The Role of Integrated Resource Planning in Improving Water Resource Management within the Great Lakes Region

The water industry as a whole is a rising cost sector, which simply means the future cost of water services will be greater than historical costs.[1] Nationwide, the U.S. EPA estimates water and wastewater infrastructure will require over $500 billion dollars[2] of capital spending on infrastructure over the next few decades. These projections include $54.8 billion needed for combined sewer overflow (CSO) control, and another $9 billion for stormwater management programs.[3]

As communities continue to grapple with perennial budget shortfalls, mounting water infrastructure needs, and overwhelming stormwater pollution problems, we need to ensure we are making the best water infrastructure investment decisions (economically, socially and environmentally) and utilizing funds the most efficiently.

That is the purpose of this working paper; to explore how a least-cost, conservation-oriented approach termed "integrated resource planning" (IRP) can assist in improving the efficiency of water utilities, thus conserving water resources, reducing costs and bolstering community prosperity and vitality within the Great Lakes region. Now more than ever, water planning must work to incorporate sustainable practices which recognize the interconnected nature of water supply, wastewater and stormwater management. IRP is a planning methodology which works to recognize these relationships from a least-cost, publicly transparent, and scenario-based planning perspective.

1 Chesnutt et al, "Water Efficiency Programs for Integrated Water Management." (Journal AWWA, 100:5) May 2008.
2 "The Clean Water and Drinking Water Infrastructure Gap Analysis", US EPA Office of Water, Washington, DC, 2002.
3 US EPA "Clean Watersheds Needs Survey 2004: Report to Congress". Washington, D.C.

Improved Water Planning Needed within the Great Lakes Region

The Great Lakes - Superior, Michigan, Huron, Erie and Ontario are the largest surface freshwater system on Earth. These lakes contain about 84 percent of North America's surface fresh water and about 21 percent of the world's total available fresh water supply.[4] About ten percent of the U.S. population lives within the basin and annual economic activity in the Great Lakes region exceeds $200 billion.[5] The Great Lakes are a vital natural resource and the economic health of the region is directly dependent upon its continued ecological vitality.

Unfortunately current land use development patterns and a lack of effective stormwater runoff controls are increasingly degrading our fresh water resources. "Each year, more than 24 billion gallons of combined untreated sewage and stormwater is dumped into the Great Lakes."[6] Stormwater issues continue to plague and pollute our waterways as combined sewer overflows (CSOs) cause significant costs to the region economically, socially and environmentally. Not the least of which is stormwater pollution's negative impact on water supply and wastewater utility efficiency. For example, approximately 30% of the State of Illinois' allotted water diversion from Lake Michigan is attributed solely to stormwater runoff. Reducing stormwater runoff in the area would allow the State to more efficiently utilize its water supplies.

The region suffers from a lack of action in water conservation and a failure to consistently integrate conservation measures in water planning. For those communities located within the Great Lakes basin, an underlying perception of adequate or abundant water supplies stunts any real change.[7] There is an overall mindset within the region that conservation is a good idea, but measurable actions and policy requirements to assist in realizing such a goal are lacking.

A paradigm shift is needed in the way we plan and manage fresh water within the Great Lakes region. The Great Lakes – St. Lawrence River Basin Water Resources Compact (the Compact) sets the stage for potentially more holistic approaches to managing water resources within this region. However, the Compact does not specifically require or define relevant water conservation or efficiency measurements. The Compact simply states that "each Party shall develop its own water conservation and efficiency goals and objectives…and implement a water conservation and efficiency program, either voluntary or mandatory, within its jurisdiction…"[8]

To meet the Compact and other regional goals to protect and restore the Great Lakes, we need a more effective framework to unify regional water planning initiatives. Our region's water investment decisions need to factor in the complex relationship between water supply, wastewater and stormwater to benefit the health of our water resources. Incorporating the value of conservation and efficiency within the full range of water infrastructure investment decisions must become an integral step toward a more sustainable water future.

4 See EPA's website on the Great Lakes Basic Information at http://www.epa.gov/grtlakes/basicinfo.html
5 See EPA's website on the Great Lakes Strategy 2002 – A Plan for the New Millennium at http://www.epa.gov/glnpo/gls/
6 Alliance for the Great Lakes http://www.greatlakes.org/Page.aspx?pid=454
7 Great Lakes Commission, Prepared by Rebecca Lameka – Program Specialist, *"Briefing Paper: Summary of Current Water Conservation Practices in the Public Water Supply Sector of the Great Lakes-St. Laurence Region"* Supported by the Great Lakes Protection Fund. March 2004.
8 Great Lakes – St. Lawrence River Basin Water Resources Compact, December 13, 2005.

