Connecting the East to the West:
TRWD's 350 MGD Eagle Mountain Connection Project

By Alan C. Hutson, P.E.[1], Russell L. Gibson, P.E.[2] and David H. Marshall, P.E.[3]

Abstract

Tarrant Regional Water District (TRWD) supplies raw water to over thirty wholesale customers (approximately 1.6 million people) in ten Texas Counties. TRWD's existing raw water supply system is divided into an East Texas System and a West Fork System. The East Texas System includes Richland Chambers and Cedar Creek Lake with pipelines and pump stations to deliver water from East Texas to Tarrant County. The West Fork System includes Lake Bridgeport and Eagle Mountain Lakes, which serves the north and west side of Fort Worth.

The Eagle Mountain Connection Project will allow TRWD to pump water from their East Texas Reservoirs to Eagle Mountain Lake. The project includes 20 miles of 96-inch and 84-inch pipeline to connect TRWD's East Texas Supply System to their West Fork Supply System, the 430 MGD Rolling Hills Pump Station (expandable to 630 MGD), the 230 MGD Benbrook Booster Pump Station (expandable to 350 MGD), a 120-million-gallon balancing reservoir, and a number of other required facilities. The $170-million project will allow TRWD to meet rapid growth in their West Fork service area and will result in power cost savings while increasing the available yield and the reliability of the TRWD water supply system.

The project is currently under construction and scheduled for completion in March, 2008. This paper presents an overview of the project, describes lessons learned and innovations in design and construction including the following:

- System operation considerations
- Foundation design for a 7 and 14 MG pre-stressed concrete tank
- Innovative equipment purchase procedures using performance evaluations and negotiated pricing
- Innovative pipe coating systems
- Large diameter pipe installation techniques
- Innovative balancing reservoir design
- Lessons learned for hydraulic design of two flow control structures
- A subaqueous pipe and outlet structure in Eagle Mountain Lake

[1] Project Manager, Water Resources, Freese and Nichols, Inc., 4055 International Plaza, Suite 200, Fort Worth, TX 76109; phone 817-735-7315; ach@freese.com.
[2] Principal, Water Resources, Freese and Nichols, Inc., 4055 International Plaza, Suite 200, Fort Worth, TX 76109; phone 817-735-7323; rlg@freese.com.
[3] Engineering Division Manager, Tarrant Regional Water District, 800 E. Northside Drive, Fort Worth, TX 76102; phone 817-335-2491; dmarshall@trwd.com.

Introduction

Tarrant Regional Water District (TRWD) supplies raw water to over thirty wholesale customers (approximately 1.6 million people) in ten Texas counties, including Tarrant, Wise, Denton, Ellis, Parker, Navarro, Henderson, Freestone, Kaufman, and Johnson. In 2000, municipal use accounted for 97.6% of the 323,462 acre-feet of raw water supplied by TRWD. Of the municipal use, approximately 94.4% was supplied to Fort Worth, Arlington, Mansfield, and the Trinity River Authority of Texas.

TRWD's existing raw water supply system includes two major reservoirs in East Texas (Cedar Creek Lake and Richland-Chambers Lake), pipelines and pump stations to deliver water from East Texas to Tarrant County, the West Fork reservoirs (Lake Bridgeport, Eagle Mountain Lake, and Lake Worth), two terminal storage lakes in Tarrant County (Lake Arlington and Lake Benbrook), and the Benbrook Connection (which delivers East Texas water to Lake Benbrook). The locations of TRWD's existing raw water facilities and the proposed Eagle Mountain Connection facilities can be seen on Figure 1.

Water from the West Fork reservoirs is used to supply demands around the lakes and to supply Fort Worth's Eagle Mountain and Holly Water Treatment Plants in the northern part of TRWD's service area. The East Texas reservoirs contain 85% of TRWD's available supply. Two pipelines, a 90-inch line from Richland-Chambers Lake and 72-inch line from Cedar Creek Lake, are used to transport the water approximately 75 miles to Tarrant County. Lake Arlington is primarily used for terminal storage for water from the East Texas reservoirs. Lake Benbrook is also used for terminal storage of East Texas water delivered via the Benbrook Connection, a 90-inch pipeline/tunnel from the Rolling Hills Water Treatment Plant to Lake Benbrook. The terminal storage allows TRWD to reduce peak pumping requirements. TRWD operates the raw water facilities based on reservoir operating policies, contractual agreements, and permit requirements.

