APPROVED 1/20/2016 (TAC)

SUMMARIZED MEETING MINUTES

City of Scottsdale
Environmental Quality Advisory Board
Regular Meeting

5:30 p.m., Wednesday, December 16, 2015
Scottsdale Community Design Studio
7506 E Indian School Rd., Scottsdale, AZ 85251

PRESENT:	Alisa McMahon, Chair Candice Gimbel, Vice-Chair Michel Hulst, Board Member Dane Englert, Board Member Steven Schlosser, Board Member (telephonically)
ABSENT:	Bruce Travers, Board Member (Note: Ted Geisler has requested to be withdrawn from membership)
STAFF PRESENT:	Tim Conner, Office of Environmental Initiatives Anthony Floyd, Office of Environmental Initiatives Sam Brown, Office of Environmental Initiatives Elisa Klein, Water Resources Conservation Department

Call to Order:
Chair McMahon called the regular meeting of the Environmental Quality Advisory Board (EQAB) to order at 5:42 p.m.

Roll Call:
A formal roll call took place confirming the members present as stated above.

Public Comment:
None provided, one member of the public present

1. **Introduction of new Member Ted Geisler** — Chair and Board
   Mr. Conner informed the board that he had learned earlier today that Mr. Geisler has withdrawn his membership to the Board due to conflicting commitments. He had submitted an email to Mr. Conner and the City Clerk's Office. The next Board and Commission Selection Process will take place in January 2016.

2. **Approval of Summarized Meeting Minutes -- Regular Meeting: November 18, 2015. Possible action** — Chair McMahon

MOTION AND VOTE – ITEM # 2

Vice-Chair Gimbel provided a motion to approve the November 18, 2015 Summarized Meeting Minutes, Board Member Schlosser provided a second to the motion; **MOTION APPROVED 5-0**

3. **Past Member Floyd Marsh presenting summary of the following topic:** — Past Member Floyd Marsh
   - **Updated submittal to the Board - white paper on Alternative Water Softening Technologies - Discussion and possible action**

Past Board Member Marsh reviewed his recent editing effort on the white paper. He stated that this latest product represents the limits of the work that he believes he can contribute to this effort. He thought it would be best that another member take over from this point as he believes he is too close to the topic to be furtherly objective.

Mr. Marsh provided overviews of his responses to the four sets of comments that he had received.

Board Member Schlosser stated that he felt the latest draft of the white paper is of high quality as it is written and stated he believed the board should move forward with the document.

Vice-Chair Gimbel asked Mr. Marsh if there was more that needs to be done to the white paper, or if it is finished. Mr. Marsh replied that he felt the document was complete.

Board Member Schlosser said that it may be a good to bring up the large point of what the cost will be if the city does not pursue changing to salt free technologies. He thought that point should be brought to the first part of the document.

Chair McMahon asked if the Board had the rights to use Figure 1

and Table 2 as it was pulled from another report on salinity. Mr. Marsh stated that the City participated both in the contributions of content and financially. That should give the City the appropriate rights; also he felt that the source was acknowledged in the general bibliography and on each of the documents. There was discussion regarding the phrasing of the citing of the source on the two documents, and there was an agreement that the citation should simply use the phrase “from”.

Chair McMahon also asked if there was an omission of the summary matrix. It was discovered that Mr. Conner had unintentionally left that page out of the document presented to the Board, and agreed to find the most current version of that document for inclusion.

Board Member Schlosser asked if the intended audience was the Mayor and Council. Chair McMahon suggested that the document could be used also to educate the public. Vice-Chair Gimbel asked if releasing it to the public would be advancing it before the staff policy was framed. Board Member Hulst said EQAB as an advisory group should advise the Mayor and Council. The Mayor and Council could then direct EQAB and/or Water Resources staff to pursue the issue further. All members appeared to agree with Board Member Hulst’s interpretation.

Vice-Chair Gimbel stated that she felt the executive summary needed to state what was found in the research, and what the Board was recommending to the Mayor and Council. Additionally, she felt that the scenario of what may happen if action is not taken should also be in the executive summary.

Mr. Marsh recalled an internal memo in 2008 that was the impetus of the Salt Free Rebate Program. He suggested that the Board might also be able to pull information from that that memo and the original report.

