2.2 Cost-Effectiveness Analysis

Discussion

The decision whether to implement a water conservation program should be based on some type of benefit-cost or cost-effectiveness analysis. The underlying concept is a comparison of the inputs of any action with the outcomes, usually expressed in dollars. In evaluating water conservation efforts, the decisions center around comparison of the costs of implementing a program against the "costs of conserved water" or the "avoided costs" of acquiring new sources of water. In the strictest sense, if the analysis shows that the water user will gain positive value (benefit-cost) or that the costs of one option are less than the costs of another (cost effectiveness), then the conservation program should be implemented. In reality, there are external factors that are also considered such as public perception, long term environmental considerations, or political factors that may affect the decision.

A variety of analytical processes are used in making these types of decisions. One of the most common is use of present value techniques to evaluate expenditures or income incurred at different times. Present value takes into account the time value of money. Basic principles that are part of making valid present value analyses include:

- Selection of the appropriate discount rate.
- Consistency in the consideration of inflation.
- Matching the time period for the analysis.
- Ensuring that all appropriate cost and benefits are considered.

There are many studies, models and worksheets that have been developed to guide the decisions for implementing water conservation programs using present value analysis. For these decision models to be more accurate and consistent, they may be quite detailed in the assumptions made, statistical smoothing of data, and consideration of influencing parameters such as weather or natural replacements.

The challenge is to make an analysis that reflects real life situations and is complete, but still comprehensible and usable. It is important that in an analysis that consistently compares the costs of implementing a conservation program to the costs of water saved or deferred, that the costs themselves be consistently developed.

Program Costs

To determine the program costs of a BMP it is important to include those costs associated with both administration and implementation. They can be categorized generally along the lines of:

- Capital expenditures for equipment or conservation devices.
- Operating expenses for staff or contractors to plan, design, or implement the program.
- Costs to the customers.

Program costs should be measured in reference to the opportunity costs of a program – that is, what must be foregone in order to provide the service. The costs should be realistic costs, both direct and indirect, that would be incurred above and beyond those the entity would normally incur if the program were not implemented. The timing of the costs is extremely important, whether up front, one time only, intermittently recurring, or ongoing on a periodic basis. The analysis should use all of the costs incurred over the life of the program. Specific program considerations for the different BMPs will be developed.

Each BMP has one or more of the costs and benefits categorized below. Cost considerations specific for BMPs are summarized in Section H under the individual BMPs.

- Start up: Any equipment necessary to initiate a BMP such as a computer for database tracking, software, specialized equipment, etc.
- Staff and administrative costs: Water conservation staff or contractor costs for implementing the BMP on an ongoing basis.
- Marketing and promotion: Costs for bill stuffers, media advertising, direct mail, etc., to let customers know about the BMP program. In many cases, marketing and outreach costs and expenses can be reduced or spread out when multiple BMPs are implemented by an entity.
- Materials: Costs for education and other materials provided to customers such as student workbooks and plant guides, etc.
- Incentive: Cost of incentives or rebates and/or any free equipment provided to customers.

Costs of Saved Water

If a conservation program will result in less water used (saved water) from existing supplies or less water needed from a wholesale supplier, then the benefits to the user are developed along the lines of:

- Direct avoided costs of treatment and delivery of water, including labor, energy, and chemicals.
- Costs of water not purchased from a wholesale supplier.
- Other expenses associated with the cost of providing water.

These costs are sometimes known as marginal operating costs. In the case of saved water, the costs that are to be compared to the costs of implementing the program are those directly saved by the provider, and not always the same as the lost revenues at the retail rate that would have been charged to the consumer.

Other benefits that may be considered include:

- Direct benefits: reductions in hot water use, energy use, and landscape labor costs when the frequency of watering and fertilizing is reduced.

- Indirect benefits: better air quality when energy use is decreased; and improved runoff water quality when fertilizer and herbicide use is reduced in landscape related BMPs.
- Environmental: One example would be reduced water withdrawals from rivers due to implementation of BMPs, resulting in more inflows to bays and estuaries.

Avoided Costs of Supply

Avoided water supply costs are those total costs, both capital and operational associated with new water supply that is deferred, downsized, or eliminated because of the conservation effort. These include:

- Capital costs of construction of production, treatment, transportation, storage, and related facilities.
- Costs of obtaining water rights and permits.
- These costs may also include avoided costs of additional wastewater treatment facilities if significant.
- Directs avoided costs of treatment and delivery of water, including labor, energy, and chemicals.

