TCEQ Interoffice Memorandum

CCO# 84686

TO: Office of the Chief Clerk
Texas Commission on Environmental Quality

THRU: Iliana Delgado
Team Leader

FROM: Tracie Donnelly
Water Rights Permitting Team

DATE: October 23, 2012

SUBJECT: City of Abilene
WRPERM 12747
CN600242671, RN106535248
Application No. 12747 for a Water Use Permit
Texas Water Code §§ 11.121, 11.042, 11.085., Requiring Published and Mailed Notice
Clear Fork Brazos River, Brazos River Basin
Throckmorton, Haskell and Shackelford Counties

The application and partial fees were received on August 17, 2011. Additional information and fees were received on June 7, 2012. The application was declared administratively complete and filed with the Office of the Chief Clerk on October 23, 2012. Published and mailed notice of the application to the water right holders of record in the Brazos River Basin is required pursuant to 30 TAC §295.151.

The City of Abilene seeks authorization to construct and maintain a dam and reservoir (Cedar Ridge Reservoir) on the Clear Fork Brazos River, Brazos River Basin, in Throckmorton, Haskell and Shackelford Counties; to divert and use not to exceed 34,400 acre-feet of water per year from the perimeter of the proposed reservoir for municipal, domestic, industrial, agricultural, livestock, steam electric, mining and recreation purposes for use in the City's existing and future wholesale and retail service area; to use the bed and banks of Lake Fort Phantom Hill on Elm Creek, Brazos River Basin to convey authorized water; and to authorize an exempt interbasin transfer to those portions of Callahan, Nolan, Mitchell, Scurry, Eastland, Brown, Comanche, and Taylor Counties located in the Colorado River Basin.

Fees have been paid and the application is sufficient for filing.

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
2012 OCT 23 PM 4:26
CHIEF CLERKS OFFICE

Tracie Donnelly
Water Rights Permitting Team
Water Availability Division

OCC Mailed Notice Required ☑YES ☐NO

Bryan W. Shaw, Ph.D., *Chairman*
Carlos Rubinstein, *Commissioner*
Toby Baker, *Commissioner*
Zak Covar, *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

October 23, 2012

Mr. Martin Rochelle
Lloyd Gosselink
816 Congress Avenue, Suite 1900
Austin, Texas 78701

RE: City of Abilene
WRPERM 12747
CN600242671, RN106535248
Application No. 12747 for a Water Use Permit
Texas Water Code §§ 11.121, 11.042, 11.085, Requiring Published and Mailed Notice
Clear Fork Brazos River, Brazos River Basin
Throckmorton, Haskell and Shackelford Counties

Dear Mr. Rochelle:

This acknowledges the receipt of the requested additional information and fees in the amount of $31,881.33 (Receipt Nos. R229909A&B, enclosed) on June 7, 2012

The application was declared administratively complete and filed with the Office of the Chief Clerk on October 23, 2012. Staff will continue processing the application for consideration by the Executive Director.

Please be advised that additional information may be requested during the technical review phase of the application process.

If you have any questions concerning the application, please contact me at (512) 239-0083 or at tracie.donnelly@tceq.texas.gov.

Sincerely,

Tracie Donnelly, Project Manager
Water Rights Permitting
Water Availability Division

Enclosures

cc: Mailing List

2012 OCT 23 PM 4:26
CHIEF CLERKS OFFICE
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

TCEQ 11-JUN-12 10:29 AM

TCEQ - A/R RECEIPT REPORT BY ACCOUNT NUMBER

Fee Description	Fee Code / Account# / Account Name	Ref#1 / Ref#2 / Paid In By	Check Number / Card Auth. / User Data	CC Type / Tran Code / Rec Code	Slip Key / Document#	Tran Date	Tran Amount
WTR USE PERMITS	WUP	R229899	1095		BS00023286	11-JUN-12	-$50.00
	WUP	4108	060812	N	D2804379		
	WATER USE PERMITS	DULICK, DOREEN M, ESTATE OF/BABCOCK, DEIRDRE D	RCROWDER	CK			
	WUP	R229900	1013		BS00023286	11-JUN-12	-$50.00
	WUP	4108	060812	N	D2804379		
	WATER USE PERMITS	BOYD, JILL A/DAILEY, PHYLLIS S/BOYD, ROBERT P	RCROWDER	CK			
	WUP	R229906A	60305396		BS00023286	11-JUN-12	-$172.00
	WUP		060812	N	D2804379		
	WATER USE PERMITS	NUSTAR TERMINALS PARTNERS	RCROWDER	CK			
	WUP	R229909A	444201		BS00023286	11-JUN-12	-$30,911.25
	WUP	12747	060812	N	D2804379		

