WaterSMART: Development of Feasibility Studies under the Title XVI Water Reclamation and Reuse Program for Fiscal Year 2017

North Alamo Water Supply Corporation
420 S. Doolittle Road Edinburg, Texas 78539
(956) 383-1618 · (800) 734-0620

Feasibility Study of Energy-Efficient Alternatives for Brackish Groundwater Desalination for the North Alamo Water Supply Corporation

Applicant
North Alamo Water Supply Corporation
Steven Sánchez
General Manager
420 S Doolittle Rd, Edinburg, TX 78542
Email: ssanchez@nawsc.com
Address:

Project Managers:
Robert Rodríguez, rrodriguez@nawsc.com
Jorge A. Arroyo, PE jorge.arroyo@freese.com

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Executive Summary

Date: January 5, 2017
Applicant Name: North Alamo Water Supply Corporation
Counties: Hidalgo, Willacy and Cameron
State: Texas

The North Alamo Water Supply Corporation (NAWSC or Corporation) provides potable water and wastewater utility service for rural residents of eastern Hidalgo, Willacy, and northwestern Cameron Counties. The NAWSC's boundary encompasses 973 square miles in the Lower Rio Grande Regional Planning Area (Region M). NAWSC serves more than 33,000 metered connections from six surface water treatment plants and five brackish groundwater reverse osmosis desalination treatment plants. The 33,000 metered connections represent an estimated population of 140,000. The Corporation's wastewater system serves approximately 2,000 connections [1].

The 2016 TWDB Region M Water Plan recommends developing 20,195 acre-feet of brackish groundwater desalination (BGD) over the next 50 years; nearly 18,000 acre-feet of this capacity is to be installed during the 2020 decade -See Table 1. BGD is a recommended strategy for fourteen entities in Region M including NAWSC [2]. This proposed 12-month study will examine energy use at NAWSC's existing BGD operations and determine the feasibility of implementing cost effective energy-efficiency improvements. The study will review BGD recommendations in the Region M Plan to determine possible revisions to the plan based on the findings of this study.

Improving the cost-effectiveness of BGD will benefit NAWSC's current and future desalination operations Region M. However, the potential benefits of this study transcend NAWSC and Region M. BGD is critically important to the future of Texas; 11 of the 16 regional water planning groups in Texas included BGD to meet future water supply needs. Furthermore, BGD is being investigated as a water supply opportunity in Oklahoma [3]. The results of this study will likely be valuable beyond Region M and Texas to other areas with similar source water quality profiles.

Table 1- Water Management Strategies in the 2016 Region M Water Plan for the 2020 Decade (acre-feet/year)

RECOMMENDED STRATEGY	AMOUNT
CONSERVATION	69.7 % (196,573)
OTHER SURFACE WATER	7.5% (21,124)
DIRECT REUSE	9.5% (26,726)
GROUNDWATER DESALINATION	6.2% (17,555)
GROUNDWATER WELLS AND OTHER	4.8% (13,557)
OTHER STRATEGIES	1.2% (3,493)
SEAWATER DESALINATION	1% (2,800)

Technical Study Description

The focus of this study is on identifying and determining the feasibility of energy-efficient alternatives for brackish groundwater desalination (BGD).

In the current Texas State Water Plan, 11 of the 16 regional water planning groups included BGD as recommended water management strategy or as a project to meet future water supply needs [4]. Clearly, BGD is a growing source of water supply in Texas (as well as in Oklahoma), but, as noted in the 2016 Biennial Report on Desalination submitted to the Texas Governor on December 1, 2016, the Texas Water Development Board (TWDB) states that "the relatively high cost and site specificity of seawater and brackish groundwater desalination compared to the cost of developing conventional fresh water supplies continue to be an impediment to advancing desalination in Texas" [5].

There are currently 46 municipal desalination plants in Texas capable of producing 123 million gallons per day. Most of these facilities rely on reverse osmosis (RO) technology [6]. Although reverse osmosis is an effective treatment technology, the energy required for treatment is one of the factors limiting broader application of BGD throughout the state [7]. In low salinity BGD applications, power consumption accounts for 10 to 22 percent of the total cost of water production and between 28 to 52 percent of the operational costs [8].

NAWSC is interested in reducing the energy demand of its BGD operations by examining the energy saving potential of implementing nano-filtration membranes (NF) in the treatment process. NF can be used to desalinate low salinity brackish groundwater for drinking purposes while using less power than RO. In 2013, the TWDB and the U.S. Bureau of Reclamation (Reclamation) studied the use of NF for desalinating brackish groundwater sources in Texas. The study determined that NF, when compared to RO, can reduce the energy consumption by approximately 40 percent for a representative sample of brackish groundwater water sources in Texas [7]. The sample included brackish water data from the Southmost Regional Water Authority and North Cameron Regional WSC - a NAWSC operated facility. The proposed feasibility study will examine NF chlorides rejection and its implication on permeate blending capacity; an increase in the size of the BGD facility may be required to compensate for the more limited blending capability of NF permeate with raw brackish groundwater.

NAWSC's five BGD plants have an average age of 9 years and are nearing the point where RO membranes will need to be replaced. Given that these facilities treat relatively low salinity brackish groundwater sources, the timing is right to explore the feasibility of cost effective alternatives to increase BGD energy-efficiency at these locations. NF is a promising candidate to achieve this objective.

This study will assess current energy use at two of NAWSC's existing BGD facilities, identify opportunities for increased energy-efficiency, develop energy-efficient alternatives, conduct life-cycle cost comparison analysis to determine cost-effectiveness and provide inter-state technical and information transfer. The study will include a review of the recommended BGD water management strategies in the 2016 Region M Plan to determine if the energy optimization of the NAWSC BGD facilities can be applied to future BGD facilities in the Rio Grande Regional Water Planning Area.

