Section 8 – Existing Supply – Ogallala Aquifer - Bailey County Well Field (BCWF)

Content

a. Map of the BCWF and Transmission Line
b. Groundwater Availability Model
c. Shallowater Well Field
d. 2006 City Groundwater Treatment Study (Pump Station #10)

Summary

The City just finished a Groundwater Utilization Study in March of 2007 for the Ogallala Aquifer in both the Bailey County Well Field and the area under the City of Lubbock. Groundwater was the only source of water for the City of Lubbock prior to the creation of CRMWA. The Bailey County Well Field has been a significant part of that supply both before and after the creation of CRMWA.

The study points out that the BCWF cannot be over-pumped if the City of Lubbock wants this supply to last for the next 50 years. It has been recommended that the well field not be pumped more than 10,000 acre-feet annually. The 1992, the Comprehensive Ground Water Management Study recommended that pumping not exceed recharge at about 3,400 acre-feet annually. If the BCWF is over-pumped, the supply will not last 50 years. Even if it lasts 50 years, additional wells will need to be added as the water level drops in order to keep production levels up.

While the total amount of pumping needs to be limited to extend the life of the BCWF, the water supply source can still provide almost 50% of the peak summer day demand for water since the wells and transmission line can deliver 40 million gallons per day (mgd) of water to the City of Lubbock. A project is currently underway, based upon information provided in the 2007 Groundwater Utilization Study, to rehab and develop new wells in the BCWF to keep production capacity up to 40 mgd.

The City also had a Shallowater Well Field. This facility has not been used for years due to poor water quality. The facility may be rehabilitated and used to supplement the BCWF for about $1.2 to $1.5 million.

The City also had a well field within the City's limits. The 2007 Groundwater Utilization Study indicated that annual recharge in the aquifer under the City to be about 12,000 acre-feet annually. This alternative was studied, but again water quality and the cost of developing the well field were issues of significance. The capital cost alone for the proposed Pump Station #10 well field and treatment facilities would reach almost $20 million for only 5,000 acre feet of water. This well field would not be sustainable due to the amount of pumping in a small area, so the life of the Pump Station #10 well field was projected to be 50 years. For this reason, pumping for park irrigation was recommended. This lower volume of pumping could be sustainable over time and since the parks are dispersed throughout the City, an expensive well field collection system would not need to be developed.

The BCWF should provide about 25% of our total annual supply if the recommendations are followed to limit pumping. BCWF, however, does provide 50% of the peak day capacity. Once the BCWF ceases to be operational, an alternative peak day source must be developed. The alternatives would be to construct Canyon Lake #7 or recharge the BCWF.

Section 8 – Existing Water Supply – Bailey County Well Field (BCWF)

a. 2007 Groundwater Utilization Study

City of Lubbock
Groundwater Utilization Study

March 23, 2007

DBS&A engineering geoscience hydrology

Daniel B. Stephens & Associates, Inc.

City of Lubbock
Groundwater Utilization Study

Prepared for **City of Lubbock, Texas**

March 23, 2007

STATE OF TEXAS
T. NEIL BLANDFORD
GEOLOGY
License Number 1034
LICENSED
PROFESSIONAL GEOSCIENTIST

T. Neil Blandford
Texas Professional Geoscientist No. 1034

Daniel B. Stephens & Associates, Inc.

6020 Academy NE, Suite 100 • Albuquerque, New Mexico 87109

Executive Summary

The City of Lubbock (City) contracted Daniel B. Stephens & Associates, Inc. (DBS&A) and Parkhill, Smith and Cooper, Inc. (PSC) in June 2004 to conduct an evaluation of the sustainability of groundwater resources available to the City. This effort is referred to as the groundwater utilization study. The source of the City's current water supply is the Canadian River Municipal Water Authority (CRMWA) pipeline, supplemented by Sandhills Well Field water during periods of peak demand. In order to supply anticipated increases in water demands, the City is considering, among other options, continued and possibly expanded use of groundwater resources within the Sandhills Well Field in northern Bailey and northwestern Lamb Counties, and use of groundwater beneath the City itself. Technical issues evaluated as part of the groundwater utilization study include the following:

- Groundwater quality in the vicinity of Lubbock, historical changes in land use within and near the City, historical changes in water levels beneath the City, and the locations of known potential sources of groundwater contamination

- The ability of the Ogallala aquifer beneath Lubbock and in the Sandhills Well Field area to sustain projected rates of groundwater pumping over a 50-year predictive period

- Identification of alternative non-potable uses of local groundwater beneath the City, and associated costs of implementation

- A screening assessment of the Dockum aquifer beneath the Sandhills Well Field

- Development of strategies and recommendations for improved groundwater management and protection

It has been known for some time that groundwater levels beneath Lubbock have been rising, as opposed to declining or remaining stable, in contrast to many locations on the Southern High Plains. The rising water levels have led to the formation of a significant groundwater "mound" beneath the City. Two maps of groundwater elevations beneath Lubbock for 1990 and 2003 were completed as part of this study. Based on these maps, it is apparent that the groundwater mound has expanded substantially from 1990 to 2003, and the center of the mound has moved to the south, in the direction of urbanization. Observed water levels at monitor wells are increasing most rapidly south of Loop 289.

