	\$19,937	\$25,996	\$74,909	\$437,400	\$0	82%	15%	3%			
KARNES CITY	KARNES	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$70,135	\$0	95%	5%	0%				
KENNEDY	KARNES	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$24,613	\$0	70%	30%	0%				
KIRBY	BEAR	\$994	\$1,112	\$1,393	\$2,300	\$6,242	\$7,603	\$9,666	\$13,090	\$19,937	\$25,996	\$35,370	\$0	60%	40%	0%				
LACOSTE	MEDINA	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$14,494	\$0	73%	27%	0%				
LEON VALLEY	BEAR	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$46,440	\$0	73%	27%	0%				
LOCKHART	CALDWELL	\$994	\$1,112	\$1,393	\$2,300	\$6,242	\$7,603	\$9,666	\$13,090	\$19,937	\$25,996	\$38,048	\$0	61%	39%	0%				
LYTLE	ATASCOSA	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$47,725	\$0	78%	22%	0%				
MARTINDALE	CALDWELL	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$8,176	\$0	80%	20%	0%				
MOUNTAIN CITY	HAYS	\$994	\$1,112	\$1,393	\$2,300	\$6,242	\$7,603	\$9,666	\$13,090	\$19,937	\$25,996	\$35,370	\$0	100%	0%	0%				
NATALIA	MEDINA	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$24,613	\$0	90%	10%	0%				
NIEDERWALD	CALDWELL	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$36,145	\$0	90%	10%	0%				
SABINAL	UVALDE	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$39,269	\$0	99%	1%	0%				
SAN ANTONIO (SAWS)	BEAR	\$886	\$983	\$1,199	\$1,836	\$4,525	\$5,519	\$7,020	\$9,526	\$14,537	\$25,996	\$93,182	\$290,347	\$0	77%	20%	3%			
SHAVANO PARK	BEAR	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$43,405	\$0	100%	0%	0%				
UNIVERSAL CITY	BEAR	\$994	\$1,112	\$1,393	\$2,300	\$6,242	\$7,603	\$9,666	\$13,090	\$19,937	\$25,996	\$68,148	\$0	86%	14%	0%				
UVALDE	UVALDE	\$994	\$1,112	\$1,393	\$2,300	\$6,242	\$7,603	\$9,666	\$13,090	\$19,937	\$25,996	\$56,290	\$0	65%	35%	0%				
VICTORIA	VICTORIA	\$994	\$1,112	\$1,393	\$2,300	\$6,242	\$7,603	\$9,666	\$13,090	\$19,937	\$25,996	\$39,269	\$0	76%	24%	0%				
WINDCREST	BEAR	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$39,269	\$0	85%	15%	0%				
YANCEY W/SC	MEDINA	\$1,156	\$1,328	\$1,706	\$3,132	\$9,731	\$11,848	\$15,023	\$20,304	\$25,996	\$25,996	\$14,494	\$0	97%	3%	0%				



The final step in this process was to convert the annual cost to a unit cost so that this strategy could be compared to other potentially feasible water management strategies. In order to do this, the difference between the annual cost for each scenario were first calculated (i.e., between 10% and 5%). This value was then divided by a 5% water demand reduction from the year 2010 demand to obtain a marginal cost. Finally, the marginal cost values were averaged to obtain a unit cost (i.e., the unit cost for 15% is the average of 5%, 10%, and 15%).