Board Member Schlosser said maybe it was time to give the Council the bad news that if they don’t choose to take action, the there is a $90 million dollar problem that may be the alternate option to reducing the salinity problem. Board Member Hulst was in agreement that now is the time to give the Council that information.

Mr. Marsh reminded the Board that it will be important to keep

current contact with the local and national water associations to keep the document a living document.

Mr. Conner suggested that the Board might consider minor modifications to the white paper as submitted by Mr. Marsh combined with a cover memo from the Board with the larger points that the Board felt needed to be brought to the front of the communication. Also Mr. Conner strongly suggested that the report and the cover memo should be reviewed for comments and corrections by the Water Resources staff.

MOTION AND VOTE – ITEM # 3

Motion #1 by Board Member Schlosser to adopt Mr. Marsh's document with minor modifications discussed and incorporate a brief cover memo to highlight summary points, Second provided by Board Member Hulst.

Motion #2 by Board Member Schlosser to accept Mr. Marsh's current document so that the board may further edit it for content, organization, and grammar, and to create a cover letter describing the need for ongoing research and updating of this topic, summarize key points and encourage a call to action by the Council to either direct the board or staff to initiate additional measures to address the issue of reduction of salinity through the use of salt free water softener systems. Second provided by Board Member Hulst;
MOTION #2 APPROVED 5-0

4. **Administrative Report - Discussion** — Tim Conner, Anthony Floyd & Board Members
   - **Updates and opportunities – Conner**
   - **Annual Report Draft – Conner**
   - **January business meeting overview – Conner**
   - **Green Building Lecture update – Floyd**

5. **Updated overview of progress for the idle reduction during student pickup and drop off at Scottsdale Unified School District. Discuss next steps for EQAB. – Discussion and possible action** — Board Member Gimbel, Chair McMahon

Vice-Chair Gimbel briefed the board members who had recently been appointed on the history of the school idling issue. Chair McMahon said she wanted the Board to know that the reference packets were still being worked on and would be brought back to a future meeting. She also said that she was considering consulting with Julie Finke of ADEQ and Bill Sheaffer with the Clean Cities Coalition. They had both been involved in the issue and have also worked with other districts and communities on this issue. Item to return to next meeting for an update.

6. **Board discussion and possible action regarding Transportation Director's Transportation Master Plan Update Presentation. – Discussion and possible action** — Chair McMahon

   No discussion, no action. Item to return to future agenda

7. **Board discussion and possible action regarding the development of the 2015-2016 EQAB work program topics list including the possible reassignment of projects previously championed by retiring board members – Discussion and possible action** — Chair McMahon & Board Members

   A brief discussion took place. Board Member Schlosser said in addition to the alternate water softener technology he would be interested in solid waste management. Board Member Englert said he was interested in extreme heat cities, carbon inventories, urban heat island effect water supply and possibly a gas powered leaf blower ordinance. No action was taken. Item to return to future agenda

8. **Discussion regarding possible City participation in the United Nations Climate Summit Compact of Mayors – Discussion and possible action** — Board Member Gimbel

   No discussion, no action. Item to return to future agenda

9. **Board Members' reports, updates and suggestions for future agenda items – Discussion** — Chair McMahon & Board

   - Possible Regional Greenhouse Gas Inventory
   - Future Water Resources program overview and salinity presentation

- Future Solid Waste presentation/discussion
- Extreme heat cities/ASU discussion

10. **Updates and reminders –** — Chair McMahon & Board Members
    - Next EQAB Regular Meeting Wednesday, January 20, 2016 at the Community Design Studio 5:30 p.m.
    - Next Green Building Lecture – January 7, 2016 at 7:00 PM at the Granite Reef Sr. Center. Topic: New Year Resolutions: Green Home Care
    - Additional announcements by Board Members & Staff

Adjournment: With no further business to discuss, the Environmental Quality Advisory Board adjourned at 8:10 p.m. — Chair McMahon & Board

ATTACHMENTS:

White paper:

*"Scottsdale Unsalted" A Review of Alternative Salt-Free Water Treatment Technologies for Effective Salinity Management**

"SCOTTSDALE UNSALTED": A REVIEW OF ALTERNATIVE SALT-FREE WATER TREATMENT TECHNOLOGIES FOR EFFECTIVE SALINITY MANAGEMENT*

Executive Summary

Water conservation, supply management, sustainable water quality, and salinity reduction are inextricably linked challenges in Scottsdale's water future. Various sources and reports conclude that the Phoenix metropolitan region accumulates salt at an estimated net rate of 1.2 million tons annually. Sustainability of regional water supplies requires that this long-term net salt balance must be reduced, and not increase, in order to preserve quality of existing groundwater and reclaimed water supplies. As salinity levels of reclaimed water increase at the same time as reuse of reclaimed water also increases with potable supply to meet the demands of population increases, salinity will itself become an ever increasing management challenge.