STUDY SCOPE

1. Introductory Information
    - 1.1. Identify North Alamo Water Supply Corporation (NAWSC) as the non-Federal project sponsor;
    - 1.2. Describe NAWSC's service area and population served; current water supply system and treatment capacities;
    - 1.3. Provide a map of the service area and location of major water supply features;
2. Literature Review
    - 2.1. Energy use and energy-efficiency in BGD operations;
    - 2.2. Nano-filtration membranes in brackish groundwater desalination;
    - 2.3. Water planning in the Lower Rio Grande Valley; and,
    - 2.4. Brackish groundwater availability in the Lower Rio Grande Valley portion of the Gulf Coast Aquifer.
3. Statement of Problems and Needs

3.1. Summary of Water Supply Needs and Water Supply Alternatives:

3.1.1. Summarize the 2016 Region M Water Plan findings regarding population, water demand, water supply and water supply needs projections and recommended water management strategies for the NAWSC service area and Region M;

3.1.2. Identify and describe the 2016 Region M Plan criteria for evaluating and selecting water management strategies;

3.1.3. Summarize the water supply and water management strategies findings and recommendations of the Rio Grande Basin Study;

3.2. Discuss need to procure cost-effective energy-efficient BGD for existing and future BGD facilities:

3.2.1. Identify key economic indicators for the study area and for Region M

3.2.2. Discuss potential long-term saving that may be achieved by implementing energy efficient BGD.

4. Water Reclamation and Reuse Opportunities

4.1. Describe current and potential uses for reclaimed water;

4.2. Describe water rights market in the Lower Rio Grande Valley and the opportunities for water reuse within that market;

4.3. Describe water reuse management strategies recommended in the 2016 Region M Water Plan;

4.4. Describe interactions between increased BGD supplies and potential reuse for the NAWSC water supply system and others;

4.5. Examine potential impact of increased BGD desalination on water reuse;

5. Baseline Development

5.1. Select two of NAWSC's five BGD facilities for the study; and, for each one of the two, prepare the following:

5.2. Process flow schematics;

5.3. Inventory existing water treatment equipment;

5.4. Compile raw and treated water quality data;

5.5. Prepare current energy use budget;

5.6. Identify and describe opportunities for energy-efficiency improvements;

5.7. Describe the No-Change scenario.

6. Alternatives Development

6.1. Define energy-efficiency goal;

6.2. Define alternative selection criteria;

6.3. Develop up to three energy-efficient options (Title XVI Project Options),

including but not limited to:

6.3.1. Operational modifications without replacing existing equipment;

6.3.2. Replace existing high pressure pumps with higher efficiency pumps;

6.3.3. Add (or replace) energy recovery systems with higher efficiency energy recovery systems;

6.3.4. Partial or complete retrofit existing reverse-osmosis system with nano-filtration systems;

6.3.5. For each alternative, quantify potential energy savings to be realized;

6.3.6. For each alternative, identify permitting strategy;

6.4. Water Reuse Considerations in the Analysis of Alternatives:

6.4.1. Examine potential changes to permeate and concentrate flow patterns resulting from proposed alternative modifications;

6.4.2. Examine concentrate routing options to maximize reuse potential;

6.4.3. Examine water-rights issues pertaining to increased concentrate discharges and additional reuse potential attributed to BGD water supplies;

6.4.4. Quantify potential impact to recommended reuse water management strategies in the Region M Water Plan;

6.5. Alternative Selection and Economic Analysis:

6.5.1. Conduct a life-cycle analysis of proposed energy-efficient BGD alternative;

6.5.2. Rank alternatives per defined selection criteria;

6.5.3. Select preferred alternative (Recommended Title XVI Project):

6.5.3.1. Conduct cost comparison of selected alternative and existing/projected BGD (status-quo on energy use) development;

6.5.3.2. Identify the degree to which top ranked BGD energy-efficient alternative is cost-effective, and the economic benefits to be realized with implementation;

6.5.3.3. Describe energy savings implications on water use;

6.5.3.4. Describe impacts of improved BGD on surface water use and brackish groundwater extractions.

7. Potential Environmental Impacts and Benefits of Selected Project Alternative

7.1. Examine potential benefits to the Arroyo Colorado and Lower Laguna Madre system;

7.2. Discuss whether, and to what extent, the proposed Title XVI project will have potentially significant impacts on endangered or threatened species,

public health or safety, natural resources, regulated waters of the United States, or cultural resources;

7.3. Discuss whether, and to what extent, the project will have potentially significant environmental effects, or will involve unique or undefined environmental risks;

7.4. Describe the status of required Federal, state, tribal, and/or local environmental compliance measures for the proposed Title XVI project, including copies of any documents that have been prepared, or results of any relevant studies;

7.5. Discuss/provide any other information available to the study lead that would assist with assessing the measures that may be necessary to comply with NEPA, and other applicable Federal, state or local environmental laws such as the Endangered Species Act or the Clean Water Act;

7.6. Discuss how the proposed Title XVI project will affect water supply and water quality from the perspective of a regional, watershed, aquifer, or river basin condition;

7.7. Describe/discuss the feasibility study's outreach strategy;

7.8. Describe the potential effects the project may have on historic properties; including potential mitigation measures, the potential for adaptive reuse of facilities, an analysis of historic preservation costs, and the potential for heritage education, if necessary.

8. Legal and Institutional Requirements

8.1. Analysis of any water rights issues potentially resulting from implementation of the proposed project;

8.2. Discussion of legal and institutional requirements (e.g., contractual water supply obligations, Indian trust responsibilities, water rights settlements, regional water quality control board requirements), state, and/or local requirements with the potential to affect implementation of the project;

8.3. Discussion of the need for multi-jurisdictional or interagency agreements, any coordination undertaken, and any planned coordination activities;

8.4. Discussion of permitting procedures required for the implementation of water reclamation projects in the study area, and any measures that the non-Federal project sponsor can implement that could speed the permitting process;

8.5. Discussion of any unresolved issues associated with implementing the proposed project, how and when such issues will be resolved, and how the project would be affected if such issues are not resolved;

8.6. Identification of current and projected wastewater discharge requirements resulting from the proposed Title XVI project (e.g., brine disposal);

8.7. Description of rights to wastewater discharges resulting from

implementation of the proposed Title XVI project.

9. Financial Capability of Sponsor ^

If this grant is secured, NAWSC is financially capable and has resolved to implement this feasibility study. NAWSC's resolution is included in this package as required. Pending NAWSC Board approval, NAWSC will contract with Freese and Nichols to perform the study.