An example cost calculation for the City of Uvalde is provided in Table 5.2.2-2 and Table 5.2.2-3. Using data supplied by the TWDB (Table 5.2.2-1), the “Share of WUG’s Need Applied to Factor” row is populated. In this case, 65% of the demand is applied to Domestic/Residential use and 15% to Commercial use. There is no demand associated with Manufacturing for the City of Uvalde. Next, the demand associated with each water use is determined by multiplying the total year 2020 demand times the percentage associated with each use type (i.e., 4,052 acft x .65 = 2,634 acft for domestic/residential demand). Using the methodology described above, the risk factor was determined for each scenario. Next, the economic impact factor was determined for each use type using the data supplied by the TWDB and shown in Table 5.2.2-1. These factors are constant from one drought management scenario to the next, with the exception of the factors for Domestic/Residential which were determined by interpolating between the values supplied by the TWDB for the risk factor associated with scenario. For example, for the 5% drought management scenario (a 7.6% reduction in residential/domestic use) for the City of Uvalde, the associated economic impact factor for domestic/residential is \$1,053; however, for the 10% reduction scenario (a 15.3% reduction in residential/domestic use), the economic impact factor is \$1,267.

Next the total economic impact for each use type is calculated by multiplying the proportional demand times the risk factor times the economic impact factor (i.e., 2,642 acft x 0.1312 x \$1,173/acft = \$437,627 for the residential sector with a 10% reduction). This same formula was used to determine the economic impact for each use type. Note, that the only WUGs for which commercial and manufacturing water use was reduced are Lockhart, Leon Valley, Kirby, Carrizo Springs, Kennedy, Castroville, La Coste, Uvalde and Victoria. Next, the economic impacts for each use type were summed to obtain a total economic impact (in this case and most cases just for domestic/residential). This type of process was used to determine the total economic impact for each of the drought management scenarios.

Table 5.2.2-2. 5 Percent Drought Management Scenario (City of Uvalde)

	<i>Domestic/ Residential</i>	<i>Com- mercial</i>	<i>Manu- facturing</i>	<i>Total/ Combined</i>
Share of WUG’s Need Applied to Factor (%)	65%	35%	0%	
Proportional Demand (acft)	2,642	1,410	0	
5% DM WMS Risk Factor	0.0744	0	0	
5% Reduction Economic Impact Factor (\$/acft)	\$1,053	\$ 56,290	-	
5% DM WMS - Total Economic Impact (\$)	\$ 206,377	\$ -	\$ -	\$ 206,377

Table 5.2.2-3. 10 Percent Drought Management Scenario (City of Uvalde)

	<i>Domestic/ Residential</i>	<i>Com- mercial</i>	<i>Manu- facturing</i>	<i>Total/ Combined</i>
Share of WUG's Need Applied to Factor (%)	65%	35%	0%	
Proportional Demand (acft)	2,642	1,410	0	
10% DM WMS Risk Factor	0.1312	0	0	
10% Reduction Economic Impact Factor (\$/acft)	\$ 1,267	\$ 56,290	-	
10% DM WMS - Total Economic Impact (\$)	\$ 437,627	\$ -	\$ -	\$ 437,627

To determine the unit cost for the 10% drought management scenario for Uvalde, the following steps were completed. First, marginal costs for both the 5% and 10% scenarios were calculated. For the 5% scenario, this is simply the total economic impact divided by 5% of the total year 2010 demand (i.e., \$191,091 / 203 acft = \$945/acft). For the 10% scenario, a marginal cost must first be calculated. This is calculated as the difference in total economic impact between the 10% and 5% drought management scenarios, divided by 5% of the total year 2010 demand (i.e., (\$405,211 - \$191,091) / 203 acft = \$1,059/acft). To calculate the unit cost for the 10% drought management scenario, the marginal costs of the 5% and the 10% scenario are averaged (i.e., (\$945 + \$1,059) / 2 = \$1,002/acft).

The methodology was presented above for all WUGs showing a need in 2020. San Antonio Water Supply (SAWS), who does not have a need in 2020, also requested to be included in the drought management analysis. SAWS prefers to utilize a multi-decadal approach to drought Management. They are considering a 5% demand reduction for 2020, a 12% demand reduction for 2030, and 16% demand reductions for 2050-2070.

5.2.2.3 Yield from Drought Management Strategy

The yield associated with drought management is simply the year 2020 projected demand times the appropriate percentage depending upon which scenario is used (5%, 10%, 15% or 20%). These values are summarized below in Table 5.2.2-4.