The groundwater mound beneath the City is believed to have the following three primary sources:

1. Increased recharge at playas within the urbanized parts of the City. As the City expanded and the acreage of paved surfaces increased, runoff from precipitation routed to the playas has increased. In addition, some playas have been modified to add capacity as drainage control structures, and such modification likely increased recharge potential.

2. Groundwater pumping within the urbanized regions of the City that historically occurred for irrigation and municipal supply has ceased, and a corresponding rise in water levels occurred.

3. Groundwater recharge from direct infiltration from precipitation and return flow from lawn and park irrigation, leaky water supply and sewer lines, and various other sources typical of a municipality. Because the City's water supply has either been obtained from CRMWA or the Sandhills Well Field for about the last 40 years, much of this recharge is an imported source of water.

In addition to the volume of recharge that occurs from the sources listed above, formation of the groundwater mound is also a function of the aquifer hydraulic conductivity, specific yield, and geometry. The groundwater mound occurs primarily within a region of relatively low aquifer permeability and relatively high aquifer base elevation, and beneath an urbanized area with a relatively high concentration of playa lakes that serve as drainage features for increased (compared to non-urban conditions) stormwater runoff.

Saturated thickness beneath the City is as low as approximately 25 feet in the northernmost reaches east of I-27 and north of Loop 289. Maximum saturated thickness values (up to 125 feet) occur outside of the southwest portion of Loop 289 beneath the groundwater mound, and inside Loop 289 in the north-central portion of the City.

The Lubbock area groundwater model was developed to estimate future water availability. The Lubbock area model actually consists of two linked models: one for the simulation of regional effects and one for the simulation of local effects focused more on the City of Lubbock area. The regional model uses 1-mile-square cells, while the local model uses ¼-mile-square cells. The purpose of the regional model is to simulate reasonable aquifer conditions in the vicinity of the local model boundary.

Three predictive simulations were conducted using the Lubbock area model. The predictive simulations included several combinations of potential future pumping for irrigation of parks, irrigation of school grounds, local non-potable groundwater utilization by industry and miscellaneous other uses, and groundwater pumping associated with the Pump Station 10 (PS-10) project.

The City has already initiated a program to convert some parks to utilization of local groundwater for irrigation, and more parks will be converted in the future. Total future groundwater pumping for irrigation of parks within the City is estimated to be 1,228 acre-feet per year (ac-ft/yr). Pumping for irrigation of school grounds will be conducted by the Lubbock Independent School District, but could affect the availability of groundwater pumping within the City limits. The total future groundwater pumping for irrigation of school campuses is estimated to be 606 ac-ft/yr. The total estimated pumping for industrial and other non-potable uses is 2,009 ac-ft/yr.

Required pumping for the PS-10 project is estimated to be 7 million gallons per day (mgd) for 4 months per year in order to provide 5 mgd of treated (potable) water. This rate equates to about 2,567 ac-ft/yr. In the predictive simulations, 17 wells were used to supply the required PS-10 demand in the general region of the south Loop 289.

Sufficient groundwater and aquifer yield exist beneath Lubbock to supply anticipated demands for irrigation of park grounds, irrigation of school grounds, and approximately 2,000 ac-ft/yr of other/industrial uses. Sufficient groundwater also exists to supply additional demand on the order of that required for the PS-10 project. However, local aquifer conditions may not be suitable for a sustainable 50-year supply at some of the selected PS-10 production well locations. It would be prudent to either (1) seek more productive parts of the aquifer to provide all or a portion of the PS-10 supply, or (2) conduct more detailed field analyses of sustainable well yield to affirm or deny the groundwater availability predications in the vicinity of planned PS-10 wells.

The feasibility and associated costs of providing groundwater to high-volume users within the City for non-potable uses were also considered during this study. Providing local groundwater to high-volume users would reduce the load on the potable supply. Historical water use data, along with survey information obtained as part of this study, were used in the evaluation. Water quality was evaluated in order to determine treatment costs necessary for the various applications. Approximately 1.3 billion gallons (about 3,900 acre-feet) of potable water could be saved annually by providing local groundwater to high-volume users. The cost of producing and providing the water to area users ranges from $1.15 to $6.08 per 1,000 gallons. As of March 2006, the unit cost of potable City water was $1.69 per 1,000 gallons for commercial users and $1.83 per 1,000 gallons for residential users. A new rate structure is planned for implementation during the spring of 2007. The new rate structure has three blocks that range in cost from $2.09 to $3.61 per 1,000 gallons. The cost-effective use of local groundwater would be best achieved when planned for and constructed in the early stages of new residential, commercial, and industrial development.