An Introduction to Integrated Resource Planning

Before integrated resource planning, there was least-cost planning. Least-cost planning (LCP) is a methodology that strives to equally assess demand and supply-side solutions to determine an appropriate mix and achieve the least-cost outcome. Least-cost planning arose in the 1980's within the energy utility sector in response to rising costs, poor forecasting track records and growing concerns about environmental externalities. Since then some organizations within the transportation sector have used this planning method as well.

Since the 1990's, LCP has evolved into a more sophisticated planning approach called integrated resource planning (IRP). IRP encompasses least-cost planning concepts by ensuring demand-side initiatives are treated equally along side supply-side projects. Integrated resource planning is a more comprehensive mechanism than earlier least-cost approaches. IRP emphasizes scenario planning and develops a portfolio of options for utilities. IRP also emphasizes the importance of establishing a more open and participatory decision-making process and coordinating the many institutions that govern water resources.

IRP recognizes that demand is malleable and demand forecasts are not a fixed input, but rather they can be manipulated within a planning model. This methodology is as much a way of thinking about water resource planning as it is a specific set of planning techniques.

> "Water providers routinely consider a community's long- and short-term goals and needs, compare various alternatives for achieving the stated objectives, and choose the approach that meets those needs, objectives and goals with the least cost. But often, only supply-side options are considered – ways to provide more water or more wastewater treatment capacity. As the costs of obtaining water and of treating water and wastewater rise, approaches which use less water more efficiently to deliver unchanged or improved services are increasingly proving to be the least-cost alternatives. Under this approach, demand-side options are considered on the same footing as supply-side options."[9]

Key Components of an IRP Process[10]

- Clear goals and policy objectives adopted by the utility management
- A planning horizon or future design year
- An interdisciplinary process, considering not just engineering details but also a range of key policy objectives
- Equal treatment of supply-side and demand-side options (a level playing field)
- Consideration of supply reliability
- Explicit consideration of uncertainty
- An open process with a heavy dose of public participation

9 Rocky Mountain Institute "Water Efficiency – A Resource for Utility Managers, Community Planners, and Other Decision makers." Through Cooperative Agreement with the U.S. Environmental Protection Agency Office of Water, Office of Wastewater Enforcement and Compliance. November 1991.

10 AWWA Manual M50, 2nd Ed. Water Resources Planning – A Manual of Water Supply Practices, 2007

A Sample IRP Process[11]

1. Develop demand forecast
   - Forecasting forms the basis for much of the planning process. It is important to keep in mind that actual demand levels are bound to vary from the forecast, and can actually be manipulated by effective demand-side initiatives.
2. Define policy objectives
   - IRP must carefully identify multiple and potentially conflicting policy objectives. These set the broad bounds of what a water supplier is trying to achieve through the resource planning effort.
3. Develop measurable evaluation criteria
   - Evaluation criteria must assess the performance of resource alternatives against the policy objectives.
4. Assess and characterize supply-side and demand-side options
   - IRP treats demand-side (conservation & efficiency) options as a resource equivalent to supply-side (facility & build-out) options. Plans must carefully distinguish between conservation measures (technologies or management practices) and conservation incentives (outreach/education & media initiatives).
5. Define major future uncertainties
   - A critical feature of a well-developed IRP process. Uncertainties are issues that may have a critical influence on the utility's demand or its ability to develop future resources, or both.
6. Develop resource sequences and strategies
   - Sequence is defined to mean a deterministic progression of utility actions regarding facility and (demand-side and supply-side) resource additions.
   - Strategy is defined as a probabilistic multi-branched "tree" of sequences defining the utility actions that should be taken under various sets of uncertainties and their outcomes.
7. Assess potential institutional structures
   - Are the resource strategies established institutionally and financially feasible?
8. Formulate and implement final recommendations
9. Continuously evaluate actual results of the planning process and adjust accordingly

11 Gary Fiske and Anh Dong, "IRP: A Case Study form Nevada." (Journal AWWA) 1995.

The Needed Inclusion of Stormwater Management within IRP

Continued progress in managing water resources depends on a better integration of stormwater management within water supply and wastewater planning and management. "Decision makers have rarely accorded stormwater management, the third dimension of local water resources management, the same priority as water supply and wastewater treatment."[12]