Table 5.2.2-4. Drought Management Yield

<i>Entity</i>	<i>Yield (acft)</i>			
	<i>5%</i>	<i>10%</i>	<i>15%</i>	<i>20%</i>
Alamo Heights	111	222	332	443
Asherton	17	34	51	68
Atascosa Rural WSC	80	160	239	319
Carrizo Springs	114	227	341	454



Table 5.2.2-4 (Continued)

Entity	Yield (acft)			
	5%	10%	15%	20%
Castroville	40	79	119	159
Cibolo	267	534	801	1,069
Converse	127	254	380	507
Garden Ridge	83	166	249	332
Green Valley SUD	91	182	273	364
Hondo	103	205	308	411
Karnes City	31	63	94	125
Kenedy	71	142	213	284
Kirby	47	94	141	188
LaCoste	6	13	19	25
Leon Valley	93	186	279	372
Lockhart	113	225	338	450
Lytle	29	58	87	115
Martindale	9	19	28	37
Mountain City	1	2	4	5
Natalia	14	28	42	56
Niederwald	4	8	11	15
Sabinal	22	45	67	89
San Antonio/SAWS	55	110	166	221
Shavano Park	160	320	479	639
Universal City	203	405	608	810
Uvalde	856	1,711	2,567	3,422
Victoria	60	120	180	241
Windcrest	33	66	99	132
Yancey WSC	111	222	332	443

5.2.2.4 Drought Management Strategy Costs

For each selected WUG, risk factors for 5%, 10%, 15%, and 20% drought management scenario reductions were calculated (Table 5.2.2-5). For the 5% reduction scenario, the risk factors ranged from 0.0008 for Mountain City, indicating there is very little risk of a higher per capita use rate occurring than what occurred in the year 2011, to 0.7295 for the City of Martindale, indicating a much greater risk of demand being greater than supply. For the 20% scenario, the risk factors ranged from a low of 0.012 for Mountain City to a high of 0.876 for Martindale.

As described above, these risk factors were then used to determine an annual cost for a planned supply less than demand for the year 2020 (Table 5.2.2-6). For the 5% reduction scenario, the annual cost ranged from \$17 for Mountain City to a cost of \$244, for Leon Valley. For the 20% reduction scenario, the annual cost ranged from \$385 for Mountain City to a cost of almost \$9 million for Uvalde. The two most important factors driving the annual cost are the risk factor and whether or not that WUG supplies water for commercial and manufacturing purposes (at the 20% reduction level), as these uses have high impact factors.

Finally, the annual cost data were used to calculate a unit cost so that comparisons could be made with other potentially feasible water management strategies (Table 5.2.2-7). For the 5% scenario (supply equal to 95% of dry condition demand), the unit costs ranged from \$6/acft/yr for Lytle to a high of \$15,038/acft/yr for Martindale. For the 20% scenario (supply equal to 80% of dry condition demand), the unit costs ranged from \$75 for Lytle to a high of \$10,045 for Uvalde. Again, the high unit costs for Uvalde are primarily due to the high risk factors (i.e., the year 2011 per capita was lower than in many previous years) and the high economic impact factors associated with commercial and manufacturing uses. The decadal percent reductions, yields, and costs for SAWS are presented in Table 5.2.2-8.