TCEQ 11-JUN-12 10:29 AM

TCEQ - A/R RECEIPT REPORT BY ACCOUNT NUMBER

Fee Description	Fee Code / Account# / Account Name	Ref#1 / Ref#2 / Paid In By	Check Number / Card Auth. / User Data	CC Type / Tran Code / Rec Code	Slip Key / Document#	Tran Date	Tran Amount
WTR USE PERMITS	WATER USE PERMITS	ABILENE, CITY OF	RCROWDER	CK			
				Total (Fee Code):			-$31,183.25

JUN 2012

TCEQ 11-JUN-12 10:29 AM

TCEQ - A/R RECEIPT REPORT BY ACCOUNT NUMBER

Fee Description	Fee Code / Account# / Account Name	Ref#1 / Ref#2 / Paid In By	Check Number / Card Auth. / User Data	CC Type / Tran Code / Rec Code	Slip Key / Document#	Tran Date	Tran Amount
WTR USE PERMITS	WATER USE PERMITS	ABILENE, CITY OF	RCROWDER	CK			
				Total (Fee Code):			-$31,183.25

2012 JUN

Lloyd Gosselink
ATTORNEYS AT LAW

816 Congress Avenue, Suite 1900
Austin, Texas 78701
Telephone: (512) 322-5800
Facsimile: (512) 472-0532
www.lglawfirm.com

Mr. Rochelle's Direct Line: (512) 322-5810
[redacted]

June 7, 2012

Ms. Tracie Donnelly (MC 160)
Water Rights Permitting & Availability Section
Texas Commission on Environmental Quality
12100 Park 35 Circle
Building F, 3rd Floor, Room 3101
Austin, Texas 78753

VIA HAND DELIVERY

Re: City of Abilene
WRPERM 12747
CN600242671
Application No. 12747 for a Water Use Permit
Texas Water Code § 11.121, Requiring Published and Mailed Notice
Clear Fork Brazos River, Brazos River Basin
Throckmorton and Shackelford Counties (450-25)

Dear Ms. Donnelly:

This letter is submitted on behalf of my client, the City of Abilene (the "City" or the "Applicant"), in response to a Request for Information ("RFI") we received from the Texas Commission on Environmental Quality ("Commission"), dated May 3, 2012, and in connection with the above-referenced application (the "Application"). The following responses are numbered in accordance with the inquiries included in the Commission's May 3, 2012 RFI letter.

Response to Question No. 1:

Explain how impacts on water rights located within the pool of the proposed reservoir will be mitigated. Records of the commission indicate that a senior water right, Certificate of Adjudication 12-4175, is located within the pool of the proposed reservoir.

1. The City proposes to enter into an agreement with the owner of Certificate of Adjudication No. 12-4175 to acquire this water right and/or to agree to provide the owner of Certificate No. 12-4175 with an equivalent amount of water supply from Cedar Ridge Reservoir, once constructed. Any other water rights located within the pool of the proposed reservoir will be similarly addressed.

CC C MAIL 7 MAR 2012

Response to Question No. 2:

Confirm that return flows authorized for diversion by Certificate of Adjudication 12-4161 will be diverted from Cedar Ridge Reservoir and discharged into Lake Fort Phantom Hill.

2. Yes. All water, including return flows, to be diverted from Cedar Ridge Reservoir will be delivered either directly into the City's raw water system for subsequent treatment and use, and/or discharged into Lake Fort Phantom Hill.

Response to Question No. 3:

Provide the following information in support of the request to use the bed and banks of Lake Fort Phantom Hill Reservoir to convey return flows and surface water appropriated under any permit issued for this application that are diverted from Cedar Ridge Reservoir:

a. USGS Topographic Map showing the specific reach of the watercourse for which authorization is requested defined by the beginning or upstream point (discharge point) and the end or downstream point (diversion point). Staff could agree that the downstream point of the segment could be represented at the dam for Lake Fort Phantom Hill Reservoir.

b. Description of the reach to be authorized including at a minimum:

i. The latitude and longitude for the beginning and end points of the reach;
ii. Length of reach. Provide the distance in river miles from the discharge point to the point of diversion.
iii. Volume to be conveyed. This must include the maximum annual amount that will be conveyed.
iv. Conveyance losses including the method used to calculate losses due to transportation, evaporation, seepage, channel or other associated carriage losses.

c. An assessment of the adequacy of the quantity and quality of the flows remaining after the proposed diversion to meet instream flow needs and bay and estuary freshwater inflow needs.