The Texas Water Development Board has very detailed cost guidelines for determining the values of the water management strategies in Section 4.2.9 of its Guidelines for Regional Water Plan Development. In making the comparisons it is very important that costs for water supply facilities still needed, but deferred until some point in the future, are discounted properly in the present value analysis.

Determination of Water Savings

Besides development of the costs themselves, the next most important number in a cost effectiveness analysis is the actual volume of water saved associated with a particular conservation BMP. Careful efforts should be made to ensure that the volumes of water savings are associated with the costs incurred. In some BMPs, the water savings associated with a conservation measure may be continual or permanent, where in other cases they can be determined over a defined life.

In some cases there can be an easy correlation. For example, each toilet retrofit measure is estimated to save 10.5 gallons per day per person. The total amount of water saved by the measure can then be estimated from the number of measures to be implemented. A toilet has an average life of 25 years so the savings due to the program would be estimated over the total life, even though the period of program implementation may be less than that.

In other cases, due to the nature of the BMP, there really are not easy ways to predict water savings. In reality, when BMPs such as these are included along with other water conservation activities, there will be a complementary or synergistic effect that should enhance the overall success of the initiatives.

Cost-Effectiveness Considerations

To make valid cost effectiveness decisions, costs must be presented on a comparable basis. In comparing the costs of conservation programs, the costs of saved water, or avoided costs of water, the costs are usually condensed down to terms of dollars per acre ft ($/ac ft) or dollars per measure ($/unit).

Two levels of comparison costs can be developed from the analyses. At the first level, for general comparison purposes, costs are given as an annualized or amortized value, which is the equivalent to an equal payment per time period over the life of the program for a one-time cost or stream of costs. The second level of costs for specific measures is the present value of all costs for a specific scenario, usually calculated and expressed in $/ac ft.

Example Cost Effectiveness Models

Two models have been developed to provide examples of how the cost effectiveness of conservation programs can analyzed. The example BMP Cost Analysis Spreadsheet is designed for use to evaluate the costs of implementing a BMP. The example Supply Analysis Spreadsheet allows future expenditures to obtain water supply over a period of time to be valued in the present. Then these expenditures can be compared with the present day costs of implementing conservation programs.

Cost of BMP versus New Water Supply: The cost per acre-foot of new water supply and treatment capacity can be compared to the cost per acre-foot achieved by implementing the BMP. The Municipal Supply Analysis Table provides an example of the water supply cost savings that can be achieved by implementing one or more BMPs.

Notes on Present Value and Discount Rate

In order to compute net present value, it is necessary to discount future benefits and costs. This discounting reflects the time value of money. Present value analysis allows a comparison of alternative series of estimated future cash flows – either costs or income. To do a present value analysis we use a “discount rate” which by general definition reflects the minimum acceptable rate of return for investments of equivalent risk and duration.

Benefits and costs are worth more if they are experienced sooner. The higher the discount rate, the lower is the present value of future cash flows. For typical investments, with costs concentrated in early periods and benefits following in later periods, raising the discount rate tends to reduce the net present value.

What discount rate should be used? In constant dollar analyses the real discount rates used reflect the treatment of inflation and the adjustment of future costs for real price escalation. In the private sector, discount rates can vary significantly from investor to investor. We are using the TWDB recommended discount rate of 6 percent that is in line with current economic expectations and those frequently seen used in energy and water conservation projects.

By comparison, the Office of Management and Budget in its Circular A-94 Update (2004) recommends a base rate for Federal project evaluations to be determined using a nominal discount rate of 5.5 percent for 30 year projects. This rate is supposed to approximate the marginal pretax rate of return on an average investment in the private sector in recent years. The Federal Energy Management Program uses life cycle costing for project decision making for potential energy and water conservation projects and has established a nominal rate (includes a general price inflation factor) of 4.8 percent for 2004. The TWDB Planning group periodically uses an EPA recommended 6.38 percent in water infrastructure cost effective analyses.

Example Spreadsheet for BMP Cost Effectiveness Analysis

Municipal conservation programs typically involve the implementation of a combination of several BMPs. In this spreadsheet example are models based upon existing state plumbing code which will account for expected changes in demand due to natural replacement of less efficient plumbing fixtures over the next several decades. These anticipated changes are accounted for in the Cost Savings Analysis and Program Planning sheets that the conservation analyst will use to determine cost-effectiveness. This model can be expanded to include additional BMPs in a scenario-building model that can be used in conjunction with the Supply Analysis Needs worksheet.