Table 5.2.2-5. Risk Factors

Entity	Risk Factors					
	5%	10%	15%	20%	Commercial	Manufacturing
Alamo Heights	0.0457	0.079	0.123	0.177		
Asherton	0.0010	0.005	0.024	0.055		
Atascosa Rural WSC	0.0262	0.040	0.058	0.079		
Carrizo Springs	0.0720	0.122	0.187	0.231		
Castroville	0.0131	0.024	0.044	0.056	0.015	0.015
Cibolo	0.0312	0.049	0.071	0.109		
Converse	0.0540	0.094	0.140	0.194		
Garden Ridge	0.0126	0.028	0.044	0.066		
Green Valley SUD	0.0912	0.121	0.155	0.193		
Hondo	0.0393	0.078	0.123	0.178		
Karnes City	0.3651	0.414	0.468	0.517		
Kenedy	0.0038	0.014	0.035	0.050		
Kirby	0.0142	0.047	0.115	0.115	0.029	
LaCoste	0.0201	0.042	0.089	0.130	0.016	
Leon Valley	0.1593	0.221	0.282	0.326	0.155	
Lockhart	0.0204	0.060	0.131	0.135	0.037	
Lytle	0.0078	0.027	0.065	0.107		
Martindale	0.7295	0.781	0.829	0.876		
Mountain City	0.0008	0.003	0.007	0.012		
Natalia	0.0357	0.054	0.078	0.111		
Niederwald	0.0687	0.105	0.143	0.182		
Sabinal	0.0162	0.024	0.036	0.053		
Shavano Park	0.0112	0.022	0.037	0.061		
Universal City	0.0173	0.044	0.091	0.143		
Uvalde	0.0744	0.131	0.195	0.213	0.097	
Victoria	0.0010	0.003	0.014	0.041	0.000	
Windcrest	0.0278	0.057	0.103	0.151		
Yancey WSC	0.1768	0.221	0.264	0.309		

Table 5.2.2-6. Total Annual Cost

Entity	Total Annual Cost			
	5%	10%	15%	20%
Alamo Heights	\$87,612	\$172,990	\$307,165	\$568,763
Asherton	\$313	\$1,866	\$9,958	\$33,520
Hondo	\$67,015	\$154,377	\$278,585	\$535,657
Karnes City	\$235,400	\$306,600	\$399,868	\$525,068
Kenedy	\$4,346	\$18,771	\$62,388	\$193,881
Kirby	\$8,672	\$34,557	\$177,313	\$507,722
LaCoste	\$2,295	\$5,661	\$14,762	\$37,049
Leon Valley	\$244,245	\$408,575	\$628,175	\$3,852,331
Lockhart	\$29,702	\$106,305	\$322,078	\$1,584,982
Lytle	\$4,244	\$17,546	\$49,259	\$132,900
Martindale	\$153,755	\$192,026	\$232,196	\$283,990
Mountain City	\$17	\$77	\$195	\$385
Natalia	\$10,618	\$18,571	\$31,096	\$56,145
Niederwald	\$5,441	\$9,691	\$15,190	\$24,515
San Antonio/SAWS	\$14,194	\$31,787	\$62,170	\$114,122
Shavano Park	\$48,727	\$138,993	\$333,296	\$659,686
Universal City	\$206,377	\$437,627	\$856,946	\$8,774,270
Uvalde	\$12,788	\$49,551	\$237,222	\$952,662
Victoria	\$31,013	\$75,775	\$157,282	\$312,780
Windcrest	\$120,620	\$175,413	\$239,591	\$324,504
Yancey WSC	\$136,751	\$276,602	\$516,940	\$2,211,819



Table 5.2.2-7. Average Unit Cost

Entity	Average Unit Cost			
	5%	10%	15%	20%
Alamo Heights	\$791	\$781	\$924	\$1,283
Cibolo	\$595	\$558	\$617	\$944
Converse	\$1,032	\$1,055	\$1,206	\$1,684
Garden Ridge	\$291	\$367	\$447	\$564
Green Valley SUD	\$1,930	\$1,490	\$1,465	\$1,733
Hondo	\$653	\$752	\$905	\$1,305
Karnes City	\$7,533	\$4,906	\$4,265	\$4,201
Kenedy	\$61	\$132	\$293	\$682
Kirby	\$184	\$367	\$1,255	\$2,695
LaCoste	\$361	\$446	\$775	\$1,459
Leon Valley	\$2,626	\$2,197	\$2,252	\$10,356
Lockhart	\$264	\$472	\$954	\$3,521
Lytle	\$147	\$304	\$569	\$1,152
Martindale	\$16,444	\$10,269	\$8,278	\$7,593
Mountain City	\$14	\$32	\$54	\$80
Natalia	\$756	\$661	\$738	\$999
Niederwald	\$1,451	\$1,292	\$1,350	\$1,634
Sabinal	\$369	\$313	\$354	\$460
San Antonio/SAWS	\$257	\$288	\$375	\$517
Shavano Park	\$305	\$435	\$695	\$1,032
Universal City	\$1,021	\$1,082	\$1,413	\$10,849
Uvalde	\$15	\$29	\$92	\$278
Victoria	\$18	\$781	\$924	\$1,283
Windcrest	\$520	\$444	\$484	\$553
Yancey WSC	\$1,205	\$1,219	\$1,518	\$4,872