3. Please consider the following responses to this RFI:

a) Enclosed herewith as **Attachment A**, please find a USGS Topographic Map showing the bed and banks reach of Lake Fort Phantom Hill.

b) The Applicant seeks to use the bed and banks of Lake Fort Phantom Hill to discharge, convey and divert up to 34,400 acre-feet of surface waters, less conveyance losses, appropriated under any permit issued for this Application that are diverted from Cedar Ridge Reservoir at any point along the perimeter of Lake Fort Phantom Hill. The coordinates of the upstream point of the reach (upper end of Lake Fort Phantom Hill) are 99.710284°W (Long) and 32.528401°N (Lat). The coordinates of the downstream point of the reach (Lake Fort Phantom Hill dam) are 99.668474°W (Long) and 32.616443°N (Lat). The length of this reach is approximately 7.66 miles. The Applicant seeks to convey the total diversion authorization volume of surface water (up to 34,400 acft/yr, less conveyance losses) included in this Application. Any losses of water discharged to Lake Fort Phantom Hill will be calculated in accordance with the official approved accounting plan that will be developed as part of this Application. The Applicant has already secured the right to use the bed and banks of Lake Fort Phantom Hill to convey up to 24,640 acft/year, less conveyance losses, of the City's return flows pursuant to Certificate of Adjudication 4161C.

c) The quantity and quality of flows remaining after these proposed diversions are sufficient to meet instream flow needs and bay and estuary freshwater inflow needs, as documented in Section 5.4 and Section 6 of the *Supplemental Application, Engineering and Environmental Information Document for Cedar Ridge Reservoir.*

Response to Question No. 4:

Provide a complete set of the Water Availability Model (WAM) input files referenced in the supplemental materials for the application. Staff recognizes that WAM input files were submitted with the application. However, the submitted files are labeled as "bwam3" and "crr_bwam3". The supplemental materials refer to three WAM files, "Baseline (Run 1)", "Run 2", and "Run 3".

4. Enclosed herewith as **Attachment B,** please find a disc containing the complete set of the Water Availability Model (WAM) input files referenced in the Application. These files are contained in folders labeled Run 1, Run 2, and Run 3. This disc also contains a text file, called *CRR_Records_Only.dat,* with only the records related to Cedar Ridge Reservoir, as well as the WRAP Sim.exe that was used to simulate the model for the Application analysis.

Response to Question No. 5:

Indicate how impacts on other water rights and the environment, resulting from the applicant's subordination agreements with the Brazos River Authority, will be mitigated. Be aware that staffs review of water available to the application as a result of these agreements will consider the impacts of the agreements on all other water rights in the Brazos River Basin and the environment.

5. As addressed in Section 5.5, page 5-25, of the *Supplemental Application, Engineering and Environmental Information Document for Cedar Ridge Reservoir,* there are no practical impacts to any water rights resulting from the subordination agreement executed with the Brazos River Authority. Any impacts to the environment from the subordination agreement in the reach of the Clear Fork and Brazos River down to Possum Kingdom Reservoir will be mitigated by passing inflows to Cedar Ridge for:

- Environmental flow needs as identified in Section 5.3.4.2, page 5-10;
- Pass-throughs for downstream senior water rights not subject to the subordination agreement;
- Spills from the reservoir; and/or
- Naturally occurring runoff generated below Cedar Ridge Reservoir.

These components of flow are sufficient to mitigate environmental and/or water right impacts associated with the subordination agreement entered into between the City and the Brazos River Authority.

Response to Question No. 6:

Remit fees in the amount of $157,644.83, as described. Please make check payable to TCEQ or the Texas Commission on Environmental Quality.

Filing	*$ 1000.00*
Recording ($1.25 x 9 pages)	*11.25*
Use (34,400 acre-feet x $1.00)	*34,400.00*
Storage (277,127 acre-feet)	*277,127.00*
Notice (Brazos River Basin)	*970.08*
TOTAL FEES	*313,508.33*
FEES RECEIVED	*100.00*
BALANCE DUE	*$313,408.33**

****Pursuant to 30 TAC 295.133, if the total use fee for a permit exceeds $1,000, the applicant shall pay at least one-half of the use fee when the application is filed, and one-half within 180 days after notice is mailed to the applicant that the permit is granted. If the applicant does not pay the entire amount owed before beginning to use state water under the permit, the permit is annulled and reverts to the status of a pending, filed application requiring notice, the payment of notice fees, and the balance of the use fees.***

Amount due prior to the application being declared administratively complete.	***$157,644.83***
Amount due within 180 days after notice is mailed that the permit is granted.	***$155,763.50***

6. Pursuant to our telephone conversations with you regarding the fees, and your subsequent agreement as to the appropriate storage and use fees in light of 30 Texas Administrative Code § 295.134 (relating to Maximum Fees) to be assessed as part of the Application, we have recalculated the fees owed at this time, as follows:

Filing	$1000.00
Recording ($1.25 x 9 pages)	11.25
Use (34,400 acre-feet)	10,000.00
Storage (227,127 acre-feet)	50,000.00
Notice (Brazos River Basin)	970.08
TOTAL FEES	$61,981.33
FEES PAID	100.00
BALANCE DUE	$61,881.33

As 30 TAC § 295.133(b) authorizes an applicant to pay one-half of a use fee exceeding $1,000 at the time the application is filed and one-half within 180 days after notice is mailed to the applicant that the permit is granted, the City hereby remits one-half of the $60,000 use fee. The City understands that it will be obligated to remit an additional $30,000 within 180 days after notice is mailed that the permit is granted. Enclosed please find the City's check for $31,881.33, which covers all outstanding additional fees, including one-half of the total use fee.

The City will provide the remaining additional seventeen (17) items requested in the RFI as data and information become available and prior to the TCEQ's completion of its technical review.

The City appreciates the opportunity to provide this additional information. Should you have any questions regarding these responses or the Application, please feel free to call either Cristina Ramage (322-5887) or me at your earliest convenience.

Sincerely,

Cristina Ramage for
Martin C. Rochelle

MCR/ldp
2171732
ENCLOSURES

cc: Mr. Tommy O'Brien
Mr. Scott Hibbs
Mr. Ken Choffel
Mr. Cory Shockley
Ms. Cristina Ramage

RECEIVED
TCEQ
SUPPLY DIV.
2022 JUN 7 PM 3 50

Attachment A

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HAMBY QUADRANGLE
TEXAS
7.5 MINUTE SERIES (TOPOGRAPHIC)
SW/4 NUGENT 15' QUADRANGLE

Downstream Point of Diversion Reach

Upstream Point of Diversion Reach

PHANTOM HILL LAKE FORT ELEVATION 1626

Elm Creek

Deadman Creek

Cedar Ridge Creek

Hamby

Lanius

JONES CO
TAYLOR CO

CALLAHAN CO

Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography from aerial photographs by ER-55 plotter
Aerial photographs taken 1954. Field check 1957

Polyconic projection. 1927 North American datum
10,000-foot grid based on Texas coordinate system, north central zone
1000-meter Universal Transverse Mercator grid ticks, zone 14, shown in blue

Areas covered by dashed light-blue pattern are subject to controlled inundation

To place on the predicted North American Datum 1983, move the projection lines 10 meters south and 34 meters east as shown by dashed corner ticks

UTM GRID AND 1987 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Revisions shown in purple compiled from aerial photographs taken 1984 and other sources
This information not field checked. Map edited 1987