The Eagle Mountain Connection Project will allow TRWD to pump water from their East Texas Reservoirs to Eagle Mountain Lake (EML). The growing demand for local use around the TRWD West Fork reservoirs and growing demands on the City of Fort Worth's Eagle Mountain and Holly water treatment plants will make it increasingly difficult to meet the demands currently served by the West Fork reservoirs. Most of TRWD's existing and planned future supplies are associated with the East Texas reservoirs, so movement of the water from the East Texas reservoirs to delivery points in the West Fork service area is critical to meet future demands. In addition, the project will greatly increase the reliability of the TRWD water supplies during a drought or pipeline malfunction. The project reduces the potential for drought in the West Fork from one in ten years to one in fifty years.

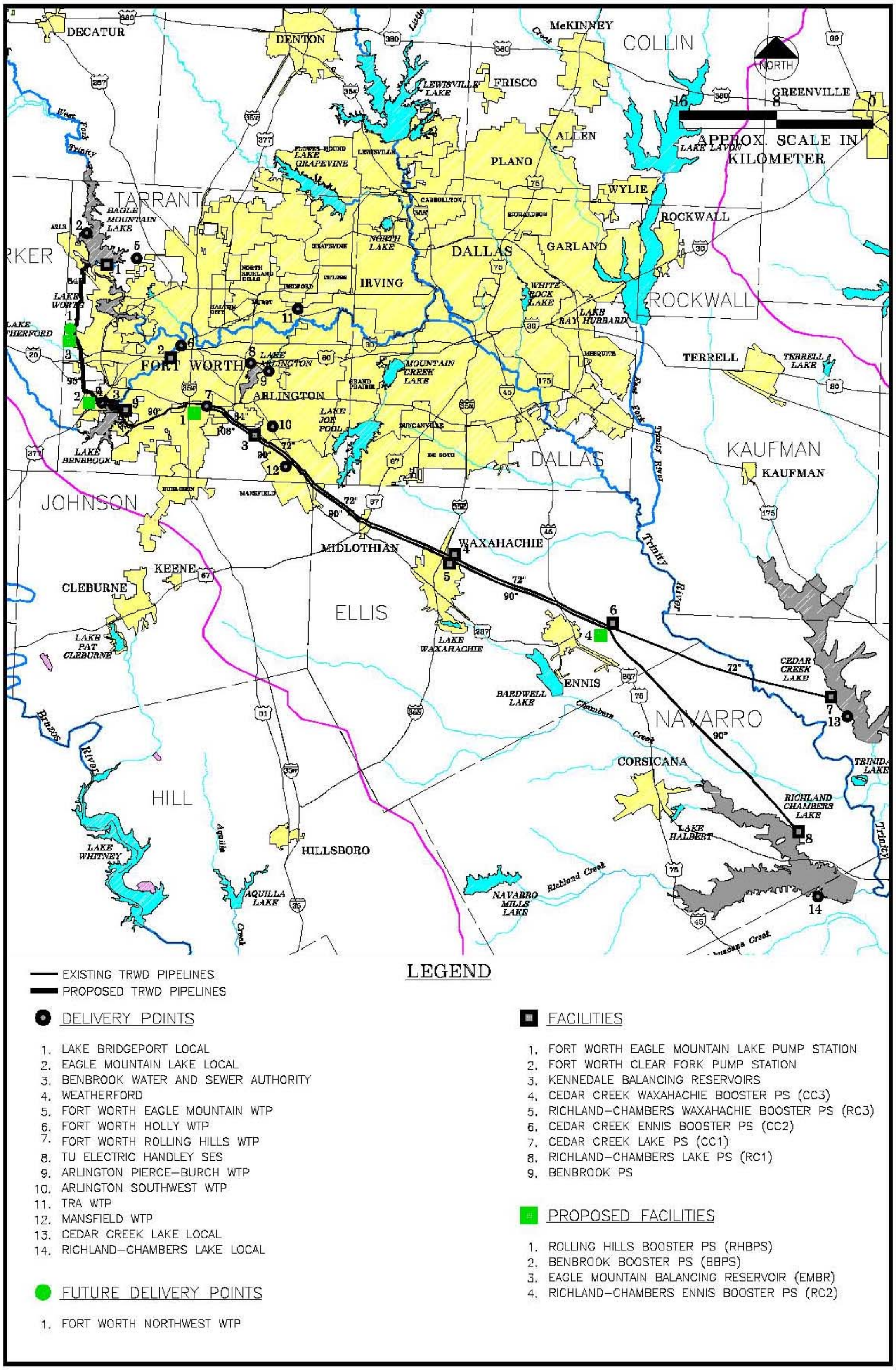

Figure 1. TRWD Existing Raw Water System and Proposed Improvements

The following facilities will be constructed as part of the project:

- 20 miles of 96-inch and 84-inch pipeline
- 430 MGD Rolling Hills Pump Station (expandable to 630 MGD)
- 230 MGD Benbrook Booster Pump Station (expandable to 350 MGD)
- 120-million-gallon balancing reservoir
- Clear Fork flow control and outlet structures
- Eagle Mountain flow control and subaqueous outlet structure

Eagle Mountain Pump Station Facilities

Rolling Hills Booster Pump Station

From the Kennedale Balancing Reservoir, TRWD can serve the Fort Worth Rolling Hills Water Treatment Plant by gravity through parallel 108” and 84” pipelines. The existing 90” Benbrook Connection Pipeline continues from the WTP to Benbrook Lake where water can be stored in the winter for use to meet peak demands in the summer.

The Rolling Hills Booster Pump Station (RHBPS) is located just south of the Rolling Hills WTP, off the 90” pipeline. The original concept of the pump station was to boost water from the balancing reservoir over a high point on the Benbrook Pipeline to feed the Eagle Mountain Connection. During analysis of the gravity feed system to the WTP, it was determined that the existing 108” and 84” pipeline could not meet the system demands by gravity. Several options were studied including building a third gravity flow pipeline and raising the balancing reservoir. Although these upgrades will be required at a later date, it was determined that low head pumps could be added to the Rolling Hills BPS to delay these upgrades for 20 years. Pumping peak demands into RHWTP allows the hydraulic grade line at the RHBPS to be lowered approximately 44 feet, which significantly increases the hydraulic capacity of the existing pipelines between KBR and RHWTP. The low-head pump station will add approximately six million dollars to the RHBPS cost, as opposed to a new gravity pipeline that would cost approximately thirty million dollars. This concept provides the optimum solution because TRWD will be able to gravity feed RHWTP during average flow conditions and will pump into RHWTP only during peak flow conditions.

Vertical turbine pumps in suction cans are required at the RHBPS due to net positive suction head available (NPSHA) limitations and potential variations in the suction head. The RHBPS will pump into RHWTP with low-head pumps and reduced-speed high-head pumps and over the hill at Longhorn Park with high-head pumps. VFD’s will reduce the speed of the high-head pumps so they can run in parallel with the low-head pumps. This innovation reduced the number of pumps required, thus reducing costs, while also maintaining good pumping efficiencies and operational flexibility. The RHBPS will initially be constructed with four high-head and two low-head pumps, with provisions for expansion to four high-head and five low-head pumps. There will be one additional pump slot for flexibility. Figure 2 shows the RHBPS under construction.

Figure 2. Rolling Hills BPS Suction Valve Isolation Vault and Pump Barrels

Benbrook Booster Pump Station

The Benbrook Booster Pump Station (BBPS) is located below Benbrook Dam in southwest Tarrant County. The BBPS will receive flow from the Rolling Hills Booster Pump Station and pump water through the 96"/84" pipeline to Eagle Mountain Lake.

The recommended layout for the BBPS includes three large pumps and one small pump initially. The smaller pump is required to meet low flows and to supplement higher flows. All four pumps will be required to meet the maximum 230 MGD capacity and the 170 MGD firm capacity. A total of six pumps will be required for a future capacity of 350 MGD. The BBPS will ultimately have six pump slots.

Side-suction, horizontal split case pumps will be installed at the BBPS. Bottom-suction, horizontal split case pumps were also evaluated for the BBPS, but were determined to be less cost effective due to additional building construction costs for a basement pipe gallery. In addition, the side-suction pumps facilitate a floor plan layout with better access to the suction piping. Figure 3 is a photo of the BBPS under construction. The suction tank at the BBPS is sized for 14 million gallons.