In the City of Scottsdale (Scottsdale/City) water service area, it is estimated that residential water softeners add between 15 to 20 percent of source salts to the salt load from supplies treated and delivered in the service area. In Scottsdale, these salt sources cumulatively add about 350 milligrams per liter (parts per million, ppm) representing about one third of the total dissolved solids (TDS) in the reclaimed water supply treated for reuse. The City estimates it spends $3 million in annual operating costs to remove salinity from its potable and reclaimed supplies reused for turf irrigation and recharge. Reclaimed water is an essential portion of Scottsdale's total long range water supply.

The purpose of this white paper is to provide a qualitative comparison of four (4) salt-free alternative technologies relative to typical residential salt-based water softening. This paper provides a comparative evaluation of these alternative technologies. The central conclusion is that technical and economic assessment of these technologies is evolving and a number of challenges remain to make direct quantitative comparisons. This paper concludes with six specific conclusions, suggested follow up and policy recommendations.

Problem Statement and Paper Objective

Increasing salinity due to salt build up through continual importation of higher salt water sources (surface water) and advanced treatment of the City's wastewater stream (reclaimed water) for reclaimed irrigation use and recharge is a rapidly emerging water management issue for Scottsdale. Overall this salinity load becomes one of the major factors impacting effective water reuse and reclamation. If salinity levels continue to rise and future salinity limits are imposed by regional jurisdictions, a standalone brine disposal facility could cost Scottsdale an estimated $90 million to construct and $2 million per year to operate (JLSC Strategy for Water Softener Salinity Control and Management, 2014).

Increasing TDS in reclaimed wastewater supplies is costly to treat and also creates a brine stream disposal challenge. Recent studies indicate that salt reduction at the initial source, reducing salinity before it enters the municipal wastewater stream, is the most cost effective option. Capital construction and annual operating costs for centralized removal through advanced treatment systems are far more expensive options.

Based on Scottsdale's proactive reuse and recharge programs for ensuring sustainability of future water supplies, increasing salinity is a central challenge. These water supply management goals

result in higher salinity levels due to advanced wastewater treatment processes to reclaim, reuse and recharge the City's available water supplies. For example, in the Scottsdale water service area, it is estimated that residential water softeners add 15 to 20 percent of all source salts, such as those in water supplies imported through the Central Arizona Project (CAP) and SRP delivery systems. Sodium, much from residential and commercial water softening, is the single component projected to have the greatest impact on regional salinity. As a result of this increasing salinity, Scottsdale estimates it currently spends $3 million in annual operating costs to remove salinity from potable and reclaimed water supplies.

Addressing this salinity management concern, in 2008 the City developed an initial assessment of salinity impacts and recommendations for sodium reduction in Scottsdale's reclaimed water supplies. This internal report referenced in the bibliography for additional details was prepared by Water Resources staff and provided an overview of the salinity concern in the City's water sources based on available data, an assessment of this data and several recommendations for a proposed program to address the issue. This assessment became the foundation, together with more detailed research and analysis in water-wastewater master plan updates, for the City's pilot salinity reduction rebate program for residential water softening devices implemented in July 2014. The initial rebate program, designed to focus on customer-generated salt impacts of residential softener usage, comprises a two-year pilot program. This pilot program focused on three options to reduce residential water softer impacts, test the rebate approach including rebate amount for each option and measure the public's response to mitigate the salinity issue.

This white paper provides a qualitative comparison of four (4) salt-free alternative technologies relative to residential salt-based water softening such as ion exchange. Each of these alternative technologies is typically referred to as water conditioning or treatment through physical or mechanical processes. Water is not chemically softened through these processes. No ion exchange occurs using these water conditioning alternatives to remove the hardness component. Rather, these scale forming components of hard water are modified through treatment or conditioning such that scale does not build up on home plumbing and appliances.