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

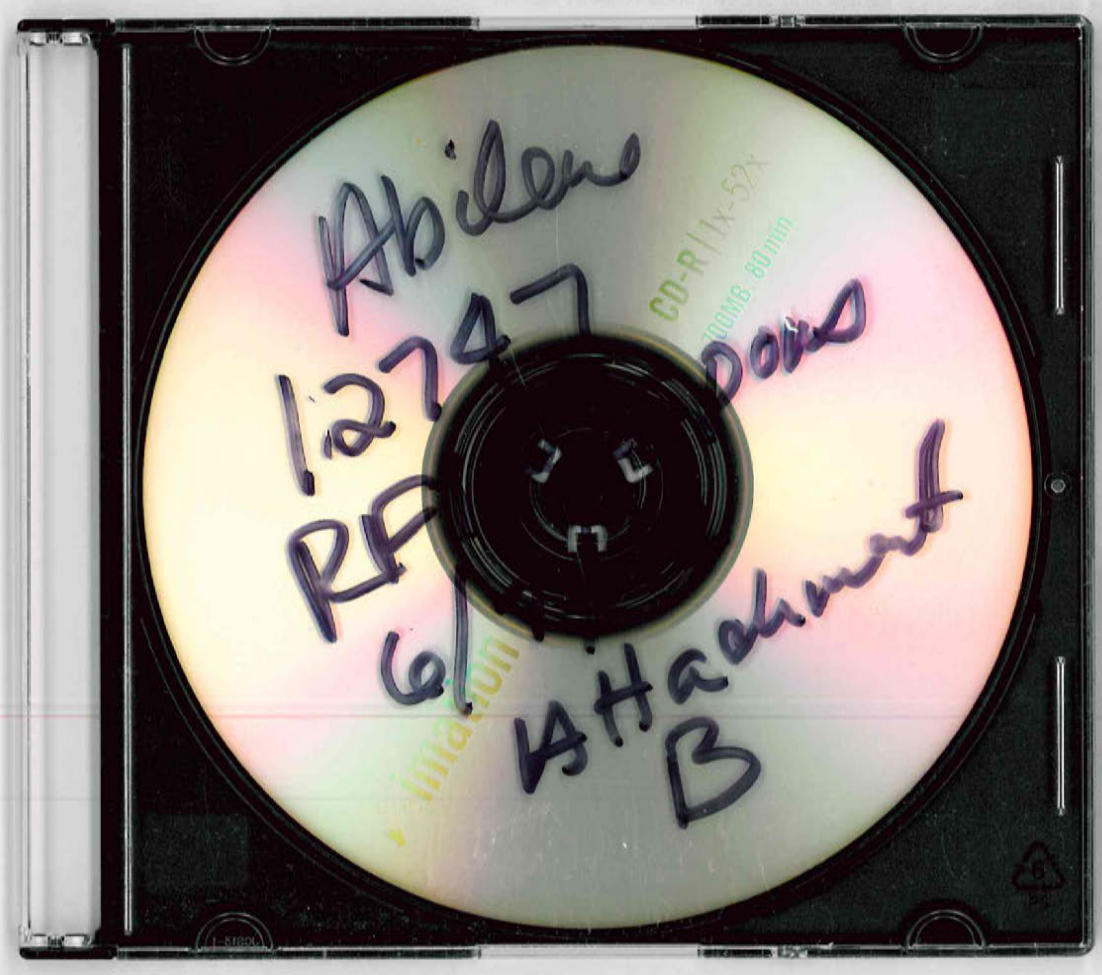
3299-312

ROAD CLASSIFICATION

Primary highway, hard surface
Secondary highway, hard surface
Light-duty road, hard or improved surface
Unimproved road
Interstate Route
U. S. Route
State Route

HAMBY, TEX.
SW/4 NUGENT 15' QUADRANGLE
32099-E6-TF-024

1957
PHOTOREVISED 1987
DMA 6049 II SW – SERIES V882


Abilene
12747
RF
60
Attachment
B
CD-R 1x-52x
700MB 80min

City of Abilene

June 7, 2012

Water Availability Model (WAM) Input Files

Available Upon Request

Contact

Mr. Chris Kozlowski

(512) 239-1801

May 17, 2012

RE: Phone call with Tina Rammage about fees in RFI1

Informed Ms. Rammage that the fees in the RFI were incorrect and that the actual use fees were $50,000 for storage and $10,000 for other uses.

Tracie Donnelly

Carlos Rub' 'ein, *Commissione*
Toby Baker, *Commissioner*
Mark R. Vickery, P.G., *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

May 3, 2012

Mr. Martin Rochelle
Lloyd Gosselink
816 Congress Avenue, Suite 1900
Austin, Texas 78701

CERTIFIED MAIL

91 7108 2133 3935 1948 0887

RE: City of Abilene
WRPERM 12747
CN600242671
Application No. 12747 for a Water Use Permit
Texas Water Code § 11.121, Requiring Published and Mailed Notice
Clear Fork Brazos River, Brazos River Basin
Throckmorton and Shackelford Counties

Dear Mr. Rochelle:

This acknowledges receipt, on August 18, 2011, of the referenced application and fees in the amount of $100.00 (Receipt No. R132834, enclosed).

Additional information and fees are required before the application can be declared administratively complete.

1. Explain how impacts on water rights located within the pool of the proposed reservoir will be mitigated. Records of the commission indicate that a senior water right, Certificate of Adjudication 12-4175, is located within the pool of the proposed reservoir.

2. Confirm that return flows authorized for diversion by Certificate of Adjudication 12-4161 will be diverted from Cedar Ridge Reservoir and discharged into Lake Fort Phantom Hill.

3. Provide the following information in support of the request to use the bed and banks of Lake Fort Phantom Hill Reservoir to convey return flows and surface water appropriated under any permit issued for this application that are diverted from Cedar Ridge Reservoir:

    a. USGS Topographic Map showing the specific reach of the watercourse for which authorization is requested defined by the beginning or upstream point (discharge point) and the end or downstream point (diversion point). Staff could agree that the downstream point of the segment could be represented at the dam for Lake Fort Phantom Hill Reservoir.

    b. Description of the reach to be authorized including at a minimum:

        i. The latitude and longitude for the beginning and end points of the reach;
        ii. Length of reach. Provide the distance in river miles from the discharge point to the point of diversion.

cc:

Janice Bezanson, Executive Director
Texas Conservation Alliance
1605 Mission Trail
Salado, TX 76571

Bob Brandes
Atkins Senior Consultant
6504 Bridge Point Parkway, Suite 200
Austin, Texas 78730

Mark McPherson
McPherson LawFirm, PC
6300 Bank of America Plaza
901 Main Street
Dallas, TX 75202