Figure 3. Benbrook Booster Pump Station Foundation

Tank Design

The project includes a seven million gallon storage tank at the RHBPS and a fourteen million gallon tank at the BBPS. Prestressed concrete storage tanks (AWWA D-110) were selected over steel tanks (AWWA D-100) because of the lower expected life cycle costs and to prevent downtime for painting. Both tanks have a specially designed tank floor slab. The tanks are 65 feet high and 70-feet high respectively. The size and height of the tanks are near the maximum ever constructed by the local prestressed concrete tank contractors. The tanks have 114-inch and 96-inch inlet and outlet pipes that must penetrate the floor slab. The foundation soil conditions at the RHBPS tank is weak fat clays. The foundation at the BBPS tank is competent limestone at a relatively shallow depth.

A recent structural failure on a similar size prestressed concrete tank floor is thought to be due to the design of the membrane floor slab. It is believed that the slab failed in shear near the connection between the outlet pipe encasement and the floor slab.

Because of the project conditions and the recent tank floor slab failure, the Owner and Engineer agreed to investigate the membrane floor slab design for the proposed tanks. The results of this study are as follows:

1. The typical industry practice is to leave the design of the foundation with the tank manufacturer with little or no specific design constraints. Finite element method (FEM) analysis of the stiffness discontinuities introduced by inlet pipe

connections tends to drive the designer toward thinner membrane-type concrete floors. In general, a thinner membrane will result in lower stresses. These lower stresses coupled with lower material costs of thin membranes are a strong inducement for a competitive tank manufacturer to make the floor as thin as possible. In the author's opinion, the problem inherent in this approach is two-fold. First, the slabs are so thin that shrinkage cracks are created along most of the slab reinforcement. These cracks must be repaired and maintained at considerable expense and are not considered reliable. Second, the thin brittle membrane is very susceptible to local discontinuities due to localized variations in the subgrade. The author recommends that the design constraints imposed on the tank manufacturer should be such that the post-crack slab have sufficient depth and reinforcement to be capable of the following:

   a. The slab section should be capable of resisting the computed stresses according to the ACI 350 criteria with the additional environment load factor.
   b. The slab should have a minimum capacity to account for real-world discontinuities to be expected in the subgrade.

2. The AWWA D110 standard provides for design of the foundation with either a structural floor or membrane slab. Under many conditions the membrane slab will prove to be the least costly type of foundation; however, the nature of the subgrade and the size of the tank (as well as economics) should be used to determine the type of foundation to be used.
3. There are several assumptions that are critical to the design of the membrane slab. The AWWA D110 provides the following statements:
   a. "In cast-in-place concrete membrane floors, loads are assumed to be transmitted to the subbase directly through the membrane floor."
   b. "The subgrade for membrane floors must be of uniform density and compressibility to minimize differential settlement of the floor and footings."
   c. "Compaction shall achieve a density of at least 95 percent of the maximum laboratory density determined by ASTM D1557." This is modified proctor and not standard proctor.
   d. "Overexcavation and replacement with compacted imported material may be required if foundation soils are unsatisfactory for the imposed loadings or do not provide uniform support."
   e. "The subgrade for all types of floors shall be so designed that leakage through the floor will not cause erosion and settlement in excess of that provided for in the design or will not cause other types of failure."
4. The AWWA standard is somewhat general and leaves much to be determined by the tank designer and the Owner's Engineer. The use of a membrane floor requires a careful examination to assure himself the fundamental assumptions regarding the membrane floor are being met with the design and construction.
5. The foundation preparation is critical to the performance of the floor slab. As a result, the responsibility for the quality of the construction of the tank foundation should be assigned to the tank contractor. Split responsibility for the foundation preparation and floor slab design and construction can lead to problems.

Since the RHBPS tank had poor soil conditions, large inlets and outlets, and tall height, the design required a three foot thick slab supported by 175 drilled shafts, as shown in Figure 4. The BBPS had competent limestone foundation conditions; therefore, the design included a twelve inch double reinforced slab supported by highly consolidated crushed stone flexible base material. The flexible base sits on the limestone, and a below slab drainage system was provided.

Figure 4. Drilling and Placing Piers for the Rolling Hills Tank Foundation

Pump Pre-purchase

The pumps, motors, and VFD's were purchased using a negotiated bid process, which was permitted by special legislation for the Tarrant Regional Water District. The legislation allows TRWD to use the negotiated bid process where the conventional bidding process is not practical to achieve competitive bidding of specialized equipment.