The feasibility study will determine the project costs required to retrofit the existing BGD facilities with improved energy-efficient modifications. Future federal grant funding opportunities will be monitored and pursued. Additionally, BGD is a recommended water management strategy in the Texas State Water Plan; NAWSC may pursue funding from the State of Texas to implement additional BGD supplies in the 2020 decade.

As part of this task, the study will develop:

9.1. Proposed schedule for project implementation;

9.2. Discussion of the willingness of the non-Federal project sponsor to pay for its share of capital costs and the full operation, maintenance, and replacement costs;

9.3. A plan for funding the proposed project's construction, operation, maintenance, and replacement costs, including an analysis of how the non-Federal project sponsor will pay construction and annual operation, maintenance, and replacement costs;

9.4. Description of all Federal and non-Federal sources of funding and any restrictions on such sources, for example, minimum or maximum cost-share limitations.

10. Research Needs

Although no research needs are anticipated to implement the potential project selected, if any research needs are identified the following will be addressed:

10.1. Description of research needs associated with the proposed water reclamation and reuse project, including the objectives to be accomplished through research;

10.2. Description of the basis for Reclamation participation in the identified research;

10.3. Identification of the parties who will administer and conduct necessary research;

10.4. Identification of the timeframe necessary for completion of necessary research.

11. Extrapolation of Findings to Region M Water Plan Recommended Water Management Strategies

11.1. Review costing of recommended BGD strategies in the Region M Plan;

11.2. Report results to the regional water planning group; and, if appropriate, recommend revisions to cost ranking of recommended water management strategies.

12. Outreach Activities

12.1. Develop list of stakeholders;

12.2. Develop and maintain project web page;

12.3. Provide project briefing(s) to the Lower Rio Grande Regional Water Planning Group and to all entities with recommended brackish groundwater desalination strategies in Region M;

12.4. Brief Texas Commission on Environmental Quality staff and solicit feedback on permitting of alternative energy efficiency options;

12.5. Provide project briefing to the Oklahoma Water Resources Board on findings of the project.

Evaluation Criteria

Statement of Problems and Needs (10 points)

In 2013, the Rio Grande Regional Water Authority and Reclamation completed the Lower Rio Grande Basin Study (Basin Study) which evaluated the impacts of climate variability on water supply imbalances within Region M. The study concluded that "the magnitude and frequency of water supply shortages within the study area are severe, even before projecting the effects of climate change" [9]. The study noted that, per the 2012 Region M Plan, the population in the eight-county region is expected to grow from 1.7 million in 2010 to 4.0 million in 2060, resulting in the need for an additional 592,000 AFY, or about 35 percent of the total water demand. The Basin Study determined that climate change may increase the shortage by an additional 86,438 AFY.

Since then, a new regional water plan has been adopted noting that the population is projected to grow from 1,961,000 in 2020 to 4,029,000 in 2070; water supply needs in the 2070 decade will be in the order of 800,000 AFY, nearly 50 percent of the total projected demand for the region in the 2070 decade [2], as noted in

Table 2. NAWSC's share of the projected water supply needs is estimated at nearly 29,000 AFY in the 2070 decade.

Table 2- 2017 Projected Water Supply Needs in Region M in acre-feet/year

	2020	2030	2040	2050	2060	2070
Mining	5,290	4,641	5,488	5,565	5,758	6,337
Livestock	-	-	-	-	-	-
Steam Electric Power	2,984	5,635	8,866	12,805	17,608	23,501
Manufacturing	2,529	3,388	4,243	4,994	5,992	7,067
Municipal	48,534	86,393	132,173	190,834	251,976	312,410
Irrigation	658,049	608,580	557,158	502,526	447,439	448,029
Total	717,386	708,637	707,928	716,724	728,773	797,344

The Region M Planning Group adopted several water management strategies to meet anticipated water supply shortages -See Table 1. BGD, already an important component of the current regional water supply portfolio, is a prominently ranked recommended strategy in the plan for the 2020 decade. Currently, the installed BGD capacity in Region M is 29,627 AFY [6], the 2016 Region M Plan recommends an additional 20,195 acre-feet of BGD; nearly 18,000 acre-feet of this recommended capacity is to be developed during the 2020 decade. NAWSC is one of fourteen entities for whom BGD is a recommended water management strategy in the Region M Plan.

The Basin Study also recommended BGD as a strategy to meet future needs. The study concluded that BGD was "the most suitable [water management strategy] for preliminary engineering and affordability analysis" and recommended three generalized locations for future desalination plants in Cameron and Hidalgo counties [10]. TWDB also recognized the strategic importance of BGD in Region M and conducted a brackish groundwater characterization study in the region. The study concluded that the Lower Rio Grande Valley portion of the Gulf Coast Aquifer contains more than 40 million acre-feet of slightly saline groundwater (1,000 to 3,000 mg/l of dissolved solids), 112 million acre-feet of moderately saline groundwater (3,000 to 10,000 mg/l of dissolved solids), and 123 million acre-feet of very saline groundwater (Over 10,000 mg/l of dissolved solids) [11].

In addition to pressing water needs, NAWSC's service area is economically disadvantaged. Issues of affordability are particularly relevant to water utility service. This study will consider key economic development factors to document the importance of reducing the cost of water utility service. It is estimated that power consumption accounts for 28 to 52 percent of the operation and maintenance cost of BGD [8]. Realized gains in power use efficiency will directly benefit NAWSC's customers.

In summary, the projected water supply shortages in Region M are severe. BGD is a recommended water management strategy intended to meet some of those needs. By implementing NAWSC's proposed feasibility study ahead of when new BGD supplies will be needed, the region will better understand the feasibility of developing more energy-efficient and cost-effective approaches to desalinate brackish groundwater sources. A reduction in the cost of BGD will encourage the development of this important water management strategy in Region M and elsewhere.