Utility baseline information is required to be put in, as well as confirmation of assumptions for program implementation. Information required to be input for these BMPs includes:

	Example
2000 SF Population	752,791
2000 MF Population	248,658
Institutional Population	0
2000 SF Units	270,788
2000 MF Units	207,215
1995 SF Units	63,294
1995 MF Units	203,574
SF Growth Rate (Calc Ann Avg)	0.6%
MF Growth Rate (Calc Ann Avg)	0.4%
No. of ICI Customers	20,000
SF Household Size	2.78
MF Household Size	2.44
No. of Bathrooms per SF House	2.0
No. of Bathrooms per MF Unit	1.2

The following data is used by default, unless the user has more accurate data.

Category:	**Default**
No. of Bathrooms per SF House	2.0

No. of Bathrooms per MF Unit	1.2
No of Irrigation Months	6
% of High Use SF customers	10%
No. of MF Units per Washer	18
No. of MF Units per Complex	50
Additional Data:	
Toilet Natural Replacement Rate	2.0%
Showerhead Natural Replacement Rate	6.7%
Annual SF Program Goal (Housing Turnover Rate)	6.7%
Annual MF Program Goal (MF Housing Turnover Rate)	10%
Percent of SF Units with CWs	95%
Discount Rate	6.0%
Projected Inflation Rate	2.0%

These models also use net free ridership assumptions, a very real consideration in plumbing fixture program analysis. This considers the number of measures receiving an incentive that would have done the program anyway less the number of measures that were done because of the publicity about the conservation program without any incentives (free drivers).

The resulting information can be used in decisions to select cost effective BMPs to meet the water saving goals of the utility.

TABLE 1 EXAMPLE BMP COST SAVINGS MODEL

	Selected Length of Program (years)	Life of Measure (years)	Savings per Residential Capita (gpd)	Savings per Living Unit (gpd)
Residential	1	2	3	4
SF Toilet (ULFT) Retrofit BMP	10	25.0	10.5	29.2
SF Showerheads and Aerators BMP	10	15.0	5.5	15.3
MF Toilet (ULFT) Retrofit BMP	10	25.0	10.5	25.6
MF Showerheads and Aerators BMP	10	15.0	5.5	13.4
SF Irrigation Survey	10	10.0	18.0	50.0
ICI Irrigation Survey	10	10.0	NA	NA

	No. of Measures / Living Unit	Savings per Measure (gpd)	Natural Penetration Rate	Program Penetration Goal
Residential	5	6	7	8
SF Toilet (ULFT) Retrofit BMP	2.0	14.6	18%	80%
SF Showerheads and Aerators BMP	2.0	7.6	53%	80%
MF Toilet (ULFT) Retrofit BMP	1.2	21.4	20%	80%
MF Showerheads and Aerators BMP	1.2	11.2	53%	80%
SF Irrigation Survey	1.0	50.0	0%	50%
ICI Irrigation Survey	NA	470.0	0%	25%

	Number of Measures at Penetration Rate	Estimated Annual Savings (at Penetration Rate) (gpd)	Estimated Annual Savings (at Penetration Rate) (acre-ft/yr)	Number of Years to Reach Penetration Goal
Residential	9	10	11	12
SF Toilet (ULFT) Retrofit BMP	275,761	4,024,725	4,508	22
SF Showerheads and Aerators BMP	110,990	848,518	950	11
MF Toilet (ULFT) Retrofit BMP	138,200	2,950,563	3,305	15
MF Showerheads and Aerators BMP	64,077	716,600	803	8
SF Irrigation Survey	13,539	676,970	758	10
ICI Irrigation Survey	5,000	2,350,000	2,632	10

TABLE 1 cont.