The goal of this effort is to provide a comparative evaluation of these alternative technologies such that the City can provide background and input to residential and commercial customers allowing them to make informed decisions on replacing conventional water softeners. The results of this effort are not exhaustive and should be considered a work in progress. This is because the development of performance standards, device testing and certification of the technologies by independent industry organizations are themselves in progress and not complete in all cases. In addition, key operational parameters of interest, such as long-term reliability, annual operating costs and long-term (10 year) capital costs are not universally available in quantitative terms. EQAB, however, feels that this assessment of initial information is useful to City decision makers and water customers to make informed decision on a qualitative basis. This is the context in which this background and these recommendations are provided. This initial effort provides a building block as the standard development, scientific testing and certification process advances for individual devices within specific technologies.

Introduction to Water Salinity and Impacts in Scottsdale

Simply defined salinity is the total amount of both natural and inorganic minerals dissolved in water. Such dissolved minerals are commonly referred to as salts such as sodium, potassium, calcium, magnesium, sulfate and chlorides measured as total dissolved solids (TDS) in milligrams per liter (mg/l). Most of Arizona has hard water defined as the hardness minerals of calcium and magnesium greater than 120 milligrams per liter or hardness of 7 grains per gallon (gpg). These salts contribute to increased salinity entering the wastewater stream through back flushing of ion exchange water softening systems.

Reclaimed water is the single supply that expands with increased municipal water use. Thus increasing salinity levels limit the potential of reclamation and potential reuse of water supplies with major economic impacts. Increased salinity of the supply presents challenges to the ultimate end users and threatens the quality of both groundwater and surface water supplies whether reclaimed and reused for irrigation or recharge. Reclaimed water is the source most directly and immediately impacted by high salinity. In 2014, the City treated and delivered an estimated 2.1 billion gallons (6,445 acre feet) of reclaimed water for turf irrigation and more than 1.3 billion gallons (3,990 acre feet) of advanced treated reclaimed water to underground storage through recharge. To make the most beneficial use of these reclaimed water supplies, they must be treated to advanced levels to reduce salinity to acceptable levels which is costly.

As an overview of water salinity impacts in the Phoenix metropolitan region, various sources and reports conclude that the region accumulates at an estimated net rate of 1.2 million tons annually. Impacts and costs of regional salinity are subtle and dispersed across all societal sectors with an estimated increased cost of more than $30 million for the Phoenix metropolitan region. Sustainability of future water supplies will require that this long-term net salt balance must be maintained (and not increase) in order to preserve quality of the existing groundwater and reclaimed water. However, as salinity levels of reclaimed water increase at the same time as reuse of reclaimed water also increases, salinity will itself become an ever increasing management challenge. Therefore, over the long term the two resource issues have compounding impacts and salt sources must be diverted from the regional wastewater treatment stream and reuse cycle. One solution to the salinity issue that can be controlled is diversion of a portion of this contributing salt load from the regional wastewater stream. Water softening from all possible activities is one of those “point of diversion sources” that can be effectively managed through future water salinity policy.

Scottsdale continually evaluates salinity loading in reclaimed water supplies and its impacts. Estimates indicate that nearly a third (32 %) of the total salinity (TDS), estimated to be 1,100 milligrams per liter (mg/l) in reclaimed supplies, is derived from residential and commercial softening diverted into the wastewater stream being treated and reclaimed, whereas, an estimated 60 % comes from natural sources in raw surface water sources from SRP and CAP supplies before treatment for potable uses. The remaining salinity load represents miscellaneous human activities such as food processing wastes and cooling tower discharges.

Approach to Technology Assessment

This EQAB effort has been a collaborative endeavor. In addition to independent research, we engaged other informational sources. We invited and benefited from four briefings by City Water Resources staff focused exclusively on salinity management issues and reduction strategies, both

before and following adoption of the 2014 salinity rebate program. The Board also hosted and participated in three presentations at monthly Board meetings made jointly by the Arizona Water Quality Association (a state-level non-profit trade organization) representatives and technical and regulatory policy staff of the national Water Quality Association, an international non-profit trade association of the water treatment industry. These sessions included periodic updates of the process for standard development, testing and certification of the salt-less scale reduction (water conditioning) technologies.