Water Reclamation and Reuse Opportunities (15 points)

The objectives of this feasibility study include identifying and evaluating cost-effective energy-efficient brackish groundwater desalination improvements. The study will examine the energy usage of existing NAWSC BGD operations and then identify viable energy-efficiency improvements to those facilities. It is expected that the findings and conclusions from this study will inform and encourage efforts of the Lower Rio Grande Regional Water Planning Group and of relevant water utilities in Region M to pursue development of BGD supplies.

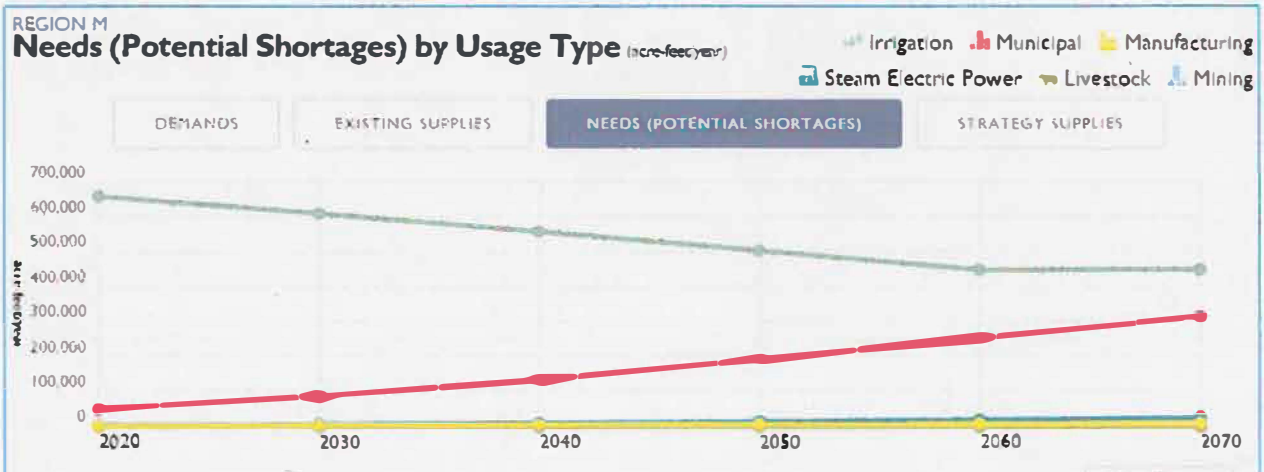
To the extent that BGD adds new water to the water supply portfolio, it not only provides a relief to existing and overtaxed surface water sources, it creates a drought tolerant source of water for reclamation purposes. Additionally, the market of water rights in the Lower Rio Grande Valley provides a viable mechanism to transact the placement of new water for potential water reuse customers. Irrigation and municipal needs are likely customers for reuse supplies.

Fifty-six percent of the projected water supply needs in the Region M plan correspond to Irrigation (Figure 1). The recommended water management strategies for irrigation add up to 267,000 AFY [2], leaving an unresolved need of approximately 181,000 AFY by the 2070 decade. Additional BGD concentrate discharges, resulting from a

shift to NF from RO, would introduce a less saline concentrate in the discharge system. This improved quality of the concentrate could facilitate its use for irrigation purposes.

Another reuse opportunity is created by the need to implement direct reuse water management strategies. The Region M plan recommends development of approximately 27,000 AFY of direct reuse (potable and non-potable) during the 2020 decade -See Table 1. Creating new brackish groundwater desalination supplies will add an estimated 14,000 AFY of non-surface water supplies (80 percent of 17,500 AFY of new BGD supplies by 2070) as potential source for water reuse.

This feasibility study will quantify and examine the potential impact to water reuse management strategies resulting from development of new brackish groundwater desalination supplies. Also, the study will consider the potential reuse value of changes in the composition and volume of concentrate discharges resulting from operational changes such as a shift to nanofiltration for existing BGD.



	2020	2030	2040	2050	2060	2070
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Livestock	0	0	0	0	0	0
Steam Electric Power	2,984	5,635	8,866	12,805	17,608	23,501
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Municipal	48,534	86,393	132,173	190,834	251,976	312,410
Irrigation	658,049	608,580	557,158	502,526	447,439	443,029
Total	*717,386*	*708,637*	*707,928*	*716,724*	*728,773*	*797,344*

Figure 1- Region M Plan, Projected Needs [Source: https://2017.texasstatewaterplan.org/region/M]

Description of Potential Alternatives (15 points)

The feasibility study will develop and consider energy-efficient alternatives to existing BGD RO operations. If successful, more cost-effective BGD strategies can be implemented on existing facilities and on future facilities with similar water quality (source and permeate) profiles.

In this study, current source water and permeate water quality goals will be established as a baseline reference (Baseline Option). The baseline option (Energy Use Status Quo) would generally maintain the current energy budget since existing membranes

would be replaced with similar membranes when needed. NAWSC operates five RO BGD facilities with an average age of nine years. It is reasonable to expect that many of these facilities are facing or will soon require membrane replacement.

Option 1 would be to replace existing RO membranes -when needed- with more efficient RO membranes. Again, given the average age of the NAWSC facilities, new [more efficient membranes] have come in the market.

Options 2 and 3 will be to install NF membranes (as a partial or total retrofit of existing desalination trains) which would require additional brackish groundwater extractions.

Other options or modifications of options 1-3 could be considered once the facilities are inventoried and energy use profiles are developed for existing operations, and a desalination technology market review is completed. The market survey will require coordination with membrane manufacturers and energy recovery and pump equipment distributors.

The use of NF will likely require changes to brackish groundwater extractions -given that NF permeate will likely have a more limited blending capability than RO permeate. Consequently, the concentrate discharges will vary, both in chemical composition and quantity. In the profiling of the facilities, the discharge points and conveyance will be identified and the potential for reuse for agricultural irrigation will be considered as well as the impact on added water in the system with a direct reuse potential.

Water Supplies (15 points)

The goal of this study is to develop more cost-effective means to desalinate brackish groundwater. The development of these supplies in states with a documented abundance of brackish groundwater has the potential to accelerate and potentially broaden new, relatively drought tolerant water supply sources. The addition of new non-surface water sources could provide needed relief to many areas greatly dependent on surface water. Therefore, the study does not intend to reduce or postpone the development of BGD; rather it seeks to facilitate development of new water supplies.