Table 5.2.2-8. SAWS Analysis

	2020	2030	2040	2050	2060	2070
% Reduction	5%	5%	5%	5%	5%	5%
Yield (acft)	745	910	1,079	1,253	1,429	1,599
Average Unit Cost	\$342	\$342	\$342	\$342	\$342	\$342

APPENDIX E
Scope of Work and Response to TWDB Comments

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EXHIBIT B

SCOPE OF WORK

The CONTRACTOR shall update the current Uniform Costing Model (UCM) to correct bugs that were discovered during the fourth cycle of regional water planning, reflect more recent construction costs, reflect relevant updates to the regional water planning guidelines, and improve the functionality of specific modules. The Scope of Work includes the following tasks, listed in priority order:

- A. Update UCM documentation consistent with planning guidance:
 - 1. Provide an update to the accompanying “Uniform Costing Model User’s Guide” document (User’s Guide) reflecting all relevant changes to each module of the Costing Model. The updated User’s Guide will include an appendix documenting all changes and explaining how modules were evaluated and updated based on SOW tasks. After evaluation, if an update is not determined to be necessary, provide an explanation.
 - 2. Ensure the updated UCM is consistent with Section 5.5 of the *First Amended General Guidelines for Fifth Cycle of Regional Water Plan Development*, or if amended, the most recent version of that document.
- B. Correct bugs and errors identified during the fourth cycle of regional water planning, including:
 - 1. Multiple issues were identified with the drop-down menus for pipe diameters in the hydraulics and well field modules. Repair any non-functioning drop-down options and update to include appropriate ranges for all drop-downs, e.g., pipe diameter and pressure classes.
 - 2. For pipelines built along declining elevations, the model erroneously yields power being generated and money earned.
 - 3. In the well field module, the tool does not include the electricity cost to pump water to ground level at the individual well level but does include this cost for the whole well field. Evaluate the need for adding electricity cost at the individual well level and update if appropriate. In either case, clarify the intended functionality of the module in the User’s Guide.
 - 4. Errors were identified in the summing of costs on the 'Costing Summary' tab, wherein some values are not being captured.
 - 5. The date does not display properly on the 'Costing Summary' tab.
- C. Update pertinent cost data where necessary, including:
 - 1. Update construction costs to reflect recent costs of actual projects (e.g., trenching costs in rock/soil and urban/rural settings).
 - 2. Tables in the 'Reference – Cost Indices' tab, the Construction Cost Index (CCI) and Producer Price Index (PPI), must be updated.
 - 3. Revise assumptions regarding interest rates in accordance with agency guidance.
 - 4. Cost estimates for wells shallower than 100 feet deep will be evaluated and included if sufficient data is available.
 - 5. Cost estimates for aquifer storage & recovery (ASR) wells will be reevaluated and revised accordingly.