Stan West
County Commissioner, Precinct 4
Shackelford County
P.O. Box 2405
Albany, Texas 76430

Bryan W. Sl. , Ph.D., *Chairman*
Carlos Rubinstein, *Commissioner*
Toby Baker, *Commissioner*
Mark R. Vickery, P.G., *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

May 3, 2012

Mr. Martin Rochelle
Lloyd Gosselink
816 Congress Avenue, Suite 1900
Austin, Texas 78701

CERTIFIED MAIL

RE: City of Abilene
WRPERM 12747
CN600242671
Application No. 12747 for a Water Use Permit
Texas Water Code § 11.121, Requiring Published and Mailed Notice
Clear Fork Brazos River, Brazos River Basin
Throckmorton and Shackelford Counties

Dear Mr. Rochelle:

This acknowledges receipt, on August 18, 2011, of the referenced application and fees in the amount of $100.00 (Receipt No. R132834, enclosed).

Additional information and fees are required before the application can be declared administratively complete.

1. Explain how impacts on water rights located within the pool of the proposed reservoir will be mitigated. Records of the commission indicate that a senior water right, Certificate of Adjudication 12-4175, is located within the pool of the proposed reservoir.

2. Confirm that return flows authorized for diversion by Certificate of Adjudication 12-4161 will be diverted from Cedar Ridge Reservoir and discharged into Lake Fort Phantom Hill.

3. Provide the following information in support of the request to use the bed and banks of Lake Fort Phantom Hill Reservoir to convey return flows and surface water appropriated under any permit issued for this application that are diverted from Cedar Ridge Reservoir:

    a. USGS Topographic Map showing the specific reach of the watercourse for which authorization is requested defined by the beginning or upstream point (discharge point) and the end or downstream point (diversion point). Staff could agree that the downstream point of the segment could be represented at the dam for Lake Fort Phantom Hill Reservoir.

    b. Description of the reach to be authorized including at a minimum:

        i. The latitude and longitude for the beginning and end points of the reach;
        ii. Length of reach. Provide the distance in river miles from the discharge point to the point of diversion.

iii. Volume to be conveyed. This must include the maximum annual amount that will be conveyed.
iv. Conveyance losses including the method used to calculate losses due to transportation, evaporation, seepage, channel or other associated carriage losses.

c. An assessment of the adequacy of the quantity and quality of the flows remaining after the proposed diversion to meet instream flow needs and bay and estuary freshwater inflow needs.

4. Provide a complete set of the Water Availability Model (WAM) input files referenced in the supplemental materials for the application. Staff recognizes that WAM input files were submitted with the application. However, the submitted files are labeled as "bwam3" and "crr_bwam3". The supplemental materials refer to three WAM files, "Baseline (Run 1)", "Run 2", and "Run 3".

5. Indicate how impacts on other water rights and the environment, resulting from the applicant's subordination agreements with the Brazos River Authority, will be mitigated. Be aware that staff's review of water available to the application as a result of these agreements will consider the impacts of the agreements on all other water rights in the Brazos River Basin and the environment.

6. Remit fees in the amount of **$157,644.83**, as described. Please make check payable to TCEQ or the Texas Commission on Environmental Quality.

Filing	$	1000.00
Recording ($1.25 x 9 pages)	$	11.25
Use (34,400 acre-feet x $1.00)	$	34,400.00
Storage (277,127 acre-feet)	$	277,127.00
Notice (Brazos River Basin)	$	970.08
TOTAL FEES	$	313,508.33
FEES RECEIVED	$	100.00
BALANCE DUE	$	**313,408.33***

*Pursuant to 30 TAC 295.133, if the total use fee for a permit exceeds $1,000, the applicant shall pay at least one-half of the use fee when the application is filed, and one-half within 180 days after notice is mailed to the applicant that the permit is granted. If the applicant does not pay the entire amount owed before beginning to use state water under the permit, the permit is annulled and reverts to the status of a pending, filed application requiring notice, the payment of notice fees, and the balance of the use fees.

Amount due prior to the application being declared administratively complete.	$157,644.83
Amount due within 180 days after notice is mailed that the permit is granted.	$155,763.50

Please submit the above requested information and fees by May 31, 2012 or the application may be returned pursuant to Title 30 TAC §281.18.

Additional information will be required prior to completion of technical review.

1. Provide for analysis all supporting materials in the form of models, spreadsheets, and data files used in forming the flow recommendations including but not limited to input and output files for IHA and HEFR models. If default HEFR parameters presented in the Texas Environmental Flows Science Advisory Committee document *Use of Hydrologic Data in the Development of Instream Flow Recommendations for the Environmental Flows Allocation Process and the Hydrology-Based Environmental Flow Regime (HEFR) Methodology Third Edition* were changed, explain the changes and justification for those changes. In addition, indicate how the IHA was parameterized and the basis for the parameterization. Subsequent to the review of the supporting material, staff may have technical questions and would be amenable to a meeting with the applicant to discuss the process used in forming the flow recommendations.