Two strategic water planning reports recommend development of brackish groundwater desalination as the means to secure the water supply needs of Region M. The Region M Water Plan recommends sixteen BGD management strategies to supply 20,900 AFY of new water supplies by the 2070 decade -nearly 18,000 will need to be installed in the 2020 decade [2]. After conducting a review of alternatives [10] the Lower Rio Grande Basin Study concluded that "distributed brackish desalination systems could feasibly provide the target production volume to municipal groups". Additionally, 11 of the 16 regional water planning groups in Texas selected BGD as a recommended water management strategy to meet future water supply demands. BGD is also being investigated as a water support opportunity in Oklahoma.

[1] Based on the US Water Resources Council Principles and Guidelines for Water and Related Land Resources.

The NAWSC feasibility study will be an effective step in advancing the development of BGD in Region M and in other areas of the southwestern United States. By examining the feasibility of cost-effective energy efficiency BGD alternatives, the study will inform the development of additional BGD supplies in areas with similar water quality profiles.

An indication of this potential is provided by Reclamation's study of nanofiltration for low salinity brackish groundwater desalination in Texas. This study indicates that NF could be used to desalinate low salinity groundwater at a lower energy cost [7]. The potential application of this approach to many other locations in Texas is illustrated in Figure 2.

Furthermore, BGD is being investigated as a water supply alternative in Oklahoma. In February 2013, the Oklahoma Water Resources Board issued a supplemental report to the 2012 Oklahoma Comprehensive Water Plan titled "Marginal Quality Water Issues and Recommendations." The report was the culmination of the Marginal Quality Water Technical Workgroup whose purpose, as directed by the Oklahoma Legislature, was to analyze the opportunities centered around Marginal Water Quality in Oklahoma. The NAWSC study, although not in Oklahoma, may further Oklahoma's momentum to develop available marginal quality source-waters including brackish groundwater. It may also provide an opportunity for cross-state technical and information transfer; especially regarding overcoming technical, regulatory, environmental and implementation constraints to using brackish groundwater as an alternative water source.

A shift from RO to NF for BGD would require larger brackish groundwater extractions -probably in the order of 10 percent or more additional extractions. Although the product stream would be comparable to the blended product from an RO facility, the use of NF would result in a larger concentrate stream. As noted, the study will also examine the feasibility of any energy-efficiency modifications to existing and future BGD operations on the reuse potential of the concentrate streams and the wastewater resulting from additional BGD supplies incorporated into the regional system.

In conclusion, BGD is recognized as a critical component of the current and future water supply portfolio of NAWSC and Region M. The study will review the water supply knowledge gained through the TWDB's and Reclamation's efforts and determine the impact that a more cost-effective BGD supply would have to the regional water supply landscape.

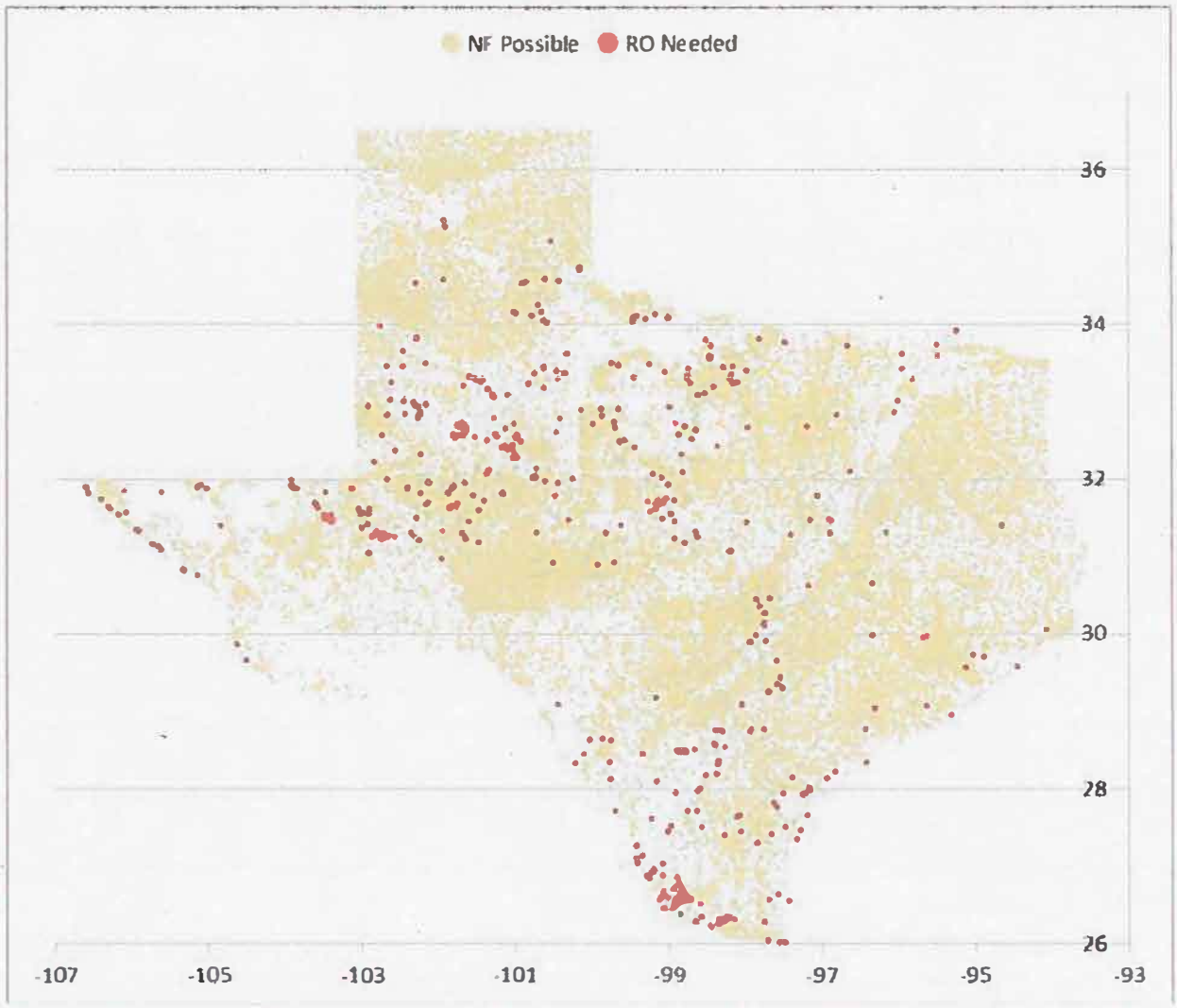

Figure 2 - Geographical locations of wells with sodium concentrations under 1,120 mg/L that can be effectively reduce TDS concentrations to below 500 mg/L using a NF membrane (based on performance modeling of three NF membranes). [Source: Reclamation]