The Owner and Engineer decided to purchase the pumps, motors, and VFD's directly from the manufacturers and provide the equipment to the installation contractor. Conventional bids were taken for the pumps, motors, and VFD's; however, only two bids were received for the BBPS horizontal pump package, and no bids were received for the RHBPS vertical pump package. Discussion with potential bidders indicated they did not want to accept the commercial terms in the contract. In particular, the domestic pump suppliers objected to no limits on consequential damages and no caps on liquidated damages. It should be noted that the standard purchase documents prepared by the Engineer Joint Contract Document Committee (EJCDC) do not have any limits on consequential or liquidated damages. The two bids received were for the horizontal pump package from foreign pump suppliers, who did not object to the standard EJCDC conditions.

After conventional bids did not result in achieving competitive bids on the pumping equipment, TRWD rejected all bids, and initiated the negotiated bid process. The process includes the following steps:

- The Engineer prepares bidding documents, including defining the bid-negotiation process and selection criteria.
- The Owner receives sealed price proposals from the bidders. Bidders are allowed to write any exceptions to the technical specifications and commercial terms and conditions.
- The Owner and Engineer review and rank the proposal according to the criteria.
- The Owner and Engineer meet with the shortlist of suppliers and negotiate technical and commercial terms and price with each supplier.
- The Owner makes a final selection based upon the selection criteria.

For this project the selection criteria included the following:

- Evaluated Bid Price (Capital and Life Cycle Cost) – 25% weighting
- Equipment Performance – 25% weighting
- Manufacturer Quality Control and Experience – 25% weighting
- Conformance to commercial terms – 25% weighting

Five bids were received for the RHBPS vertical pump package and four were received for the BBPS horizontal pump package. The successful bidder for the RHBPS vertical pumping units was Sulzer Pumps, with National Oil Well motors and Allen Bradley VFD’s. The successful bidder for the BBPS horizontal pumps was Hitachi Pumps, with National Oil Well motors and Allen Bradley VFD’s.

The negotiated bid process offers the following advantages to the Owner:

- It allows the Owner to consider criteria other than price for selection.
- It allows the Owner to have more control in the selection of the equipment.
- It allows the Owner to manage risk more easily.
- More emphasis is put on quality rather than price in the process.

Eagle Mountain Pipeline

The Eagle Mountain Pipeline is almost 20 miles in length and runs from Lake Benbrook in southwest Tarrant County to Eagle Mountain Lake in northwest Tarrant County. The 96”/84” pipeline has a maximum future capacity of 350 MGD.

A high point is located in the middle of the pipeline route. This high point controls the static head at the Benbrook Booster Pump Station. It was at this location where the future balancing reservoir will be located. The reservoir will serve as storage for a future water treatment plant currently being designed for the City of Fort Worth. At this connection, the pipeline reduces from 96 to 84-inches.

Pipeline Coating

The 96/84-inch pipeline is steel with a mortar lining. To increase the life of the pipeline, the steel pipe must be protected from corrosion by the pipeline coating and cathodic protection. Steel pipelines in this diameter are flexible and thus require a flexible coating. Two of the most common flexible coating systems for steel pipe are tape wrap and polyurethane. For this project, a relatively new flexible coating, side extruded polyethylene (Pritec) was also considered.

Polyurethane has been used to protect undergrounds storage tanks for over 35 years and buried steel waterlines for the last 14 years. Polyurethane coatings have excellent adhesion to steel, excellent toughness and abrasion resistance, good UV resistance, and high dielectric strength. Polyurethane is considered a high technology coating because it requires special equipment, trained personnel, and is highly dependent on proper fluid heating and mix ratios for proper coating application and cure. Experience shows that to extend the life of the coating system, the pipe must have a white metal abrasive blast with sufficient angular profile, and a clean surface for the polyurethane to achieve high adhesive qualities.

Extruded polyethylene (Pritec) is a relatively new to the water market, but has been used successfully for the last 30 years on oil and gas pipelines. The coating has been applied to several large waterlines in southern California with a mortar overcoat. Last year, an 84/60-inch pipeline in Salt Lake City was installed without a mortar overcoat.