6. Capital cost and operations and maintenance (O&M) cost formulas for advanced water treatment plants will be added for direct potable reuse projects based on TWDB Direct Potable Reuse Resource Document.
 7. Reservoir land acquisition costs will be reevaluated and revised accordingly.
 8. The O&M costs associated with water treatment plants will be evaluated and revised as appropriate. Update the User's Guide to clarify how peaking factor and plant size impact cost estimates in the UCM.
 9. Evaluate and, if appropriate, update costing capabilities for drought management water management strategies.
 10. For all project types, a unit cost of annual water supply must be added after amortization (in addition to O&M costs).
- D. Improve the functionality of the UCM and specific costing modules, including:
1. Evaluate the methodology and assumptions in the Conservation module, and revise as appropriate. If timing and budget allow, this task should be coordinated with TWDB's efforts to develop a conservation-specific tool.
 2. The Reservoir Embankment Cost Calculator module is primarily useful for developing cost estimates for off-channel or ring dike reservoirs. Evaluate the need for costing capabilities for additional types of reservoirs (e.g., on-channel) and update the UCM as appropriate. In any case, clarify the intended functionality of the module in the User's Guide.
 3. Add instructions and an example diagram directly within the worksheet for the well field module.
 4. In the pipeline hydraulics modules, provide for multiple pipe pressure classes along a single pipeline segment and describe the method for hydraulic and cost calculations for branching transmission systems in the User's Guide.
 5. In the formulas for pump station costs (a component of the pipeline hydraulics modules), allow user to specify whether the first pump station should include an intake structure.
 6. Evaluate opportunities to add capabilities to accommodate project phasing and expansion of existing infrastructure as additional considerations of the model and add them as appropriate. If adding project phasing or expansion capabilities is infeasible, update the User's Guide to describe how the UCM can be best used to effectively evaluate phased projects or project expansion.
 7. Evaluate the Costing Form tab and identify opportunities to allow users to see additional detail and to verify work. Implement appropriate modifications, including adding a text field for user's notes. Update the User's Guide to reflect any changes and to clarify how users can check details and verify work.
 8. Create custom program functions to centralize hydraulic and energy calculations.
 9. Optimize the UCM file size.

Texas Water Development Board

P.O. Box 13231, 1700 N. Congress Ave.
Austin, TX 78711-3231, www.twdb.texas.gov
Phone (512) 463-7847, Fax (512) 475-2053

Mr. Peter Newell
HDR Engineering, Inc.
4401 West Gate Blvd., Suite 400
Austin, Texas 78745

RE: Services Contract with HDR Engineering, Inc., Contract No. 1800012227, Comments on Draft
Entitled "Uniform Costing Model User's Guide"

Dear Mr. Newell:

Staff members of the Texas Water Development Board (TWDB) have completed a review of the draft report prepared under the above-referenced contract. ATTACHMENT 1 provides the comments resulting from this review. As stated in the TWDB contract, HDR Engineering, Inc. (HDR) will consider revising the final report in response to comments from the Executive Administrator and other reviewers. In addition, HDR will include a copy of the Executive Administrator's draft report comments in the Final Report.

Please note: The TWDB logo should not be used in your Final Report.

The TWDB looks forward to receiving one (1) electronic copy of the entire Final Report in Portable Document Format (PDF) and five (5) bound double-sided copies. **Please further note, that in compliance with Texas Administrative Code Chapters 206 and 213 (related to Accessibility and Usability of State Web Sites), the digital copy of the final report must comply with the requirements and standards specified in statute. For more information, visit**

<http://www.sos.state.tx.us/tac/index.shtml>. If you have any questions on accessibility, please contact David Carter with the Contract Administration Division at (512) 936-6079 or David.Carter@twdb.texas.gov.

The final product will include the final Uniform Costing Model (electronic Microsoft Excel copy) and the Uniform Costing Model User's Guide (five bound double-sided copies and one electronic PDF copy).

Please feel free to contact Mr. Ron Ellis of our Water Use, Projections, & Planning staff at 512-463-4146 or ron.ellis@twdb.texas.gov if you have any questions or need any further information.