Environment and Water Quality (15 points)

The NAWSC feasibility study will evaluate the benefits from changes in discharge water quality and water quantity resulting from the use of NF membranes. Most wastewater is discharged to the Arroyo Colorado which flows past the Laguna Atascosa National Wildlife Refuge, home of the endangered ocelot and other ecologically important plant and animal species characteristic of this unique sub-tropical environment. A water quality baseline characterizing the concentrate discharge from existing BGD RO facilities will be established for comparison against NF alternatives that would change the quality of the concentrate. It is anticipated that the lower salinity concentrate resulting from NF will have a greater benefit to the receiving environment.

The Arroyo Colorado tidal has experienced impairments of low dissolved oxygen and elevated bacteria in the upstream end of the tidal reach while the Arroyo Colorado

above tidal has also had exceedances of its bacteria water quality criterion for bacteria [12]. Although conversion of systems from RO to NF is not expected to measurably affect water quality impairments in the Arroyo Colorado, this study will evaluate possible effects on existing water quality standards and total maximum daily loads. Since this proposed change may affect rates of groundwater withdrawal, the feasibility study will evaluate potential effects of modified groundwater withdrawal rates on groundwater quality.

The feasibility study may evaluate potential beneficial ecological uses of water discharged from the NF facilities. The Rio Grande, Rio Grande Estuary and Lower Laguna Madre Bay/Basin Expert Science Team (Lower Rio Grande BBest) identified several possible ecological benefits associated with return flows in the lower Rio Grande Valley [13]. Possible enhancements may include routing discharge water to:

- ¼Existing or constructed wet stormwater control ponds. In addition to helping control stormwater runoff, these ponds create habitat for birds and other wildlife, particularly reptiles and amphibians like the Rio Grande Lesser Siren, a state-threatened species of salamander. Creating or enhancing existing wet ponds will increase habitat availability throughout the area.
- ¼Resacas. While most of the Lower Rio Grande Valley's (LRGV) resacas are in Cameron County, it is possible that some of the easternmost portions of the Resaca del Rancho Viejo may benefit from flow augmentation via enhanced return flows. Resacas provide habitat for wildlife and several of them tend to be dry; particularly in portions of eastern Cameron County. Providing a regular source of water for these resacas could return some of the ecological functions provided by these unique habitats.
- ¼Oxbow lakes of the Rio Grande (called "bancos" in Spanish). Several bancos of the Rio Grande, many of which are completely dry most of the year outside of rainy periods, can be found between Highway 83 / I-2 and the Rio Grande. More of these low-lying areas that are further away (northward) from the Rio Grande have been left to transition through ecologically succession to only intermittently flooded depressions dominated by drier thorn scrub and even invasive plant species. The identification of candidate oxbows that would benefit from enhanced surface water inflow via return / discharge flow from NF facilities would be beneficial to local flora and fauna through the increase in precious surface water area in the LRGV.
- ¼The Rio Grande tidal zone. The Rio Grande is over appropriated and at times conditions have closed the mouth of the river to the Gulf of Mexico, preventing the migration of estuarine fish and shellfish back and forth between the river and the Gulf. Although the quantity of water produced from this process will be relatively small, there is value in exploring possible ways to divert discharge water and return it to the Rio Grande where it would augment flow downstream and in the tidal region.
- ¼The Lower Rio Grande BBEST recommended reducing flows and nutrient ¼ loading from the Arroyo Colorado into the Lower Laguna Madre. Reductions ¼ of salinity and elevated nutrients have contributed to algal blooms and algal ¼

growths which have impacted seagrass beds near the mouth of the Arroyo Colorado. If flows in the Arroyo Colorado can be reduced, protection of Laguna Madre seagrass beds will likely be enhanced.

A desktop survey of existing GIS datasets, irrigation / drainage infrastructure, land use and landcover data could be readily completed to identify candidate surface depressions and impoundments (existing oxbows, resacas, etc.) and their proximity to existing return flow pathways. Communication and cooperation with existing organizations and partnerships such as the LRGV Stormwater Task Force, the Arroyo Colorado Watershed Partnership, the University of Texas Rio Grande Valley, and others would leverage this effort through each group's or organization's on –going and publicly funded work. This would lay the groundwork for more detailed study of the feasibility and/or ranking of candidate sites in future phases of this work.

Legal and Institutional Requirements (10 Points)

In 2011, the TWDB commissioned a study on the use of computer modelling as an alternative to pilot plant studies for permitting of brackish groundwater desalination systems. The study demonstrated that software modelling is a practical and acceptable means to select reverse osmosis membranes and prove their dissolved solids removal performance [14]. The Texas Commission on Environmental Quality (TCEQ) has now allowed the use of desktop modelling for high pressure membrane design in lieu of pilot testing. During this feasibility study, NAWSC will reach out to share information and solicit feedback for the use of similar computer-based approaches to demonstrate the viability of treatment modifications (including NF) that may be recommended from an energy efficiency perspective.

If successful, this project may provide a path to permitting energy-efficient modifications to Texas BGD facilities with similar water quality to those in the feasibility study area.

Also, the rights to concentrate discharge has not been discussed in Texas. This project will provide an opportunity to discuss this topic and may provide some recommendations for future studies.