Additional studies that would be useful to better quantify and evaluate the sustainability of water resources in the vicinity of Lubbock, and particularly south of Loop 289, include the following:

- Conduct a detailed water balance study at one or more playas to better constrain potential recharge rates to groundwater and changes in recharge through time.

- Obtain additional information on aquifer parameters (e.g., hydraulic conductivity) and bottom elevation near the southern fringe of urban development to gain an improved understanding of groundwater flow conditions in this area.

- Collect additional water quality samples from observation wells within the City parks and elsewhere to better constrain ambient groundwater quality estimates.

The following suggestions regarding strategies and approaches for improved groundwater management in the Lubbock area are offered to the City:

- Continue to expand and improve upon the City's water conservation plan, including the continuation of restrictions on lawn watering and providing educational information regarding the wise use of water and planning of landscape features.

- Continue to support City-wide beautification efforts and educational programs dealing with the proper disposal of household hazardous wastes and automobile fluids, as well as the proper use and disposal of pesticides, herbicides, and fertilizers.

- Future engineering designs for playa modification should consider methods and approaches to prevent groundwater contamination and enhance groundwater recharge.

- Consider aquifer storage and recovery (ASR) of CRMWA water, contingent on the successful identification and evaluation of a segment of aquifer in the area suitable for that purpose. Excess water available through the pipeline during winter months could be stored in the aquifer locally beneath Lubbock, and the same water could be extracted during peak demand periods.

- Consider more detailed evaluation of the Edwards-Trinity High Plains aquifer that lies beneath the Ogallala aquifer. This aquifer is not currently used as a significant source of water supply, but could potentially yield moderate quantities of water to wells. This aquifer could also be a good target zone for ASR, thereby avoiding potential issues of water loss to adjacent users and impacts to water quality from contaminated sites (although naturally high total dissolved solids concentration could be an issue).

- In areas of new development, plan for the use of existing and anticipated groundwater for irrigation of parks and other landscaped areas and construct the necessary facilities, along with other associated infrastructure.

Five predictive simulations were conducted using the calibrated Sandhills Well Field area model assuming constant well field pumping for 50 years at 2,000, 6,000, 10,000, 13,000, and 25,000 ac-ft/yr. A sixth simulation was conducted assuming that the well field provided 25,000 ac-ft/yr for 5 years, and then 10,000 ac-ft/yr for the following 45 years. Pumping for irrigated agriculture will continue to cause substantial water level declines in irrigated regions adjacent to the Sandhills Well Field, particularly to the north, west, and east. Future water level declines within the east-central portion of the well field area, however, will primarily be a function of City pumping, rather than adjacent agricultural pumping. The Sandhills Well Field should be able to produce 2,000 ac-ft/yr for 50 years without significant expansion, and 6,000 ac-ft/yr with some expansion. The well field can likely produce 10,000 ac-ft/yr, and possibly 13,000 ac-ft-yr, for the next 50 years with significant expansion. The well field cannot produce 25,000 ac-ft-yr over the long term, but it can produce 25,000 ac-ft/yr for a short period of time followed by long-term production on the order of 10,000 ac-ft/yr. At the end of the 50-year simulation period, the saturated thickness across much of the well field will be limited, and at a number of locations the aquifer will be severely depleted. At well field demand rates of 10,000 to 13,000 ac-ft/yr, 50 years is probably approaching the end of the useful well field life.

The Dockum aquifer is a potential groundwater resource that occurs beneath the Ogallala aquifer across the Southern High Plains, including beneath the Sandhills Well Field. Some pilot-scale testing of this aquifer at locations with existing City infrastructure (i.e., the Sandhills Well Field and possibly the Shallowater Well Field or Lubbock) would be beneficial, although obtaining potable supply from this aquifer would be expensive due to the significant depth of the aquifer (probably 1,000 feet or more), the high salt content of the water and the unknown (but expected relatively small) yield.

Section 8 – Existing Water Supply – Bailey County Well Field (BCWF)

b. Shallowater Well Field Update

CITY OF LUBBOCK
INTEROFFICE MEMORANDUM

TO: TOM ADAMS, DEPUTY CITY MANAGER

FROM: BRUCE BLALACK, WATER PRODUCTION & TREATMENT SUPERINTENDENT

SUBJECT: SHALLOWATER WELL FIELD INFRASTRUCTURE UPDATE

DATE: MARCH 26, 2007

CC: SHERRY STEPHENS, WATER UTILITES CHIEF OPERATING OFFICER

The Shallowater Well Field is located approximately 12 miles northwest of the City of Lubbock in Hockley and Lubbock Counties. The total area of the well field is approximately 2,040 acres. It is 100% developed with 17 wells. The well field has not been used for more that 25 years.