Sincerely,



Jessica Zuba
Deputy Executive Administrator
Water Supply & Infrastructure

Date: 9-13-18

Attachment

c w/o att.: Ron Ellis, Water Use, Projections, & Planning

Our Mission

To provide leadership, information, education, and support for planning, financial assistance, and outreach for the conservation and responsible development of water for Texas

Board Members

Peter M. Lake, Chairman | Kathleen Jackson, Board Member | Brooke T. Paup, Board Member

Jeff Walker, Executive Administrator

Attachment 1
HDR Engineering, Inc.
"Uniform Costing Model User's Guide"
Contract No. 1800012227
TWDB Comments to Draft Report

1. The tool does not appear to include all pipe diameters in the drop downs in all Hydraulics Calculation modules and Well Field Module. Please edit the pipe diameter drop downs to include all diameters as required by scope of work (SOW) Task B1.
2. Please correct the comment for Cell D177 on the Costing Form to accurately reflect the well depth range, if the range was updated as requested by SOW Task C4.
3. Please expand the discussion on how peaking factor affects O&M costs (8.3.3) and add a discussion of how plant size affects O&M costs as described in SOW Task C8.
4. Please clarify whether the text in cell B44 on the Cost Summary tab ("after debt service") or the text in Appendix A ("without debt service") is correct. SOW Task C10 asks for unit cost of annual water supply after amortization, but it is unclear from the cost summary tab if this calculation is correct.
5. It does not appear as though SOW Task D2 was fully addressed. Please clarify and discuss in the User's Guide whether the Dam Embankment or Costing Form module is the more appropriate module for estimating on-channel and off-channel dam projects.
6. As described in SOW Task A1, please amend Appendix A in the User's Guide to explain how modules identified in SOW tasks C4, C5, C7, C8, C9, D1, D2, D6, and D7 were evaluated even if those modules were not updated.
7. Please update the User's Guide to identify all warning flags in UCM. Explain what the warning flags indicate consistent with SOW Task A1.

8. Consistent with SOW Task A1, please correct cell reference in Appendix A for adding “Annual Cost of Water Without Debt Service (\$/1000 gal)” to the costing form. Appendix A identifies cell I260, but it should be I271.
9. Thank you for designing and providing a simplified drought management module as required by SOW Task C9. Please remove the simplified drought management module, and leave the tab in place showing the user the following text:

The TWDB plans to provide the socioeconomic report to be included in the 2021 Initially Prepared Plans in late 2019. In Fall 2019, prior to the release of the report, TWDB will also provide a drought management impact estimating tool for the RWPGs using the same model for estimating socioeconomic impacts for the 2021 Regional Water Plan. WUG specific unit cost will be provided that will be consistent with the socioeconomic impact reports.

Please also use the above text to replace the text in Section 11.1 of the User’s Guide.

Note regarding Comment 9: Using the regional average of all decades as a unit cost to calculate a drought impact on an individual WUG seems over simplified because it does not consider the magnitude of impact that depends on the proportion of the WUG’s need to the WUG’s total demand at all. For example, this approach is most likely to overestimate the impacts on municipal WUGs whose needs are lower than 30% of their demand totals, which should not result in significant monetary impact.

10. Consistent with SOW Task C9, please update the language in Section 11.2 of the User’s Guide to state that the information required to use the Drought Management Detailed Approach is not available from TWDB. If an RWPG wishes to utilize the Advanced Drought Management Modules, it will need to use its own data.
11. Consistent with SOW Task D1, please revise the note on p. 36 of the User’s Guide as follows: The TWDB is creating a new tool for Conservation which will be useful, but not required, for regional planning. Completion is estimated to be in late 2018, and TWDB will inform planning groups of its availability.
12. Please address the following typographical errors:
 - p. 7: hydraulincs should be hydraulics
 - p. 10: Section 4.1, last paragraph, reference to non-potable groundwater should be “(classified as untreated in the UCM)”

- p. 18: Section 6.0, reference in parenthesis to Section 9.1.3 should be Section 8.1.5
- p. 42: 8.1.3 Water Treatment Plans should be Water Treatment Plants
- p. 37: suggest updating reference to 2016 RWPs to 2021 RWPs

1. *The tool does not appear to include all pipe diameters in the drop downs in all Hydraulic Calculation modules and Well Field Module. Please edit pipe diameter drop downs to include all diameters as required by scope of work (SOW) Task B1.*

HDR Response: This has been fixed.