In addition, a representative of the Board participated in meetings of the Arizona Joint Legislative Study (JLS) Committee's Technical Advisory Committee as the advisory committee developed its final report to the JLS, titled *Strategy for Water Softener Salinity Control and Management*, January 22, 2014. (This report is listed in the bibliography for reference.)

In 2013, the Board also reviewed and offered general comments on the draft Project Report titled *Evaluation of Alternatives to Domestic Ion Exchange Water Softeners.* (This final publication is available as a download or hard copy at: https://www.watereuse.org/watereuse-research/08-06-evaluation-of-alternatives-to-domestic-ion-exchange-water-softeners/.) This research study conducted for the WateReuse Research Foundation was a laboratory bench test of four alternative scale reduction treatment devices compared to conventional ion exchange.

Overview of Salt-Free Alternative Technologies

With advances in water softening and conditioning, consumers now have alternatives to traditional salt-based ion exchange softeners. This section provides an overview and comparison of currently available salt-free technologies. These water treatment technologies are commonly referred to as either: 1) salt-based ion exchange water softening or 2) alternative technology salt-free water conditioning through physical and mechanical processes. Each of these technologies is described more completely and summarized in **Appendix A** and **Table 1**.

The four salt-less alternatives evaluated include: capacitive deionization (CDI); electrically induced precipitation (EIP); magnetic water treatment (MWT); and template assisted crystallization (TAC). Salt-free technologies reduce scale build-up of dissolved minerals that cause hardness forming scale inside plumbing, water fixtures and appliances without using sodium or potassium salts for chemical exchange, but do not chemically soften water. Further, most salt-less technologies do not require any drain discharge, special plumbing, back washing of media requiring additional water consumption or disposal of a concentrated brine stream.

A fifth alternative is actually an in-home portable exchange tank (PET) service that uses conventional ion exchange water softening in a portable tank for exchange. This option provides an in-home service to the residential user by periodically replacing exhausted ion exchange tanks. Though using ion exchange (IEX) as the softening process, this in-home service is in effect a salt-free alternative at the residential level, since it diverts the self-regeneration brine stream from the municipal wastewater stream to a centralized commercial facility.

Evaluation Criteria

To compare and make qualitative assessments among the alternative technologies relative to ion exchange softening (IEX), a matrix of the most relevant criteria was developed. These criteria are represented in **Table 1.** The seven key criteria selected include: a salt requirement if any, maximum power requirement to operate the system, the backwash requirement if any, scale

removal efficiency, estimated 10-year life cycle capital costs, and two key operational parameters of reliability and annual operating costs. Whenever quantifiable data were available and could be documented, specific data were used for comparisons. In cases such as long-term operational reliability and in some cases annual operating cost data were incomplete or otherwise not well defined estimates and only relative comparisons were used. It is suggested that as such data becomes more readily available and can be documented that rankings based on those criteria be updated. Ongoing development of testing standards, performance test results and certification of specific devices by certifying organizations will be a reliable source for such updated information and improved comparisons.

Summary

Although dependent on the specific needs, choices and water quality objectives of individual water consumers, there are effective salt-free alternative technologies to salt-based ion exchange water softening. These water conditioning alternatives do not soften water by direct removal of hardness per se, but provide many of the other benefits of salt-based softening, particularly effective scale prevention and removal protecting household plumbing and home appliances from scaling. Also, salt-free water conditioners retain all essential minerals for healthier drinking water. As illustrated in **Table 1** most alternative technologies require no chemicals or salt, electricity or back flushing for brine discharge and disposal with no additional water required for this operation. This translates into minimal maintenance compared to softening processes. The favorable characteristics of salt-less technologies are summarized and compared in **Table 1** relative to ion exchange softening. In this group of alternatives, TAC performs substantially better than other technologies against the evaluation criteria and demonstrated the most significant potential as an effective option to salt-based softening.

Results and Recommendations

A central conclusion of this effort, apart from the comparative overview, is that assessment of these technologies is evolving and a number of significant data challenges remain to thoroughly and effectively compare them. The most important unknowns identified by this study include: verifiable information on life-time operational reliability and both long term capital investment and operational costs. This data cannot yet be reliably documented or certification testing has not been completed. In addition, in some cases there is a lack of accepted standards for evaluating these technologies with the result that certification by recognized organizations based on testing and certification standards are not yet developed. While, in other cases they are evolving, but actual testing of devices against performance standards has not yet been started by certifying organizations.