Geraghty & Miller, Inc. performed the last evaluation of the Shallowater Well Field in 1992. At that time, the gross saturated thickness of the Ogallala aquifer under the well field was estimated to average 50 feet and the recoverable ground water reserves were estimated to be 11,475 acre-feet (3.74 billion gallons). Review of the ground water quality data indicated that the water in the well field did not meet the TCEQ secondary water quality standards for sulfate, total dissolved solids and fluoride. The quality was marginal is meeting TCEQ primary water quality standards for fluoride and nitrate. In 1992, Geraghty & Miller, Inc. estimated the potential cost of reactivating this well field to be approximately $1,240,000. This included replacing well equipment, the pump station, the 1 MG reservoir, and adding disinfection equipment. This estimate did not include any actual well rehabilitation or well collection pipeline replacement that might be needed.

Staff visual observation of the condition of the 1 MG reservoir approximately two years ago, indicated that the floor and side wall of the reservoir are in fair condition, but the flat roof of the reservoir is sagging and would need to be replaced to meet current TCEQ requirements of a sloped roof. This reservoir will be evaluated as part of the Pump System Evaluation that will occur of the next six to nine months. This evaluation will provide an engineering analysis of this reservoir and determine its potential for future use.

Extensive work and infrastructure replacement would be required to reactivate the Shallowater Well Field. The current cost of this undertaking could easily exceed $2,000,000 not including substantial well rehabilitation and well collection pipeline replacement. Before reactivation is considered, this well field needs to be thoroughly evaluated regarding actual current available ground water reserves and actual current well field production potential as well as sand production testing.

Please contact me if you have questions or need additional information.

Bruce Blalack
Water Production & Treatment Superintendent

Section 8 – Existing Water Supply – Bailey County Well Field (BCWF)

c. 2006 City Groundwater Treatment Study (Pump Station #10 Project)

Engineering Report

City of Lubbock

Groundwater Treatment Plant
Lubbock, Texas

May 2006

PSC Project # 01268305

STATE OF TEXAS
JOHN S. KELLEY
48072
LICENSED
PROFESSIONAL ENGINEER
5-31-2006

In association with

Parkhill, Smith & Cooper, Inc.
Engineers ▪ Architects ▪ Planners

May 31, 2006

Mr. Thomas Adams
Assistant City Manager
City of Lubbock
P.O. Box 2000
Lubbock, Texas 79457

Re: Groundwater Treatment Plant

Dear Mr. Adams:

This report presents the result of a feasibility study related to the treatment of localized groundwater in the vicinity of 82nd Street and Memphis Avenue and surrounding areas to potable quality. The study was authorized in January 2005 and was performed in conjunction with Black & Veatch Corporation, Dallas, Texas.

PROJECT OBJECTIVE

The purpose of the project was to reduce demand on the City of Lubbock water supply system by producing and treating existing groundwater available in southwest Lubbock to potable water quality for subsequent introduction into the existing storage reservoir located at 82nd Street and Memphis Avenue. The existing pump station would be used to pump the treated water into the distribution system. The desired quantity of treated groundwater was identified as approximately 5 million gallons per day. The purpose of this preliminary engineering study was to further identify the treatment requirements, project components and associated costs for use in the development of project construction budgets and subsequently authorized activities, including design of the improvements.

SUPPLY WELLS

The proposed supply wells were to be located in general proximity to the project site, with exact locations, capacities, and number of wells to be determined by the City of Lubbock. Due to anticipated land and right-of-way acquisition costs, most of the proposed supply well locations were assumed to be located in area parks. In addition, the supply wells and associated connecting pipelines were to be completed by the City of Lubbock and sampled, with the quality analyses and results provided for refinement of the feasibility study.

Due to reject water production associated with the anticipated treatment processes, approximately 16 to 20 supply wells, each with a capacity of about 250 gallons per minute (gpm), would have been required to produce the approximately 7 million gallons per day needed for this project.

EXISTING SITE LAYOUT

The proposed treatment plant site is located at 82nd Street and Memphis Avenue, which currently contains a new 7 million gallon ground storage reservoir and an existing pump station. The storage tank is currently filled from the distribution system, with the stored water subsequently pumped into another isolated pressure plane of the distribution system, accomplished with the use of appropriately located isolation valves.

A significant amount of landscaping improvements have been previously planned for the site and coordinated with the adjacent neighborhood association. At the time of completion of this study, those landscaping plans have been revised and are now under consideration for construction.

Parkhill, Smith & Cooper, Inc.
Engineers ▪ Architects ▪ Planners
4222 85th Street, Lubbock, Texas 79423
(806) 473-2200 FAX (806) 473-3500
Lubbock El Paso Midland

The initially proposed location for the treatment plant was identified by the City to be in the southwest corner of the pump station and reservoir tract. Due to the space requirements for the necessary treatment facilities, this location is not sufficient in either a real size or vehicular and truck access.

GROUNDWATER QUALITY

Representative ground water quality information from only one well located on the pump station tract north of the new reservoir was made available for use with this study. Several monitoring wells are apparently located in or near the general vicinity of the site, but were not sampled for analysis due to availability and cost issues with area laboratories.