2. *Please correct the comment for Cell D177 on the Costing Form to accurately reflect the well depth range, if the range was updated as requested by SOW Task C4.*

HDR Response: This has been updated.

3. *Please expand the discussion on how peaking factor affects O&M costs (8.3.3) and add a discussion of how plant size affects O&M costs as described in SOW Task C8.*

HDR Response: Added language to 8.1.3.

4. *Please clarify whether the text in cell B44 on the Cost Summary tab (“after debt service”) or the text in Appendix A (“without debt service”) is correct. SOW Task C10 asks for unit cost of annual water supply after amortization, but it is unclear from the cost summary tab if this calculation is correct.*

HDR Response: Appendix A has been revised to read “after debt service”.

5. *It does not appear as though SOW Task D2 was fully addressed. Please clarify and discuss in the User’s Guide whether the Dam Embankment or Costing Form module is the more appropriate module for estimating on-channel and off-channel dam projects.*

HDR Response: The description in 8.1.5 has been revised to address this comment.

6. *As described in SOW Task A1, please amend Appendix A in the User’s Guide to explain how modules identified in SOW tasks C4, C5, C7, C8, C9, D1, D2, D6, and D7 were evaluated even if those modules were not updated.*

HDR Response: Appendix A has been updated to include references to each of these scope of work items.

7. *Please update the User’s Guide to identify all warning flags in UCM. Explain what the warning flags indicate consistent with SOW Task A1.*

HDR Response: Appropriate language has been added for each warning flag in the Users Guide.

8. *Consistent with SOW Task A1, please correct cell reference in Appendix A for adding “Annual Cost of Water Without Debt Service (\$/1000 gal)” to the costing form. Appendix A identifies cell I260, but it should be I271.*

HDR Response: This has been updated.

9. *Thank you for designing and providing a simplified drought management module as required by SOW Task C9. Please remove the simplified version of the drought management tool and leave the tab in place showing the user the following text:*

“The TWDB plans to provide the socioeconomic report to be included in the 2021 Initially Prepared Plans in late 2019. In Fall 2019, prior to the release of the report, TWDB will also provide a drought management impact estimating tool for the RWPGs using the same model for estimating socioeconomic impacts for the 2021 Regional Water Plan. WUG specific unit cost will be provided that will be consistent with the socioeconomic impact reports.”

HDR Response: This has been updated.

Please also use the above text to replace the text in Section 11.1 of the User’s Guide.

HDR Response: This has been updated.

10. *Consistent with SOW Task C9, please update the language in Section 11.2 of the User’s Guide to state that the information required to use the Drought Management Detailed Approach is not available from TWDB. If an RWPG wishes to utilize the Advanced Drought Management Modules, it will need to use its own data.*

HDR Response: This has been updated.

11. *Consistent with SOW Task D1, please revise the note on p. 36 of the User’s Guide as follows: The TWDB is creating a new tool for Conservation which will be useful, but not required, for regional planning. Completion is estimated to be in late 2018, and TWDB will inform planning groups of its availability.*

HDR Response: This has been updated.

12. *Please address the following typographical errors:*

- *p. 7: hydraulincs should be hydraulics*
- *p. 10: Section 4.1, last paragraph, reference to non-potable groundwater should be “(classified as untreated in the UCM)”*
- *p. 18: Section 6.0, reference in parenthesis to Section 9.1.3 should be Section 8.1.5*

- *p. 42: 8.1.3 Water Treatment Plans should be Water Treatment Plants*
- *p. 37: suggest updating reference to 2016 RWPs to 2021 RWPs*

HDR Response: These have all been updated in the User's Guide