The IRP process has the potential to help achieve this integration. Current approaches to stormwater management reflect basic principles of the IRP process. Due to its direct impact on water quantity and quality, stormwater planning needs to be incorporated with water supply and wastewater planning. "Studies of water utilities across the United States show that every dollar invested in watershed protection saves tens of

thousands of dollars in water treatment costs."[13] New York City is a prime example of how utilities can save on costs by focusing on stormwater prevention. "…by investing $1.5 billion over ten years to protect the Catskill and Delaware watersheds, New York City has avoided spending $6 billion in capital and $300 million in annual costs associated with constructing and operating a new filtration plant."[14]

Instead of focusing on traditional drainage, conveyance and flood control mechanisms (grey infrastructure), communities are now looking at more holistic and beneficial approaches to managing stormwater, which also help to cut down infrastructure costs. These strategies include better site design for runoff reductions, such as low impact development and green infrastructure practices. The popularity and effectiveness of these initiatives is directly reflected by the recent demand of green project reserve funds available through the ARRA for clean water and drinking water improvements.

Aurora, Illinois recently completed a planning strategy to address water quality issues within the Fox River. The combination of a growing population and an aging stormwater infrastructure system threatened the City's drinking water supply. Through the use of green infrastructure stormwater BMPs, the City was able to avoid spending extraordinary costs in a new wastewater treatment plant while also reducing average annual runoff volume by about 10 percent and pollutant loads by about 20 percent per year.[15] In addition to cleaner water, this case study also found that green infrastructure approaches contribute to neighborhood rejuvenation and identity, habitat creation and reduced the urban heat island effect.

Philadelphia recently completed a triple bottom line assessment of traditional and green infrastructure options for managing the region's stormwater issues in order to improve water quality and quantity. A key finding of the assessment is that LID-based green infrastructure approaches provide a wide array of important environmental and social benefits to the community, which are not generally

12 Greg Lindsey, "Stormwater Management in Integrated Resource Planning."

13 Greenwalt, Travis and Deborah McGrath, "Protecting the City's Water: Designing a Payment for Ecosystem Services Program" NR&E, Summer 2009.

14 S.L. Postel & B.H. Thompson, Jr., "Watershed Protection: Capturing the Benefits of Nature's Water Supply Services, 29 Nat. Resources F. 98-108 (2005).

15 NRDC, "Rooftops to Rivers: Aurora – A Case Study in the Power of Green Infrastructure", November 2009

The Needed Inclusion of Stormwater Management within IRP (continued)

provided by the more traditional alternatives.[16] The report outlines how the additional benefits of green infrastructure can reduce other costs such as those associated with the urban heat island effect, air quality control, reduced energy needs, restored ecosystem services, enhanced recreation and improved quality of life within a community.

These kinds of innovative infrastructure analyses need to be included within the IRP process given the additional economic, social and environmental benefits green infrastructure and low impact development can provide above and beyond stormwater retention and improved water quality and quantity.

Making the Most of Our Water Infrastructure Investments – Improved Economic Efficiency

Water efficiency and conservation can be low cost alternatives to supply augmentation. Water efficiency has the potential to reduce capital and operating costs related to chemical use, energy costs, equipment down-sizing, and extending the life expectancy of facilities. "Conservation is justified when the unit cost of freeing-up existing supply capacity through demand management is lower than the unit cost of adding new supply capacity."[17]

Given the projected costs of future water infrastructure investments anticipated in national and regional assessments, it is important to understand how integrated resource planning can help ensure that water utilities are making the best investment decisions and utilizing funds the most efficiently. Several key economic concepts and practices can contribute to an integrated resource planning process. The following is a brief introduction to these concepts and how they assist in recognizing the cost effectiveness of demand-side initiatives.

Generally speaking consumers are interested in the services provided by water (washing, sanitation, irrigation, etc.) rather than water itself. If the same level of service is provided through improved efficiency rather than supplying more water, there can be significant cost savings to the community as a whole.[18] Viewed another way, a unit of water provided through a new source is equivalent to a unit of water saved through more efficient use.

This introduces the concept of avoided costs and the potential savings derived from improved efficiency and water conservation initiatives. In the context of IRP for water sector utilities, avoided costs are the incremental savings associated with not having to produce (or treat) additional units of water while meeting demand requirements.[19] There are 3 types of avoided costs: direct costs (capital and operating costs), indirect costs (externalities, etc.), and opportunity costs. Factoring in avoided cost savings when comparing supply- and demand-side initiatives is necessary in order to appropriately assess which option(s) provide the best solution at minimum cost within the IRP process.