The following conclusions, proposed follow up and policy recommendations are submitted:

- With no endorsement of brand, manufacturer or vendor, the TAC conditioning technology appears to be both the most advanced and effective based on current testing and verifiable results showing the most promise as a salt-free alternative;
- Other alternative technologies with some but limited promise ranked in relative order of highest scale removal efficiency and residential application include: 1) capacitive

Table 1 – Qualitative Comparison of Alternative Treatment Technologies Relative to Traditional Salt-based Ion Exchange Water Softening (1)

deionization (CDI); 2) electrical induced precipitation (EIP); and 3) magnetic water treatment (MWT);

- City and EQAB should continue to monitor and interact with WQA and other accredited testing and certification bodies for progress and updates in standard development, verifiable testing and certification of devices in each of the above technologies as well as new technologies that might develop;
- City should approve for installation only those technologies which meet certified minimal criteria in testing, performance standards, and operational reliability as well as meeting manufacturers' performance claims for water treatment;
- City should continue a proactive focus on consumer education regarding cost impacts of increasing salinity and the long-term benefits of alternative technologies to reduce these impacts; and
- Finally, as a component of its ongoing customer rebate feedback process, City should consider adding customer assessment of the salt-free technologies installed based on the evaluation criteria presented in this paper **(Table 1)**.

Based on this background on advances in alternative water conditioning and product performance testing and certification, EQAB stands ready to support and assist the City with future salinity management challenges.

Appendix A - Descriptive Summary of Alternative Salt-Free Technologies Relative to Traditional Ion Exchange Water Softening
Appendix B - List of Tables (1 and 2) and Figure (1)
Appendix C - General Bibliography of Literature Reviewed and Cited

*White paper prepared and submitted by the Environmental Quality Advisory Board as background for review and consideration of Mayor and Council and the City Water Resources Department. Background research, documentation and paper preparation efforts were led by Floyd Marsh, former EQAB board member (2009-2015).

Water Treatment Technology	Salt Required	Maximum Power Required (in watts)	Backwash Required	Scale Removal Efficiency	10-Year Life Cycle Cap. Costs*	Operational Parameters**	
						Reliability	Annual Costs
Ion Exchange (IEX)	Yes	50 W	Yes	65 -70 %	Moderate to High	High-salt/water use efficiency improving	Moderate
Capacitive Deionization (CDI)	No	220 W	Yes	83 %	High	ND	High
Electrically Induced Precipitation (EIP)	No	100 W	Yes, to clean electrode	54 %	High	ND	High
Magnetic Water Treatment (MAT)	No	8 W	No	53 %	Low	ND	Low
Template Assisted Crystallization (TAC)	No	None	No	99 %	Low	High, but dependent on water chemistry	Low
Portable Exchange Tank Service (PET)	Yes, portable IEX exchange tank	In central facility only	No, media regenerated at central facility	65 -70 %	High	High	High

(1) Relative comparisons with specific data taken primarily from *Evaluation of Alternatives to Domestic Ion Exchange Water Softeners,* Project Report 08-06, by Fox et.al, prepared for WateReuse Research Foundation, Alexandria, VA, published 2014, supplemented by other independent sources. Relative data and "yes/no" responses are intended for illustrating qualitative comparisons only.

***** Responses are expressed as relative range due to limited quantitative data. ****** Operational data are incomplete and taken from various sources. (ND = no verifiable data currently available).