	Penetration Estimated at 10 Yr	Program Costs per Measure	Estimated Net Free Ridership	Net Program Costs per Measure
Residential	13	14	15	16
SF Toilet (ULFT) Retrofit BMP	61%	$ 85	10%	$ 94
SF Showerheads and Aerators BMP	79%	$ 7	50%	$ 14
MF Toilet (ULFT) Retrofit BMP	70%	$ 75	10%	$ 83
MF Showerheads and Aerators BMP	82%	$ 4	50%	$ 8
SF Irrigation Survey	NA	$ 50	1%	$ 51
ICI Irrigation Survey	NA	$ 200	1%	$ 202

	Cost per AF of Water Saved (Amortized)	Total Program Costs (at Penetration Rate)	Present Value of Program Costs (year 1 = 2005)	Estimated Water Saved over Life of Measure (acre ft)
Residential	17	18	19	20
SF Toilet (ULFT) Retrofit BMP	$ 452	$ 26,044,051	$ 19,112,751	101,436
SF Showerheads and Aerators BMP	$ 168	$ 1,553,858	$ 634,306	7,128
MF Toilet (ULFT) Retrofit BMP	$ 273	$ 11,516,638	$ 9,117,548	74,364
MF Showerheads and Aerators BMP	$ 66	$ 512,620	$ 371,221	6,020
SF Irrigation Survey	$ 123	$ 683,808	$ 540,425	7,583
ICI Irrigation Survey	$ 52	$ 1,010,101	$ 980,392	26,323

	Present Value Per Acre Foot Saved	Standard Delivery Description	Other Delivery Options
Residential	21	22	23
SF Toilet (ULFT) Retrofit BMP	$ 188	free or rebate	direct install
SF Showerheads and Aerators BMP	$ 89	kits picked up by customer	door to door dist or direct
MF Toilet (ULFT) Retrofit BMP	$ 123	free or rebate	direct install
MF Showerheads and Aerators BMP	$ 62	kits picked up, installed by apt.mgmt	
SF Irrigation Survey	$ 71	audits performed by utility staff	contractor performs audits
ICI Irrigation Survey	$ 37	audits performed by utility staff	contractor performs audits

TABLE 1 cont.

Notes to Municipal cost Savings Model

SF=single-family, MF=multi-family *Population figures are from 2000 Census

Column 1 - user selects the length of time the program will be implemented for.

Column 2- assumed useful life of the measure

Column 3 - savings per person in gallons per day

Column 4 - savings per housing unit in gallons per day (Col 3 x No.of persons per living unit, input page)

Column 5 - the number of measures needed for each living unit

Column 6 - gallons saved per day for each measure

Column 7- estimated percentage penetration of efficient measures already accomplished: either defined or calculated from models

Column 8 - the potential number of customers who could be expected to implement the program with substantial marketing and outreach- includes natural replacements and retrofits

Column 9 - estimated number of measures ultimately accomplished by program (no. of MF or SF units x no. of measures per unit)

Column 10- potential savings in gallons per day (column 10 x column 7)

Column 11- potential savings for the region in acre-feet [(column 11 x 365) / 325,851]

Column 12- years to reach penetration goal selected in Column 9

Column 13- actual penetration achieved during life of program (Column 1) and desired retrofit goal per year (turnover rate, input page)

Column 14- program costs including rebates, staff time and marketing

Column 15- percentage of free ridership, or those that would participate even without incentive

Column 16- net program costs after adjusting for net free ridership

Column 17 - amortized cost per acre foot of water saved each year [(column 17 x 325,851 gallons/AF) / (column 6 x 365 days)]) amortized at discount rate over the life of the measure

Column 18 - total program cost (column 7 x column 10)

Column 19 - net present value of costs of program incurred each year

Column 20 - total acre feet of water expected to be saved over expected life of measure (col 7 x col 10 x col 2)

Column 21 - net present value of program per acre ft saved (col 20 divided by col 21)

Column 22 - delivery option(s) for which costs are estimated

Column 23 - other possible delivery options

Municipal Cost Effectiveness Example

This example shows a straight forward example of a midsize utility that is growing and that anticipates that it will have to purchase water rights or develop additional water supply. The utility would prefer to delay purchasing these additional rights if one of more BMPs would achieve the required savings to delay the purchase. This analysis does not take into account the reduced operating cost benefit to the utility of implementing the conservation measures.

A simple Example Municipal Supply Analysis spreadsheet has been set up for use by the utility to *Find the Benefit to the Utility of a Delay in Purchasing Water Supply*. The utility enters:

- increase in annual water demand (AF),
- number of AF to be purchased,
- number of years until the purchase will be made,
- cost for the additional water rights,
- years of the new supply contract,
- number of years of delay desired, and
- discount rate.