Renewable Energy and Energy Efficiency (10 points)

The primary goal of this study is to develop and determine the feasibility of cost-effective energy-efficient alternatives for low salinity BGD. Reclamation's 2015 study on nanofiltration estimated that up to 40 percent energy savings could be realized by shifting from RO membranes to NF membranes in some BGD cases. The economic gains from a lower energy cost would be partially offset by the need to extract larger volumes of brackish groundwater -estimated in the order of 10 percent increase in extractions. The feasibility study will determine the actual energy savings and the economic benefit over the life-cycle of the facilities.

Other energy-saving measures will be considered once the current energy profile of NAWSC's BGD processes are documented and an inventory of current equipment is

completed. This may include updated low-pressure RO membranes, isobaric energy recovery systems, and higher efficiency high pressure pumps.

The University of Texas estimated the water industry consumes 2.1 to 2.7 TW-h/year, which accounts for 0.5 to 0.7 percent of total electricity use in the state [15]. Through the close relationship between energy and water, increased energy-efficiency in water treatment decreases the total energy demand and, thus, the volume of water needed for energy production. As part of the baseline determination, the proposed feasibility study will measure electricity consumption at NAWSC BGD plants and provide a basis for comparison against alternative energy-efficiency modifications. The source of power to NAWSC's BGD will be examined and water-savings estimate will be developed.

Watershed Perspective (10 points)

Region M will need to develop 603,000 AFY of additional supplies by 2070; 21,000 AFY corresponds to proposed BGD sources. The current Region M plan recommends that NAWSC develop 29,000 AFY of additional supplies by 2070 with BGD accounting for approximately 8 percent of these supplies. If NAWSC's proposed feasibility study is successful in demonstrating cost-effective, energy-efficient alternatives for BGD, this will improve the economics of future BGD for both NAWSC and Region M. The knowledge gained in this study may be valuable to other areas in Texas (and in Oklahoma) with similar source brackish groundwater source quality profiles.

Creating a more robust and abundant BGD water supply will offset the pressure on overallocated surface water supplies in the Lower Rio Grande Valley. The added diversity to the water portfolio will increase the overall reliability of the regional water supply. The insertion of a drought tolerant new water source will also benefit future reuse projects that would have an original source other than surface water. The feasibility study will examine and quantify the extent to which these benefits may be realized.

Required Permits or Approvals

No permits are required to conduct the feasibility study. Implementing the recommendations of the feasibility study will require an assessment of changes to the concentrate discharge resulting from proposed BGD process modifications. If the concentrate discharge stays within the volume and quality parameters of the existing permit, no action would be needed. If the parameters of the permit are exceeded, consultation with the Texas Commission on Environmental Quality (TCEQ) will be necessary to determine whether a major or minor discharge permit amendment may be required. The modifications to the treatment process will also need to be approved by TCEQ per 30 TAC §290.

Funding Plan

If the feasibility study grant is awarded, NAWSC's funding plan will allow for the completion of the feasibility study with the pledged assistance of those supporting the project. The Feasibility Study will determine the project costs required to implement energy-efficiency modifications to

NAWSC's BGD facilities. Future funding opportunity announcements, and other available grants, will be pursued to obtain a Federal match to the NAWSC's existing local funding availability. The funding plan for the feasibility study is as follows:

Partner/Contributor	Contribution		
	Cash	In-Kind Services	Total
US Bureau of Reclamation	$90,000	$0	$90,000
North Alamo Water Supply Co.	$14,140	$33,360	$47,500
McAllen PUB	$0	$15,000	$15,000
Brownsville PUB	$0	$10,000	$10,000
Rio Grande Regional Water Authority	$2,500		$2,500
FNI R&D Fund	$3,000	$12,000	$15,000
Project Sub-Total – Cash & In-kind	$109,640	$70,360	$85,000
Project Total			$180,000

Official Resolution

On January 17, 2017, the NAWSC Board of Directors will consider a resolution agreeing to certain requirements of a WaterSMART funding opportunity for development of a feasibility study under the Title XVI Water Reclamation and Reuse Program for Fiscal Year 2017 to evaluate energy-efficiency modifications to NAWSC's BGD current facilities and future BGD supplies.

References

[1] › North Alamo Water Supply Corporation, "About NAWSC," MPC Studios Inc., 2016. [Online]. Available: http://www.nawsc.com/about-nawsc#. [Accessed 13 12 2016].

[2] › TWDB, "2017 Texas State Water Plan, Region M," 2017. [Online]. Available: https://2017.texasstatewaterplan.org/region/M. [Accessed 2016].

[3] › Oklahoma Water Resources Board, "Oklahoma Comprehensive Water Plan Supplemental Report, Marginal Quality Water Issues and Recommendations," OWRB, Oklahoma City, OK, 2010.

[4] › TWDB, "2017 Texas State Water Plan," TWDB, Austn, TX, 2016.

[5] › Texas Water Development Board, "The Future of Desalination in Texas," Texas Water Development Board, Austin, TX, 2016.

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[8] › N. Voutchkov, Desalination Engineering, Planning and Design, McGraw-Hill, 2013.

[9] Rio Grande Regional Water Authority; U.S. Department of the Interior, Bureau of Reclamation, "Lower Rio Grande Basin Study," Reclamation, Denver, CO, 2013.

[10] U.S. Department of the Interior, Bureau of Reclamation, "Lower Rio Grande Basin Study," Department of the Interior, Denver, CO., 2013.

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[12] TCEQ, "2014 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d)," TCEQ, [Online]. Available: https://www.tceq.texas.gov/waterquality/assessment/14twqi/14txir. [Accessed 16 12 2016].

[13] Lower Rio Grande Bay/Basin Expert Science Team, "Environmental Flow Recommendations Report," TCEQ, Austin, TX, 2012.

[14] TWDB, "Alternatives to Pilot Plant Studies for Membrane Technologies," TWDB, Austin, TX, 2014.

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[17] TWDB, "Desalination Projects," TWDB, [Online]. Available: http://www.twdb.texas.gov/innovativewater/desal/projects.asp. [Accessed 14 12 2016].

[18] TWDB; Affordable Desalination Collaboration, "Energy Optimization of Brackish Groundwater Reverse Osmosis Desalination," TWDB, Austin, TX, 2011.