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16 Stratus Consulting, "A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds," Final Report. August 2009.

17 Janice A. Beecher, "Avoided Cost: An Essential Concept for Integrated Resource Planning."

18 White, S.B. & Howe, C. 'Water Efficiency and Reuse: a Least Cost Planning Approach', Proceedings of the 6th NSW Recycled Water Seminar, November 1998.

19 Janice A. Beecher, "Avoided Cost: An Essential Concept for Integrated Resource Planning."

Making the Most of Our Water Infrastructure Investments – Improved Economic Efficiency (continued)

Nega-gallons refer to a measurement of water that is "produced" through conservation and efficient use of existing water supply resources; it is the idea that utilities can increase water supplies (grow water) by reducing the amount of units demanded through efficiency measures and conservation. This is an important concept when addressing how water utilities think about resource units and efficiency levels.

IRP requires that utilities enact full-cost pricing to account for all costs including internal and external, public and private, monetized and non-monetized. A complete cost analysis, which includes the broader community, is a key element of an effective IRP assessment.

A levelized cost describes the unit cost of conserved water or energy. Energy use within the water sector is a major concern from a cost, supply and climate change perspective. By analyzing these costs within the IRP process, utilities are able to better understand the full costs of a supply-side project in comparison to a demand-side initiative. It is generally accepted that by using levelized cost, it is possible to evaluate the merits of large projects in comparison to a series of smaller ones. IRP requires a full accounting of levelized life-cycle costs including direct capital costs, maintenance costs, environmental costs, time costs and preference costs.

Case Studies: Examples of Successful Demand-side Initiatives Using IRP

1) Goleta, California's District Water Conservation Staff implemented various water efficiency and public education initiatives that emphasized plumbing retrofits; including high-efficiency toilets, high-efficiency showerheads and increased rates in order to conserve water. The efficiency program cost approximately $1.5 million and reduced per capita residential water use by over 50%. These demand-side initiatives also enabled Goleta to reduce sewerage flow from 6.7 to less than 4 MGD, which delayed the expansion of a multi-million dollar wastewater treatment plant.[20]

2) The Massachusetts Water Resources Authority (MWRA) is a wholesale water provider whose withdrawals were exceeding safe levels by more than 10% annually. By initiating demand-side, water conservation programs which included leak detection and repair, plumbing retrofits and educational programs, average daily water demand dropped significantly. This allowed MWRA to defer a multi-million dollar water supply expansion project and reduce the capacity of its treatment plant.[21]

3) Cary, North Carolina implemented a water conservation program consisting of among other things public education, landscape and irrigation codes, toilet flapper rebates, residential audits and conservation rate structures. The program was able to reduce retail water production to such an extent that it minimized operating costs and allowed the City to delay two water plant expansions.[20]

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20 Rocky Mountain Institute "Water Efficiency – A Resource for Utility Managers, Community Planners, and Other Decision makers." Through Cooperative Agreement with the U.S. Environmental Protection Agency Office of Water, Office of Wastewater Enforcement and Compliance. November 1991.

21 U.S. EPA "Cases in Water Conservation: How Efficiency Programs Help Water Utilities Save Water and Avoid Costs," Office of Water, July 2002.

Case Studies: Examples of Successful Demand-side Initiatives Using IRP (continued)

4) Barrie, Ontario was facing expensive new infrastructure development due to population growth. They decided to focus on reducing demand through a conservation plan focused on replacing inefficient showerheads and toilets. The City was able to save an average of 14.5 gallons per person per day. This reduction in water units translated into reduced wastewater flows, which in turn deferred an expensive capital expansion project for five more years.[21]

Moving forward - challenges, needs, considerations and opportunities

There are a number of factors that must be considered and addressed when exploring effective ways to incorporate IRP within the broad context of water planning in the Great Lakes. The following briefly outlines some of these issues for further consideration and discussion.