In addition, new park irrigation wells were scheduled for construction by the City but also were not available for sampling and analysis. It was suggested to the City that these wells be sampled and analyzed upon construction for those constituents important to future treatment processes.

STORAGE TANK BAFFLING ISSUES

The treated groundwater will be required to be disinfected prior to introduction into the distribution system. The City of Lubbock uses chloramines as the disinfectant for potable water, which will require that chloramines also be used for disinfection of the treated groundwater prior to its introduction into the system. In order to maintain the disinfectant contact time required by TCEQ, it will be necessary to install baffles inside the storage tank to prevent short-circuiting of the flow from the inlet to the outlet. The extent of baffling required will ultimately be determined by the final flow of treated groundwater through the tank.

REJECT WATER IMPACT ANALYSIS

The reject water from the treatment processes will have concentrated quantities of the removed constituents. The disposal of the reject water is typically accomplished by discharge to a municipal sewer collection system and diluted with the normal wastewater stream. For this project, various reject water disposal options were investigated, including discharge to the adjacent sanitary sewer, discharge to the adjacent playa lake, and on-site evaporation. The preliminary results of the analysis indicate that discharge to the adjacent playa lake would likely have a rapid and detrimental effect upon the lake, increasing concentrations of nitrate and total dissolved solids to unacceptable levels. The lake volume and frequency of diluting rainfall, even with periodic purging with excessive rainfall events, would not be sufficient to adequately dilute the water quality to acceptable levels.

On-site evaporation of the reject water was evaluated but dismissed due to the lack of available area and impact on neighborhood aesthetics.

Discharge of the reject water to the sanitary sewer would have a lesser effect than the other options, but could still be significant, particularly due to elevated concentrations of fluoride and nitrogen which could detrimentally impact not only the City's desired discharge permit but also the nitrogen removal treatment processes being considered for the treatment plant upgrade.

PRELIMINARY PROCESS SELECTION

Attached as Appendix A is the Preliminary Process Selection Memorandum prepared by Black & Veatch. This document provides a greater degree of detail than discussed herein, and includes opinions of cost associated with the various treatment options available.

Of the treatment processes evaluated, two were recommended for further consideration at such time as the project becomes economically feasible. Those processes include:

1. Microfiltration/ultrafiltration (MF/UF) followed by reverse osmosis (RO) with a side stream, stabilization, primary disinfection with free chlorine, and secondary disinfection with combined chlorine;
2. Direct treatment with RO and treatment of the side stream with MF/UF, primary disinfection with ultraviolet (UV) disinfection, and secondary disinfection with combined chlorine.

Planning level cost opinions were prepared to facilitate comparison of alternative treatment processes to include water and brine treatment equipment, installation, electrical, instrumentation and controls, buildings, site work, piping, pilot testing, engineering, legal, administrative and contingency costs. The 20-year present worth costs for the two alternatives, using a 5 percent rate of return, were $27.4 million and $20.0 million, respectively, resulting in unit costs of $1.20 per thousand gallons and $0.90 per thousand gallons.

Costs of those project improvements to have been provided by the City, including wells, raw water piping, and any additional high service pumps or storage, were not included in these costs.

We appreciate the opportunity to have been of service to the City of Lubbock on this project.

Sincerely,

PARKHILL, SMITH & COOPER, INC.

By John S. Kelley

John S. Kelley, P.E.
Principal / Project Manager

JSK/sjj

Enclosures

cc: David Timmermann, P.E. Black & Veatch

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BLACK & VEATCH

MEMORANDUM

City of Lubbock
Preliminary Process Selection Memorandum

B&V Project 139065.0200
May 16, 2006

To: John Kelley (Parkhill, Smith & Cooper)

From: Nick Burns, Scott Freeman, and David Timmermann, P.E.

STATE OF TEXAS
DAVID A. TIMMERMANN
65779
REGISTERED
PROFESSIONAL ENGINEER
5/16/06

EXECUTIVE SUMMARY

The City of Lubbock is considering the construction of a new water treatment plant capable of producing 5.0 million gallons per day (mgd) of potable drinking water. Raw water would be collected from the groundwater aquifer in southwest Lubbock near the City's Pump Station 10 site through construction of a number of production wells, most of which are to be located adjacent to playa lakes in City parks. The raw water is generally characterized as having a high fluoride concentration (10 mg/L) and based on limited water quality data, may be considered as being under the influence of surface water. Characterization of the water as being under the influence of surface water or not being under the influence is a major issue that will require a greater level of analyses and discussions with the Texas Commission on Environmental Quality (TCEQ) will be required to make this ultimate determination. Water analyses were previously performed by others on one sample from an un-equipped production well at the Pump Station 10 (PS10) site and historical data was obtained from the Texas Water Development Board for two wells in the vicinity of the proposed area. This data was used to develop four treatment alternatives capable of reducing the fluoride concentration to less than 2.0 mg/L. Based on this limited data that led us to suspect that the groundwater may be under the influence of surface water, we selected and evaluated treatment process to satisfy the treatment requirements for groundwater under the influence of surface water.