2. Explain why only the lower High Flow Pulses were included in the HEFR-Based Environmental Flow Pass-Through Regime for Cedar Ridge Reservoir. Explain why the High Flow Pulses were calculated using the frequency based approach yet the proposed flow regime matrix assigns the High Flow Pulses to hydrologic conditions.

3. Provide additional documentation or details as to how refinements were made to the default HEFR recommendations. In the alternative, provide documentation or details as to why no refinements were made.

4. Verify that the proposed flow regime will enable the maintenance or improvement of all study components (biology, water quality, geomorphology, hydrology and hydraulics, and connectivity) and provide for a sound ecological environment in the Clear Fork of the Brazos River. It appears the proposed flow regime is primarily HEFR based with a refinement in the wet conditions in August to minimize adverse impacts to the juvenile Brazos water snake. Provide specific documentation supporting this refinement.

5. Verify that the work identified in the 2011 Biological Collection Study Draft Work Plan, the Supplemental Application Document, and the additional work identified in the Summary of 2011 Fish and 2009-2011 Freshwater Mussel Surveys will be used to refine the default HEFR recommendations.

6. Describe how the proposed flow regime will provide conditions suitable for sustainable mussel assemblages downstream of the proposed dam location.

7. Clarify the flow ranges observed during 2009-2010 field work. Reconcile the discrepancy in flow ranges reported on Pages 6-12, 6-44, and 6-69.

8. Describe how the "state of equilibrium with the current flow regime and sediment load" will be maintained with a subsequent reduction in pulse flows and sediment loads.

9. Indicate how releases from the multi-level outlet tower will be determined based on in-lake conditions, specifically temperature and dissolved oxygen.

10. Provide a detailed mitigation plan when available.

11. Verify that riffle habitat enhancement, protection, or restoration could serve as potential mitigation for the degradation of downstream riffle habitat due to dam construction as described on Page 6-40.

12. Identify other strategies, in addition to the periodic passage of high flow pulses that will be used to mitigate for impacts to aquatic habitats downstream of the proposed dam.

13. Indicate how inflows to the reservoir will be accounted for as either return flows authorized by Certificate of Adjudication 12-4161 or as streamflows available for impoundment and diversion under this application. Staff notes that under drought conditions, when flows at USGS gage 08084200, Clear Fork Brazos River at Lueders, Texas are zero, return flows authorized under Certificate 12- 4161 may not be available.

14. Confirm that the proposed environmental flow pass-through regime was calculated based on the total flow into the reservoir. Indicate whether the total flow used in this calculation was determined as the flow at USGS gage 0808400, Clear Fork Brazos River at Nugent, Texas multiplied by the incremental drainage area between the Nugent gage and the proposed reservoir. If the proposed environmental flow pass-through regime used the total flow, as described above, explain how streamflows at USGS gage 08084200, Clear Fork Brazos River at Lueders, Texas will be adjusted in any inflow calculations to be consistent with the flows used to calculate the pass-through regime.

15. Indicate whether flows at USGS gage08084200, Clear Fork Brazos River at Lueders, Texas will be impacted by backwater effects from the proposed reservoir. If the gage flows will be impacted by the reservoir, explain why this location will be an adequate location to measure inflows.

16. Explain why the annual demand on the proposed reservoir is intended to be a parameter in defining hydrologic condition (wet, average and dry).

17. Submit an accounting plan that demonstrates compliance with the terms and conditions of any authorization. The accounting plan is not required in order to declare the application administratively complete; however, it will be required prior to completion of technical review. The accounting plan should include, at a minimum, the following:

    a. A text document that includes:

        i. A summary of all requested authorizations.
        ii. A summary of the accounting plan.
        iii. A narrative explanation of each worksheet.
        iv. A narrative explanation of each column or lookup table in the worksheets. This section of the text document should be arranged in using the number and title of each column, as it appears in the spread sheet. At a minimum each column description must include the calculation used and/or the source of data.

b. An Excel file that includes:

I. Basic daily data such as:
   i. Gaged flows, ungaged flows, return flows, evaporation, reservoir storage;
   ii. Diversion of stored water originating from impounded streamflow, and diversion of return flows authorized by Certificate of Adjudication 12-4161. Staff could consider combining the accounting plan for this application with the existing approved return flow accounting plan for Certificate of Adjudication 12-4161;
   iii. Calculations demonstrating compliance with any environmental flow requirements;

II. The application requests authorization to discharge water diverted from Cedar Ridge Reservoir into Lake Fort Phantom Hill and subsequently divert that water. Therefore, the accounting plan should include a water balance calculation for Lake Fort Phantom Hill including all sources of diverted water, priority dates and diversion amounts and reservoir storage.