The coating system consists of a layer of butyl rubber adhesive and a layer of extruded polyethylene sheath. The butyl rubber and polyethylene layers are applied hot so the layers bond together. “Pritec” coating is a tough and durable coating that should be able to handle normal construction activities and pipe backfill with minimal damage. The greatest issue with “Pritec” is the shrinkage stresses that result from the cooling of the molten polyethylene after application. TRWD, FNI, and Corrosion Control Technologies witnessed both the application of “Pritec” and the installation of the pipe. We found that the issue of shrinkage stresses could be mitigated with proper techniques and adequate quality control.

Based on our assessment of the coating systems, both polyurethane and side extruded polyethylene were specified as options for the project. The local pipe suppliers both have the ability to apply polyurethane, but new facilities would be required to apply "Pritec". Bids were taken and polyurethane is being used on the pipeline.

Pipeline Installation

Imported angular gravel is being used for pipe bedding and embedment. This material flows well under the haunches of the pipe and is easily compacted. One contractor is using vibratory plates mounted to a backhoe to vibrate both sides of the pipe at once (see Figure 5). The other contractor is using a large compaction wheel to compact the embedment material (see Figure 6).

Figure 5. Vibratory plates for compaction of pipe embedment

Figure 6. Compaction Wheel

All joints of the steel pipeline are welded after backfill. The pipe joints are protected with heat shrink sleeves. The weld after backfill process allows the Contractor to backfill the pipe trench almost immediately after pipe laying, thereby reducing the schedule, making the site safer, and saving an estimated $2 million to $3 million on the project...

Clear Fork Outlet Structure

The service spillway at Lake Benbrook discharges into the Clear Fork of the Trinity River and is capable of making very large discharges for flood control. In addition, smaller releases are made into the river to serve the City of Fort Worth’s Holly WTP. An outlet from the 96” pipeline will allow TRWD to discharge up to 120 MGD into the river for use by the City. This outlet provides an additional source of water for the Holly WTP adding flexibility and redundancy to the overall TRWD delivery system.

The design of the clear fork outlet presented several challenges. Hydraulically, a flow range of 30 to 120 MGD was required with heads in the pipeline ranging from 75’ to 140’ above the discharge point. To control the discharge rate, several types of valves were studied to break the head including butterfly valves, sleeve valves, and multiple orifice valves. The studies showed that too many butterfly valves would be required to meet the flow conditions and sleeve valves were too expensive and required too much space for the small site. In the end, a multiple orifice valve (MOV) was selected. An

MOV is a relatively simple valve, similar to a gate valve, which uses two steel plates with multiple orifice holes drilled in them. One plate is stationary, while the other plate slides up and down. When fully open, the orifice holes align. When closed, the plate slides up to close all the holes. This type of valve has very little experience in the United States but has been used successfully in Europe. The MOV valve saved approximately $125,000 over the other valves options.

Balancing Reservoir

As mentioned previously, the Balancing Reservoir will be at the high point of the system. The reservoir will provide ease in operation of the pipeline system as well as back-up storage for TRWD's customers. Storage is needed during routine maintenance, emergencies, or pump station downtime. The storage will benefit three water treatment plants which take water from the system. The reservoir also has the benefit of providing an open water surface to block surge waves in the pipeline. The reservoir will have a capacity of 118 million gallons of water.

The interior of the reservoir will have an HDPE liner with 9-inches of soil-cement. The HDPE liner controls leakage while the soil cement provides a good surface for maintenance equipment and reduces erosion due to wave action.

The inlet is located in the southeast corner of the reservoir with the outlet on the northwest side. A pipeline runs around the perimeter of the reservoir to serve as a bypass when the reservoir is down for maintenance. One potential problem with bypassing the reservoir is that shut-of head could be introduced into the pipeline if the valves at the future WTP or the outlet structure were closed while the pumps were in operation. A standpipe will be installed on the bypass pipeline to alleviate this concern. The standpipe will also help to alleviate any surge pressures during bypass operations. Another purpose of the bypass is to allow reverse flow through the system, in case future supplies are pumped to the south from Eagle Mountain Lake.

Eagle Mountain Flow Control Structure

From the balancing reservoir, the 84" pipeline continues almost nine miles downhill to Eagle Mountain Lake. There is an elevation drop of 250' from the balancing reservoir to Eagle Mountain Lake. The flow control structure could be placed at the balancing reservoir, but this would result in open-channel flow in portions of the pipeline resulting in unsuitable velocities in the pipeline. For this reason, the flow control structure was located near Eagle Mountain Lake.