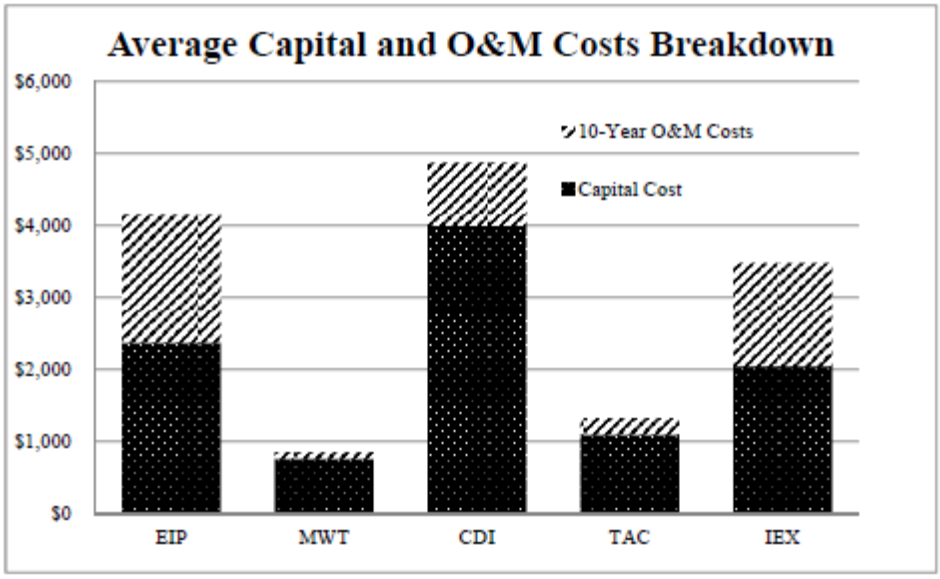

FIGURE 1: AVERAGE LIFE CYCLE COSTS WITH O&M AND CAPITAL COST BREAKDOWN

Based on the data presented in Table 2 and Figure 1, the highest 10-year life-cycle cost of the alternatives reviewed for CDI, and MWT is the lowest. It should be noted that CDI is not currently as readily available to homeowners as other technologies, and the capital cost may decrease as competition is introduced.

Adapted from: Water Reuse Research Foundation 2014, Evaluation of Alternatives to Domestic Ion Exchange Water Softeners, Project Report (3)

TABLE 2 ANNUAL ESTIMATED O&M, CAPITAL, AND 10-YEAR LIFE CYCLE COSTS BY TECHNOLOGY

Treatment Technology	System ID	Total Annual O&M Costs	Capital Cost	10-year Life Cycle Cost
Electrically Induced Precipitation	EIP 1	$236	$3,000	$5,522
	EIP 2	$184	$4,150	$5,716
	EIP 3	$88	$850	$1,597
	EIP 4	$266	$1,500	$3,768
	Averages	$194	$2,375	**$4,151**
Magnetic water Treatment	MWT 1	$7	$500	$560
	MWT 2	$4	$500	$537
	MWT 3	$7	$750	$810
	MWT 4	$31	$1,299	$1,561
	MWT 5	$7	$750	$810
	Averages	$11	$760	**$855**
Capacitive Deionization	CDI 1	$102	$4,000	**$4,873**
Template Assisted Crystallization	TAC 1	$80	$1,750	$2,432
	TAC 2	$0	$795	$795
	TAC 3	$0	$750	$750
	Averages	$27	$1,098	**$1,326**
Ion Exchange	IEX 1	$168	$1,700	$3,130
	IEX 2	$168	$949	$2,379
	IEX 3	$168	$3,495	$4,925
	Averages	$168	$2,048	**$3,478**

Adapted from Figure 1 – See Figure 1 for detailed notations

Appendix A - Descriptive Summary of Alternative Salt-Free Technologies Relative to Traditional Ion Exchange Water Softening

- Ion Exchange Softening (IEX): An ion exchange water softener (IEX) is the conventional salt-based system. This technology chemically removes hardness ions and softening hard water by exchanging sodium (or potassium) ions for the calcium and magnesium ions of hard water as the water passes through a bed of negatively charged resin beads of sodium ions. This exchange process removes the positively charged hardness particles into a brine solution. The calcium and magnesium ions essentially trade places with the sodium ions and the water is softened. When all the available sodium ions are used producing softened water, the media must be back flushed with salt brine. In contrast to salt-less systems, an ion exchange system produces truly softened water, since the hardness is removed. The major disadvantage to this process is significant salinity is added to the wastewater stream as the media is back flushed of hardness minerals and regenerated. In addition to using salt in the exchange, this process also requires additional water (estimated at 50-100 gallons per regeneration) to continue the next softening cycle.

- Capacitive Deionization Conditioning (CDI): CDI is an electro-chemical treatment process similar to typical water softening requiring regeneration of the media and brine back flushing. In this process, the hardness ions of opposite charges adsorb to charged electrodes. A solution is flushed between negative and positive charged electrodes, and the respective ions move towards their opposite charge. These electrodes acting as ion capacitors become saturated and then reverse their polarity, trapping the ions between the membranes during regeneration. After this, the cell is flushed and clean, ready to be used again. However, CDI does not use salt in this process, making it an eco-friendly choice for water conditioning. The process has high initial capital costs and operating costs due to higher energy requirements and is not a well suited technology for residential uses.