The following four alternatives were developed to treat the proposed water source:

1. Microfiltration/ultrafiltration (MF/UF) followed by reverse osmosis (RO) with a sidestream, stabilization, primary disinfection with free chlorine, and secondary disinfection with combined chlorine;
2. Direct treatment with RO and treatment of the sidestream with MF/UF, primary disinfection with ultraviolet (UV) disinfection, and secondary disinfection with combined chlorine;
3. MF/UF followed by treatment with electrodialysis reversal (EDR), primary disinfection with free chlorine, and secondary disinfection with combined chlorine; and
4. Activated alumina (AA) followed by MF/UF, primary disinfection with chlorine, and secondary disinfection with combined chlorine.

All treatment alternatives were assumed to deliver water through an air gap into the PS10 - 7 million gallon (MG) reservoir. The water would be disinfected and contain combined chlorine prior addition to the reservoir.

Each treatment alternative would have a waste stream (concentrate or brine) that is generally high in fluoride that would require special disposal considerations. Disposal of the concentrate to an existing wastewater treatment plant was evaluated. In all cases, the concentrate would require additional treatment for the removal of fluoride as the blended wastewater effluent would exceed the TCEQ water quality and United States Environmental Protection Agency (US EPA) long-term water reuse discharge requirements. Pretreatment includes a contact clarifier and the addition of calcium. The solids would require disposal off-site. Even with pretreatment, the fluoride concentration may continue to exceed the US EPA long-term water reuse requirements and it will be necessary to work TCEQ to develop an acceptable fluoride level.

Process Alternatives 1 and 2 are recommended for further consideration. A more definitive recommendation can not be made at this time based upon the limited raw water quality data that is available to definitively resolve if the groundwater is under the influence of surface water. The treatment processes in both of these alternatives will provide a high quality finished water at reasonable costs compared to the other alternatives.

The area to the west of the existing pump station in the southwest corner of the tract has been initially identified by the City for the proposed treatment plant. It is doubtful that construction of the necessary facilities would fit in this area even if a multi-story structure was utilized as access into this area for chemical deliveries would be extremely difficult. A multi-story structure may also prove to be unacceptable to adjacent neighborhood interests and concerns. The area north of the new reservoir has adequate space for siting the plant, but is currently planned for neighborhood landscape improvements.

Additional recommendations include the following:

- Additional water quality data should be collected to confirm the preliminary process assumptions used within this report to develop treatment process alternatives and opinion of cost information.
- Discussions with TCEQ should be initiated upon characterization of the source water to determine if the water would be considered groundwater under the influence of surface water and what, if any, treatment processes changes would be necessary to the proposed plan for compliance with all applicable regulations.
- Brine pretreatment alternatives should be considered. Because of the increase in fluoride concentration to the wastewater plant, deep-well injection should be evaluated in detail and a preliminary cost estimate should be developed.
- A discussion with TCEQ should be initiated on the change in fluoride concentration at the headworks of the wastewater treatment plant. This discussion should assist the City in establishing the following: (1) if pretreatment will be necessary, (2) if the resulting fluoride concentrations following lime pretreatment will be adequate, and (3) what level of treatment is necessary.

INTRODUCTION

The City of Lubbock Texas is considering the construction of a new water treatment plant capable of producing 5 mgd of potable drinking water from the aquifer in southwest Lubbock near Pump Station 10 (PS10). The water table is generally 10 to 30 ft below the surface. The raw water is generally characterized as having a high fluoride concentration and based on limited water quality data, may be considered as being under the influence of surface water. Preliminary data indicate that it has a fluoride concentration of approximately 10 mg/L, which exceeds the USEPA's maximum contaminant level (MCL) for drinking water of 4 mg/L. The Secondary MCL for fluoride is 2 mg/L. The site for the proposed WTP is on the city owned, PS10 site.

This memorandum includes the characterization of the aquifer and treated water quality goals, a regulatory review, description of four treatment alternatives, concentrate disposal evaluation, planning-level cost opinions, site considerations, and conclusions. If the City decides these options warrant further consideration, a workshop could be held to select the best option for full scale application. The workshop participants could include representatives from the City, their engineer, and TCEQ.

WATER QUALITY CHARACTERIZATION

Source water for the proposed facility would be the groundwater aquifer near PS10. The City provided analyses on one sample from an on-site but un-equipped production well at the PS10 site. Additional historical data was obtained from the Texas Water Development Board (TWDB) for existing wells in the near vicinity of the site. The treatment alternatives discussed in this memorandum are based on raw water quality data from these sources as summarized in Table 1. There is limited water quality data available and was considered the best available first approximation for this planning-level study. If the City finds the results of the preliminary study to warrant more detailed consideration, the assumptions herein could be reviewed based on additional water quality data.