The flow control structure was designed for a flow rate ranging from 30 to 280 MGD, and also to break between 35 to 230 feet of head. Several valve options were considered, including in-line sleeve valves, submerged sleeve-valves, and multiple butterfly valves with orifice plates. At first, the in-line sleeve valves appeared to be the best valve for the application due to the ability to break high heads and supply the full range of flows. Unfortunately, the sleeve valves require downstream pressure to operate without cavitation. Options to provide head downstream of the valve either reduced the flow capacity or cost too much money.

The use of parallel butterfly valves and orifice plates proved to be the preferred solution even though the cost was somewhat higher than the in-line sleeve valve option. The design calls for one 18” valve, one 24” valve and seven 36” valves in parallel. Each butterfly valve will have one or two orifice plates located downstream. The butterfly valves will generally be operated either fully open or fully closed with the flow and head loss controlled by the orifice plates. The lines are designed to be opened and closed in a specific sequence to control cavitation, surge and provide the desired flows.

Figure 7. Construction of the Eagle Mountain Flow Control Vault

Subaqueous Pipe and Eagle Mountain Outlet

The Tarrant Regional Water District requested to discharge into the main body of Eagle Mountain Lake to improve water mixing conditions and water quality in the lake. To do this, a 700’ section of pipe will be laid in the lake with an outlet structure in 20’ deep water.

Borings showed very loose sand, medium dense clayey sand, medium dense graded sand, and finally, very dense silty sand. It was recommended that the pipeline be founded in the layer of medium dense sand. The pipe had to be designed to withstand considerable settlement since it will be placed between layers of dense clayey and graded sands. Because of the material of the lake bottom, the pipeline trench was designed with 2:1 side slopes and an 8’ wide bottom. Three-inch rock was used for bedding to distribute the pipe load and reduce settlement. The pipe will be backfilled with ¾" rock up to 1' above the pipe. At the lake bottom, a 24" thick layer of riprap will be placed to provide protection from wave action and boat anchors.

Several pipe materials are suitable for underwater installation including steel, fiberglass or concrete. Steel pipe was not allowed because of the expected settlement of the pipe and corrosion concerns. Reinforced concrete pipe and fiberglass pipe options were allowed for the subaqueous pipe.

The outlet structure will use a pair of 90-degree steel bends to transition from buried pipe to the submerged outlet. The outlet structure will be embedded in concrete to provide corrosion protection and serve as a thrust block. The outlet was manufactured in the shop and shipped to the jobsite. Four piles were positioned in the lake to receive the outlet box. The structure slid down the four piles and was suspended above the bottom of the lake bottom while a concrete pad was poured below the box and then concrete placed in the box.

Figure 8. Outlet structure being positioned and lowered into Eagle Mountain Lake

With the box in place, cables will be strung from the outlet to the shoreline. The fiberglass pipe will be joined on shore and then a crane on a barge will pull the cable and the string of pipe home to the inlet on the box.

Conclusions

The Eagle Mountain Connection Project will be completed in the spring of 2008. The project was broken out into four construction contracts and three equipment contracts. The total construction cost including pre-purchased equipment is $139,127,485. Table 1 lists the different contracts and contractors for each portion of the project.

Table 1. Summary of Project Contracts and Construction Costs

Contract	Project	Contractor	Construction Cost
A	Eagle Mountain 96" Pipeline	Bar Constructors, Inc.	$ 43,725,696
B	Eagle Mountain 84" Pipeline	Garney Companies, Inc.	$ 41,718,094
C	Rolling Hills Pump Station	Archer Western Contractors, Ltd.	$ 14,433,075
C	Benbrook Pump Station	Archer Western Contractors, Ltd.	$ 19,718,928
D/E/F	Pre-purchase Equipment	Multiple Manufacturers	$ 12,574,192
G	Balancing Reservoir	TBD	$ 6,957,500
Total Construction Cost			$ 139,127,485

The project will provide the following benefits:

- Ability to meet demands in the West Fork service area,
- Flexibility in operations and future expansions,
- Increased system reliability
- Increased system yield, and
- Reduced system power cost.

Figure 9. Eagle Mountain 96-Inch Polyurethane Coated Steel Pipe