Challenges:

- One of the most significant obstacles to a fully integrated approach is the complex structure of regulations that currently exist for water supply, wastewater and stormwater planning. Water resources are governed by a fragmented and pluralistic system of institutions that oversees its regulation. Additionally, the scale (size) of a utility and whether is it publicly or privately owned also adds to variations in institutional regulation, which increases the level of fragmentation. Potential IRP strategies within the region must account for this complex web of regulations.
- Current regulations provide perverse incentives for utilities to avoid conservation and demand-side initiatives that would otherwise benefit utilities, customers and regional water resources. Cost recovery is easier for a supply-side investment even when a demand-side initiative is more efficient than a supply-side project. This structure discourages fair consideration and investment in demand-side initiatives, challenging the effectiveness of a potential IRP process.
- Another disincentive to demand-side measures is the relatively low price of water in most areas within the region. This can work against utility conservation and efficiency initiatives such as retrofit programs since consumers do not recognize the benefits as powerfully when the retail price of water is low.

Needs:

- Implementing IRP practices will require behavioral changes and a revamping of some personnel and institutional structures within water planning in order to facilitate conservation projects within water utilities. "IRP entails new roles and responsibilities for water supply utilities. Integration means that environmental, engineering, public health, financial, rate-making, social, and economic considerations all feed into the planning process."[22]

21 Rocky Mountain Institute "Water Efficiency – A Resource for Utility Managers, Community Planners, and Other Decision makers." Through Cooperative Agreement with the U.S. Environmental Protection Agency Office of Water, Office of Wastewater Enforcement and Compliance. November 1991.
22 Janice A. Beecher, "Integrated Resource Planning Fundamentals," Journal AWWA, June 1995.

Moving forward - challenges, needs, considerations and opportunities (continued)

- Utility planners and engineers will need to be equipped with the knowledge and tools to analyze the demand-side (conservation/efficiency) component of the IRP process as comprehensively and rigorously as supply-side aspects. Access to analytical tools and adequate information will be necessary in order for utilities to begin analyzing data and costs effectively. A review of current tools is important along with identifying development needs based-on gaps in available tool sets.
- Improved planning mechanisms, which assist various water sectors in working together effectively, are needed. IRP could help to facilitate improved coordination among the various agencies that govern currently segregated water resource sectors.
- A new level of public participation within the IRP process of utility decision-making will need to be encouraged and supported. Resistance on behalf of utilities to consumer involvement could be an obstacle to be overcome during an IRP process.
- Utilities will need to understand the difference between conservation *incentives* (brochures, advertisements and public outreach) and conservation *measures* (e.g., retrofits). Implementing incentives is not enough; both incentives and measures need to be a part of an integrated plan.[23]

Considerations:

- A key consideration regarding water conservation and efficiency is its impact on utility profits. Conservation can threaten revenue earnings as long as a utility's profits are directly linked to its units sold and no incentive-based regulation(s) exist to counteract this relationship.[24] Bringing IRP effectively into Great Lakes water planning will require research into decoupling utility profits from units sold. However, given the varied institutional structures within water management, this option is not necessarily applicable across the board.[25]
- Sensitivity to how utilities will need to adapt to new processes involved with IRP is necessary. Generally speaking, incentive-based systems provide more encouragement and recognition to utilities than command and control methods. This approach could also help avoid high transaction costs associated with bureaucratic systems, which often can stifle innovation and efficiency. A combination of self-regulation and incentive-based governmental oversight might be an appropriate and effective approach.[26]
- Likewise, utility scale will also need to be addressed when exploring ways in which IRP can be rolled-out within the region. Adapting expectations for mid- to small-sized utilities will be necessary to avoid overburdening utilities at this scale.

23 Amy L. Vickers, "Integrated Planning's Conservation Component: What Water Managers Need to Know."
24 Patrick C. Mann, "Integrated Resource Planning and Incentive Regulation."
25 Steve Kihm, Energy Center of Wisconsin, "When Revenue Decoupling Will Work…and When it Won't Work," The Electricity Journal, October 2009.
26 Janice A. Beecher, "Integrated Resource Planning Fundamentals," Journal AWWA, June 1995.

Moving forward - challenges, needs, considerations and opportunities (continued)

Opportunities:

There is growing support for improved water planning and management. IRP is becoming increasingly popular throughout the country as a viable approach to improved water planning and management. The Aspen Institute's Energy and Environment Program recently released a report from its Dialogue on Sustainable Water Infrastructure in the U.S. Some of the report's recommendations include the following:[26]

> "Water utilities must lead in building partnership that will use integrated water resource planning and management as a principal tool for preserving and restoring water resources while meeting human and ecosystem needs for water in the context of a changing climate."