The Example Municipal Supply Analysis spreadsheet set up for this example contains the following assumptions (region-specific data from the State Water Plan or utility generated data should be used when performing this analysis for a particular conservation program):

- The utility water demand is increasing by 1000 AF per year.
- In 10 years, the utility anticipates being at 90 percent of its existing water supply and plans to purchase an additional 25,000 AF of water.
- The new water supply will cost $400 per AF and will be a 50-year contract.
- Water costs are anticipated to rise 2 percent per year.
- The utility hopes to delay the purchase by 3 years.
- The assumed discount rate is 6 percent.

Based on these assumptions, the utility would have to conserve 3000 AF of water. The Municipal Supply Analysis spreadsheet shows the present value of water saved ($/AF). To get to this number the spreadsheet includes several calculations. First the value of a 50-year water contract starting in 2015 is determined. It has been calculated using Microsoft Excel's NPV function. In this case, the NPV function is used to calculate the total amount that a series of future payments is worth in 2015.

- The syntax of the Microsoft NPV function is NPV(rate,nper,pmt1,pmt2, pmt3,…);
- Rate is the interest rate per period. For simplicity this is presented as 6 percent per annum;
- Pmt1, Pmt2, Pmt3, …, are the annual payments for the time period selected. For this example the contract is 50 years, starting at $400 per AF in year 1 and increasing by 2 percent per year.

- Next the NPV function is used to calculate the value of the 50-year water contract if it started after a 3-year delay, which would be 2018.

  To determine the present value of the water saved, the difference in the present value in 2005 for the 2015 NPV value and the 2018 NPV value is determined. This is done using the appropriate discount factor. The difference between the 2015 and the 2018 PV values in 2005 dollars is the value of the conserved water.

  Energy and chemical deferred cost savings are calculated in a separate tab and entered in this tab.

  The present value of the delay and deferred chemical and water savings is $930 per AF that could be compared to the cost of implementing the water saving BMPs.

TABLE 2 EXAMPLE MUNICIPAL SUPPLY ANALYSIS WORKSHEET

Utility Entered Variables

1	Cost per AF	$	400	
2	No. of AF Purchase		25,000	
3	No.of Years until Purchase: No Conservation		10	
4	Annual Increase in Water Demand (AF)		1,000	
5	No of Years of Contract		50	
6	Delay Projected Due to Conservation		3	
7	Discount Rate		6.0%	
8	Increase in Water Costs per Year		2.0%	
9	Annual Cost per AF for Energy and Chemicals	$	65.00	
10	Estimated Annual Inflation in Energy and Chemical Costs		2.0%	
11	Water Savings Required (AF)			**3,000**
12				

13	Present Value of Contract if Purchased in 2015	Present Value of Contract if Purchase Delayed Until 2018	PV Value of Conservation per AF
14		642.36	
15	$8,538.78	$9,061.42	
16	0.538615114	0.447365096	
17	$4,599.12	$4,053.76	**$545.35**
18			**$384.91**
19			**$930.26**

Notes

1 Negotiated or anticipate cost per AF
2 Amount of water to be purchased in AF
3 Anticipated date when water will be purchased without conservation
4 Projected annual increase in water demand without conservation
5 Length of supply agreement
6 Desired delay due to conservation
7 Rate that will be used to discount future cost back to present value in todays' dollars
8 Projected annual increase in user rates during the period of delay
9 Actual costs for Energy and Chemicals for water treatment per AF
11 This is the total water savings needed based on the annual growth in water demand and the length of delay selected
15 Cost per AF: This amount is the value for the 50 years of payment for 1 AF in 2015 and 2018.
16 Discount to Present: The calculated discount amount from 2015 to 2005; and 2018 to 2005
17 Present Value of Delay: The difference in the discounted value from 2015 to 2005; and 2018 to 2005
18 PV of Energy and Chemical Savings: From Energy and Chemicals tab
19 Total Present Value of Delay

References for Additional Information

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3) *Cost-Effective Cost Effectiveness: Quantifying Conservation on the Cheap,* David L. Pekelney, Thomas W. Chesnutt, and David L. Mitchell, Abstract of Paper presented at AWWA National Conference June 26, 1996.
4) Office of Management and Budget Circular No. A-94 Revised, October 29, 1992.
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6) *Life-Cycle Costing Manual for the Federal Energy Management Program,* prepared for the U.S. Department of Energy, Sieglinde K. Fuller and Stephen R. Petersen, February 1996.
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