For the basis of this evaluation, the source water is considered to be groundwater under the influence of surface water. This assumption was developed because a disinfection byproduct was detected in the source water, an indicator that that water was chlorinated, and the shallow playa lakes in the region may be directly connected to the shallow aquifer. To determine if the source water is groundwater under the influence of surface water, additional water quality testing will be necessary. TCEQ will make the ultimate decision on the connectivity of the groundwater with surface water.

A summary of the finished water quality at PS10 is also listed in Table 1 based on samples collected by the City of Lubbock from April through September 2005. These data were used as the basis for finished water quality for the alternatives discussed in this memorandum. The treatment plant effluent pH would be raised with caustic to avoid corrosion and related problems, such as lead and copper leaching. Additionally, the water would be treated with chlorine (sodium hypochlorite) for disinfection and combined chlorine to match the distribution system water quality. These steps would provide finished water that is compatible with the water in the existing distribution system. Once disinfected and stabilized, the treated water would be added to the existing PS10 - 7 MG finished water reservoir.

Table 1. Average of Water Quality Data
(mg/L unless otherwise noted)

	Pump Station 10 Well (Sept. 2003)	**TWDB Well No. 23 25 904 (1990)**	**Finished Water (PS10)** (April 2005 to Sept. 2005)
pH	NA	7.4	8.0
Total Dissolved Solids	832	839	986
Total Hardness (as $CaCO_3$)	NA	364	250
Total Alkalinity (as $CaCO_3$)	194	373	186
Calcium	NA	39	63
Magnesium	NA	64	22
Potassium	NA	16	10
Sodium	NA	164	215
Silica	NA	46	21
Chloride	NA	108	267
Fluoride	9.60	5.0	0.6
Nitrate (as NO_3-N)	1.57	5.1	0.7
Sulfate	181	187	214
Bromodichloromethane, ug/L	2.95		NA

NA – Not analyzed

The primary treatment objectives were to meet TCEQ regulations and to reduce the fluoride concentration to less than 2 mg/L. Removal of TDS was not a significant treatment objective because the existing water in the distribution system has a higher TDS concentration than the shallow groundwater. Other water quality goals include the stabilization of the water to reduce corrosivity, provide disinfection, and ensure there are no compatibility issues as a result of blending the product water with the existing distribution system water.

compatible with high calcium carbonate precipitation potential. The solids would be removed and dewatering with a centrifuge or other dewatering process, stored onsite, and disposed of in a monofill or landfill.

Treatment Alternative 1 and 2 has the lowest fluoride concentration in the brine solution, 24 mg/L, but the volume is large, resulting in the highest wastewater plant fluoride influent concentration, 3.5 mg/L. Calcium precipitation would not be able to remove adequate amounts of fluoride to result in the blended treatment influent less than 1 mg/L. The anticipated plant influent fluoride concentration would be 1.8 mg/L, and would exceed the USEPA long-term water reuse guideline.

Treatment Alternative 3 would result in a wastewater plant influent fluoride concentration of approximately 2.9 mg/L and calcium precipitation would be effective in treating Alternative 3 brine resulting in an estimated blended plant influent fluoride concentration of approximately 1 mg/L, the US EPA long-term reuse guideline.

The fluoride concentration was highest in the AA regenerating solution, 110 mg/L, but had the process had the smallest waste stream flow, resulting in the lowest fluoride increase in the plant influent fluoride concentration, 2.7 mg/L. Following pretreatment, the fluoride concentration at the head of the wastewater plant would be 0.8 mg/L. A large concentration of lime would be required for treatment as a result of the high alkalinity in the AA regeneration solution.

Alternative 3 brine chloride concentration exceeds 500 mg/L, the recommended concentration for minimizing corrosion of 304 stainless steel. The chloride concentration in the other three alternatives is approximately one half, 260 mg/L. The chloride concentration of Alternative 3 may require additional consideration by the City.

Another concern with discharge into the sanitary sewer system and conveyance to the wastewater treatment plant is the sodium concentration. A portion of the wastewater effluent is discharged at land application sites. Uptake of the sodium by the vegetation may impact the types of vegetation grown on the land application sites. The sodium concentration would increase slightly. The impacts of the high sodium concentration in these concentrate streams may require additional consideration by the City.

COST OPINION

A summary of the cost opinions for the four treatment alternatives is listed in Table 8. Water quality data used for the basis of these planning-level cost opinions was limited, and better characterization of the aquifer, through collection of additional water quality data, may have a significant effect on the system design and cost. The cost opinions were developed based on estimated equipment and operating costs from Black & Veatch experience and equipment manufactures.