> "Water utilities should employ a variety of practices on the path to sustainability, including: transparency in governance and operation; public outreach and consultation; integrated water management; asset management; workforce management; conservation and efficiency (both water and energy)…"

The Compact was a big first step in acknowledging the value of the Great Lakes and the importance of intergovernmental cooperation. In an ever increasing water scarce world, it is of paramount importance that this region plan and manage its water resources with sustainability, economic efficiency and cooperation as the guiding principles for any future infrastructure decision-making processes. Ensuring the health of our water resources within the Great Lakes region is critical to our economic, social and environmental well-being. As demonstrated throughout this paper, integrated resource planning's framework can be a key contributor to achieving this goal.

26 The Aspen Institute Energy and Environment Program, "Sustainable Water Systems: Step-One – Redefining the Nation's Infrastructure Challenge," A Report of the Aspen Institute's Dialogue on Sustainable Water Infrastructure in the U.S. Pub No: 09-011. 2009.

Appendix A: Definitions

Avoided Costs

In the context of IRP for water sector utilities, avoided costs are the incremental savings associated with not having to produce (or treat) additional units of water while meeting demand requirements.[27] There are 3 types of avoided costs: direct costs (capital and operating costs), indirect costs (externalities, etc.), and opportunity costs.

Demand Management

Involves any strategy to eliminate or defer the need for an investment in new capacity by the utility, including conservation, load management, and pricing strategies.[28]

Full Cost Pricing

Attempts to account for all costs including internal & external, public & private, monetized & non-monetized.

Integrated Resource Planning

"…is a comprehensive form of planning that encompasses least-cost analyses of demand-side and supply-side management options as well as an open and participatory decision-making process, the development of water resource alternatives that incorporates consideration of a community's quality of life and environmental issues that may be impacted by the ultimate decision, and recognition of the multiple institutions concerned with water resources and the competing policy goals among them. IRP attempts to consider all direct and indirect costs and benefits of demand management, supply management, and supply augmentation by using alternative planning scenarios, analyses across disciplines, community involvement in the planning, decision making, and implementation process, and consideration of other societal and environmental benefits.

IRP includes planning methods to identify the most efficient means of achieving the goals while considering the costs of project impacts on other community objectives and environmental management goals. These planning methods specifically require evaluation of all benefits and costs, including avoided costs and life-cycle costs."[29]

"IRP is a continuous process that results in the development of a comprehensive water resource management plan. It identifies and gives balanced consideration to supply and demand management planning alternatives. It includes analyses of engineering, economic, societal, and environmental costs and considerations while balancing the needs of competing users and multiple objectives of the use of the resource. It is an open and participatory process involving all stakeholders and striving

27 Janice A. Beecher, "Avoided Cost: An Essential Concept for Integrated Resource Planning."
28 Rocky Mountain Institute "Water Efficiency – A Resource for Utility Managers, Community Planners, and Other Decision makers." Through Cooperative Agreement with the U.S. Environmental Protection Agency Office of Water, Office of Wastewater Enforcement and Compliance. November 1991.
29 AWWA MainStream, White Paper "Integrated Resource Planning in the Water Industry," June 1994.

Appendix A: Definitions (continued)

for consensus, while encompassing least-cost analyses of short- and long-term planning options, and satisfying utility and regulatory policy goals. Finally, IRP explicitly seeks to identify and manage risk and uncertainty and provides for coordination of planning between water and wastewater utilities in a specific region."[30]

Least-Cost Planning

"…term…used to describe the methodology employed by some water and energy utilities in which demand- and supply-side options are directly compared in order to determine the appropriate mix and achieve the least cost outcome."[31]

Levelized Cost

Describes the unit cost of conserved water or energy. It is generally calculated by dividing present value costs by the total volume of water saved via a demand management program over a given period.[32]

Marginal Cost

In this case refers to the cost of producing or treating (or *not* producing or treating) an additional unit of water.

30 AWWA Research Foundation (AwwaRF)

31 S.B. White, "Sustainable Water Management: A Demand Side Approach," WaterTECH conference proceedings, Brisbane, AU 1998.

32 Fane S., J. Robinson, S. White "The Use of Levelised Cost in Comparing Supply and Demand Side Options," Water Supply Vol 3 No 3 pp185-192, IWA Publishing.

This review is a part of the Center for Neighborhood Technology's (CNT) *Great Lakes Sustainable Water Planning* project generously funded by **The Joyce Foundation**. For more information please visit: www.cnt.org