- Electrically Induced Precipitation Conditioning (EIP): This conditioning method physically reduces scale in hard water using an electric field produced by a direct electrical current, which dissolves and precipitates scale forming particles such as calcium and magnesium. Passing through an electric field formed by a series of wires or magnets wrapped around the exterior of a pipe, alters the hardness ions so they precipitate in the water flow and eventually adhere onto an electrode as opposed to on metal surfaces of the plumbing or typical household devices. The special electrode which collects the scale particles requires frequent cleaning to ensure this physical removal process operates efficiently. This technology requires relatively high electrical power input to produce the necessary electric field with relatively low scale removal efficiency. These considerations limit EIP for typical residential applications.

- Magnetic Water Treatment (MWT): In the magnetic water treatment system, water is flushed through a magnetic field created by a signal cable externally wrapped around a water pipe, which neutralizes the hard minerals in the water for 2-3 hours; hence, the conditioning process is only temporary as the original hardness returns with time and scale from the hardness particles reform and depositing on surfaces. The magnetic field alters the crystals from high to low density particles that keep scale from forming. This unique form of water conditioning is becoming more available to residential customers, but questionable claims and mixed reviews detract from its effectiveness in scale reduction.

- Template Assisted Crystallization Conditioning (TAC): Much like a conventional water softener, TAC methods employ a surface-treated resin bead medium to convert hardness ions to scale-resistant forms. The water passes through the treatment medium which attracts excess dissolved hardness ions (calcium and magnesium) removing them from solution by converting them into harmless, inactive crystals that stay in suspension. These free flowing crystals continue to grow in size while in suspension. The inert particles remain indefinitely suspended without forming scale. However, while an ion exchange softener requires regeneration with addition of salt, TAC methods do not. No maintenance, salt, or even electricity is needed. While ion softeners remove magnesium and calcium ions from water through chemical exchange, TAC systems simply alter the ionic forms of the hardness minerals into a crystalline structure resulting in suspended insoluble particles to reduce scale formation. These particles remain in suspension indefinitely and will not form scale on plumbing surfaces. In addition, taste of TAC conditioned water remains the same.

- Portable Exchange Tank Service (PET): The Portable Exchange Tank (PET) option is actually a form of ion exchange softening but based on in-home service to replace the brine collection tank. This alternative provides soft water to homes and businesses using conventional ion exchange without discharging salt to the wastewater stream at the home or business. When replaced the exhausted portable tanks are regenerated at centralized treatment facilities in a controlled environment with brine reclaimed and reused, reducing the potential for salt discharge. Centralized plant regeneration from portable tanks results in no salt or water discharges to the municipal sewer system. This in-home service in addition to high monthly cost, however, can be intrusive and inconvenient to the customer.

Appendix B – List of Tables and Figure

Tables:

Table 1 – Qualitative Comparison of Alternative Conditioning Technologies Relative to Traditional Salt-based Ion Exchange Water Softening.

Table 2 –Estimated Annual and Comparative O & M and 10-year Life Cycle Costs by Alternative Technology (as adapted from Reference 3 in General Bibliography).

Figure:

Figure 1—Average Estimated and Comparative Capital and O & M Costs by Alternative Technology (as adapted from Reference 3 in General Bibliography).

Appendix C – General Bibliography of Literature Reviewed or Cited

1. Bureau of Reclamation, 2003, *Central Arizona Salinity Study, Phase I.*
2. Bureau of Reclamation, 2006, *Central Arizona Salinity Study, Phase II*.
3. WateReuse Research Foundation, 2014, *Evaluation of Alternatives to Domestic Ion Exchange Water Softeners, Project Report 08-06*, Fox, et. al. authors.
4. City of Scottsdale, 2014, *Proposed Program for Salinity and Sodium Reduction in Scottsdale's Reclaimed Water*, Internal Water Resources Department Staff Memo.
5. Technical Advisory Committee to Arizona Joint Legislative Committee on Water Salinity Issues, January 22, 2014, *Strategy for Water Softener Salinity Control & Management*, Committee Report.
6. *Water Quality for Dummies, Special Edition* produced by Water Quality Association, 2014.