Checklist

√	What to submit	Required content	Form or format	When to submit
	Mandatory Federal Forms: Application for Federal Assistance Budget Information Assurances	See Sec. D.2.2.1	SF-424, SF-424A, and SF-424B forms	*
	Title page	See Sec. D.2.2.2	Page 9	*
	Table of contents	See Sec. D.2.2.3	Page 9	*
	Technical proposal:			*
	Executive summary	See Sec. D.2.2.4	Page 9	*
	Study description	See Sec. D.2.2.4	Page 9	
	Evaluation criteria	See Sec. E.1	Pages 21 to 23	*
	Letters of support	See Sec. D.2.2.5	Page 10	*
	Required permits or approvals	See Sec. D.2.2.6	Page 10	*
	Official Resolution	See Sec. D.2.2.7	Page 10	**
	Study Budget:	See Sec. D.2.2.8	Pages 11 to 16	*
	Funding plan and letters of commitment	See Sec. D.2.2.8	Page 11	*
	Budget proposal	See Sec. D.2.2.8	Page 13	
	Budget narrative	See Sec. D.2.2.8	Page 14	*
	Unique Entity Identifier and System for Award Management	See Sec. D.3	Page 16	***

* Submit materials with your application.

** Document should be submitted with your application; however, please refer to the applicable section of the FOA for extended submission date.

*** Should be completed by application deadline; however, please refer to the applicable section of the FOA for extended completion date.

SF-424, SF-424A, and SF-424B forms may be obtained at http://apply07.grants.gov/apply/FormLinks?family=15

Mandatory Federal Forms

SF-424, SF-424A, and SF-424B forms are attached.

Letters of Support and Commitment

Texas Water Development Board (attached)

Letters of support and/or commitment are being processed by the following entities and will be submitted once available:

Lower Rio Grande Regional Water Planning Group
City of McAllen
Brownsville PUB
Lower Rio Grande Regional Water Authority
Oklahoma Water Resource Board

Official Resolution

An official resolution from the North Alamo Water supply Corporation approving the application will be considered at the January 17, 2017 meeting of the board.

Study Budget

SF4-24 PDF Budget Form is Attached

Budget Proposal

The feasibility study will document operational exergy of two of North Alamo Water Supply Corporation's (NAWSC) brackish groundwater desalination facilities; develop energy-efficiency modifications and conduct a life-cycle cost comparison to determine cost-effectiveness. In addition to selecting a preferred project embodying the more cost-effective modifications, the study will examine the Region M Water Plan recommended BGD water management strategies for NAWC and for Region M and determine whether the feasibility study findings may be extrapolated to the Region M Plan.

NAWSC will request 50 percent reimbursement of actual costs incurred for the duration of the project. These costs will consist of contractual payments to the selected consultant. In-kind services and cash contributions were previously noted and are replicated below:

Partner/Contributor	Contribution		
	Cash	In-Kind Services	Total
US Bureau of Reclamation	$90,000	$0	$90,000
North Alamo Water Supply Co.	$14,140	$33,360	$47,500
McAllen PUB	$0	$15,000	$15,000
Brownsville PUB	$0	$10,000	$10,000
Rio Grande Regional Water Authority	$2,500	$0	$2,500
FNI R&D Fund	$3,000	$12,000	$15,000
Project Sub-Total – Cash & In-kind	$109,640	$70,360	$180,000
Project Total			$180,000

The proposed consulting fee for preparing the feasibility study is provided on Table 3. In-kind services, currently estimated at $70,360, will be allocated to peer and partner review of draft documents and the following tasks:

1. Introductory Information
   1.1. Identification of non-federal sponsor
   1.2. Description of service area, population served and water supply system
2. Literature Review
   2.1. Energy use and energy-efficiency in BGD operations;
   2.2. Nano-filtration membranes in brackish groundwater desalination;
   2.3. Water planning in the Lower Rio Grande Valley; and,
   2.4. Brackish groundwater availability in the Lower Rio Grande Valley portion of the Gulf Coast Aquifer.
4. Water Reclamation and Reuse Opportunities

4.1. Describe current and potential uses for reclaimed water;
4.2. Describe water rights market in the Lower Rio Grande Valley and the opportunities for water reuse within that market;
4.3. Describe water reuse management strategies recommended in the 2016 Region M Water Plan;

5. Baseline Development
   5.2. Process flow schematics;
   5.3. Inventory existing water treatment equipment;
   5.4. Compile raw and treated water quality data;
   5.5. Prepare current energy use budget;
12. Outreach Activities
   12.2. Develop list of stakeholders;
   12.4. Provide project briefing(s) to the Lower Rio Grande Regional Water Planning Group and to all entities with recommended brackish groundwater desalination strategies in Region M;

Table 3 - Proposed Fee

	PM/Sr. Water Technologist	EIT	Sr. Water Treatment Eng.	Water Treatment Engineer	Environmental Specialist	GIS/CAD	Public Relations / Web Design	Phase Effort (hours)	Phase Budget (Dollars)
1. Introductory Information	2	8	4	5	0	20	0	39	$ 5,770
2. Literature Review	16	16	4	8	0	0	0	44	$ 8,040
3. Statement of Problems and Needs	10	11	4	4	0	0	0	29	$ 5,365
4. Water Reclamation and Reuse Opportunities	8	6	4	4	0	0	0	22	$ 4,290
5. Baseline Development	14	10	6	6	0	0	0	36	$ 7,050
6. Alternatives Development	36	52	22	36	0	0	0	146	$ 25,880
7. Potential Environmental Impacts and Benefits of Selected Project Alternative	10	4	3	2	56	0	8	83	$ 16,050
8. Legal and Institutional Requirements	14	5	10	9	4	0	6	48	$ 9,545
9. Financial Capability of Sponsor	7	2	6	6	0	0	2	23	$ 4,660
10. Research Needs	4	6	6	4	0	0	0	20	$ 3,790
11. Extrapolation of Findings to Region M Water Plan	12	16	8	4	0	0	0	40	$ 7,440
12. Outreach Activities	17	0	16	1	0	0	24	58	$ 11,760
Total									$109,640