Table 8. Planning-Level Cost Opinions				
	Alternative 1 MF/UF – RO	**Alternative 2** RO w/ MF/UF bypass	**Alternative 3** MF/UF – EDR	**Alternative 4** AA – MF/UF
Capital Cost Summary				
Equip.& Facility Cost, $	$12,300,000	$8,800,000	$13,700,000	$8,300,000
Engineering/Legal/Admin: 15 percent, $	$1,900,000	$1,400,000	$2,100,000	$1,300,000
Contingency: 25 percent, $	$3,100,000	$2,200,000	$3,500,000	$2,100,000
Project Capital Cost, $	$17,200,000	$12,200,000	$19,100,000	$11,600,000
Amortized Project Cost, $/yr	$1,400,000	$1,000,000	$1,500,000	$900,000
Cost Summary, 2.5 mgd average flow				
Annual Operating Cost, $/yr	$450,000	$340,000	$390,000	$580,000
Annual Operating Cost, $/kgal	$0.49	$0.37	$0.43	$0.63
Total Annual Cost, $/yr	$1,800,000	$1,300,000	$1,900,000	$1,500,000
Total Cost of Water, $/kgal	$2.00	$1.40	$2.10	$1.70
20 Yr Present Worth Cost, $	$22,800,000	$16,400,000	$24,000,000	$18,800,000
Cost Summary, 5.0 mgd average flow				
Annual Operating Cost, $/yr	$810,000	$620,000	$690,000	$910,000
Annual Operating Cost, $/kgal	$0.45	$0.34	$0.38	$0.50
Total Annual Cost, $/yr	$2,200,000	$1,600,000	$2,200,000	$1,800,000
Total Cost of Water, $/kgal	$1.20	$0.90	$1.20	$1.00
20 Yr Present Worth Cost, $	$27,400,000	$20,000,000	$27,800,000	$23,000,000
Present Worth Evaluation Based on 20 years with effective interest rate of 5 percent.				

The planning-level cost opinions do not include the wells, raw water piping, any added high service pumps, or storage. Planning-level costs of the water treatment options were developed to facilitate comparison of alternatives. Capital cost does include water and brine treatment equipment, installation, electrical, instrumentation and controls, buildings, sitework, and piping. Project cost includes pilot testing, engineering, legal, and administrative, and contingency. Amortized and present worth cost is based on 20 years and a 5 percent rate of return.

The capital cost for Alternative 1, is the second highest as a result of membrane filtration of all the water required by the RO system and poor recovery in the RO system. The MF/UF and RO systems account for 80 percent of the capital cost. Additionally, the process has the second highest operating cost, with the RO system accounting for more than 50 percent of the annual operating cost.

Alternative 2 requires the same RO system, but a much smaller membrane filtration system, as only the bypass stream is treated with MF/UF membranes. The reduction in size of the MF/UF system results in a $5,000,000 project cost savings over Alternative 1. The capital cost for the system is only slightly greater than Alternative 4 (AA-MF/UF). The RO system accounts for more than half of the capital cost. The process has the lowest operating cost. On a 20 year present worth basis, the alternative has the lowest total cost.

The capital costs for Alternative 3, is the highest as a result of membrane filtration of all the water required by the EDR system and capital cost of the EDR system. The EDR system accounts for more than half the capital cost. The process has second lowest operating cost, with the EDR system accounting for the majority of the cost. The process alternative has the highest present worth value.

The capital costs for Alternative 4, is the lowest of the four treatment alternatives. Membrane filtration accounts for approximately 40 percent of the capital cost, and could be eliminated if the source water was found to be groundwater and not under the influence of surface water. The AA process has a high operating cost, with the AA system accounting for nearly 60 percent of the annual operating cost. The process alternative has the second lowest present worth cost.

SITE CONSIDERATIONS

The City had initially identified the southwest corner of the existing PS 10 site as the location for the new water treatment facilities. Based on our review of a site plan provided by the City, there are numerous constraints to constructing facilities in this area. We understand the building setback from 82nd Street is approximately the south face of the pump station and the site plan shows a series of underground telephone lines approximately 85-feet north of this setback line.

Assuming a 15-foot setback from the west property line, there is approximately 60-feet to the west face of the pump station yard fence, which contains a communications tower. Therefore, approximately 100-feet by 60-feet of space remains available in this corner for the treatment facilities. Construction of a multi-story facility would help to minimize the necessary footprint but the space would still likely not be adequate to support the necessary roads for chemical deliveries and routine maintenance. For example, considering Alternative 1, a two story facility would be required with dimensions of approximately 60-feet by 80-feet. The MF/UF and ancillary equipment and common plant facilities could be housed on one floor, and the RO equipment on another. The limited space availability is another reason that the new larger diameter RO elements, which provide more compact units, would be considered for this project. A multi-story facility could include both below-ground and above-ground construction. The space is not sufficient for pretreatment of the waste prior addition to the sanitary sewer. Another location would need to be allocated for brine pretreatment and solids handling facilities.

While we understand the North part of the PS10 site is planned for site landscaping, this is the only area on the site that is of adequate size to accommodate the proposed treatment facility. A figure of the site is provided in Figure 2. The site has an area of approximately 130 x 260 ft (32,500 sq-ft), which allows for 25-foot property line setbacks. The areas required for the