III. Measurement units and any applicable conversion calculations.

If you have any questions concerning this matter, please contact me at (512) 239-0083 or by e-mail at tracie.donnelly@tceq.texas.gov.

Sincerely,

Tracie Donnelly, Project Manager - MC160
Water Rights Permitting & Availability Section
Water Availability Division

Enclosure

cc: Ms. Janice Bezanson
Mr. Bob Brandes
Mr. Mark McPherson
Mr. Stan West

CERTIFICATE OF ADJUDICATION

CERTIFICATE OF ADJUDICATION: 12-4161

OWNER: City of Abilene
P. O. Box 60
Abilene, Texas 79604

COUNTY: Jones

PRIORITY DATE: March 25, 1937

WATERCOURSE: Elm Creek, tributary of Clear Fork Brazos River, tributary of Brazos River (Fort Phantom Hill Reservoir)

BASIN: Brazos River

WHEREAS, by final decree of the 91st Judicial District Court of Eastland County, in Cause No. 32,003, In Re: The Adjudication of Water Rights in the Clear Fork of the Brazos River Watershed, Brazos River Basin, dated November 8, 1985, a right was recognized under Permit 1249A authorizing the City of Abilene to appropriate waters of the State of Texas as set forth below;

NOW, THEREFORE, this certificate of adjudication to appropriate waters of the State of Texas in the Brazos River Basin is issued to the City of Abilene, subject to the following terms and conditions:

1. IMPOUNDMENT

Owner is authorized to maintain an existing dam and reservoir on Elm Creek, known as Fort Phantom Hill Reservoir, and impound therein not to exceed 73,960 acre-feet of water of which 6500 acre-feet is authorized under Certificate of Adjudication 12-4151 issued to the West Texas Utilities Company. The dam is located in the W. A. Farris Survey 4, Abstract 177; the T.& P. RR Co. Survey 87, Abstract 366 and the J. B. Garrett Survey 32, Abstract 808, Jones County, Texas.

2. USE

A. Owner is authorized to divert and use not to exceed 20,690 acre-feet of water per annum from the aforesaid reservoir for municipal purposes.

B. Owner is authorized to divert and use not to exceed 10,000 acre-feet of water per annum from the aforesaid reservoir for industrial purposes.

3. DIVERSION

A. Location
At a point on the perimeter of the aforesaid reservoir in the W. Pendarvis Survey 65, Abstract 285, Jones County, Texas for municipal purposes.

B. Maximum rate:
(1) 69.52 cfs (31200 gpm) for municipal purposes.

(2) See special conditions contained herein for the diversion rate for industrial purposes.

4. PRIORITY

The time priority of owner's right is March 25, 1937.

5. SPECIAL CONDITIONS

A. Owner shall maintain a suitable outlet in the aforesaid dam authorized herein to allow the free passage of water that owner is not entitled to divert or impound.

B. The combined total amount of water diverted from Fort Phantom Hill Reservoir for municipal purposes under Certificates of Adjudication 12-4161 and 12-4165 shall not exceed 20,690 acre-feet.

C. Owner may not exercise the right to divert and use water authorized herein for industrial purposes until such time as owner applies for and is granted an authorized rate of diversion of raw water from the aforesaid reservoir for industrial purposes.

The locations of pertinent features related to this certificate are shown on Page 8 of Clear Fork of the Brazos River Watershed Certificates of Adjudication Maps, copies of which are located in the offices of the Texas Water Commission, Austin, Texas and the Jones County Clerk.

This certificate of adjudication is issued subject to all terms, conditions and provisions in the final decree of the 91st Judicial District Court of Eastland County, Texas, in Cause No. 32,003, In Re: The Adjudication of Water Rights in the Clear Fork of the Brazos River Watershed, Brazos River Basin, dated November 8, 1985, and supersedes all rights of the owner asserted in that cause.

This certificate of adjudication is issued subject to senior and superior water rights in the Brazos River Basin.

This certificate of adjudication is issued subject to the Rules of the Texas Water Commission and its continuing right of supervision of State water resources consistent with the public policy of the State as set forth in the Texas Water Code.

TEXAS WATER COMMISSION

/s/ Paul Hopkins
Paul Hopkins, Chairman

DATE ISSUED:

APR 1 1986

ATTEST:

/s/ Mary Ann Hefner
Mary Ann Hefner, Chief Clerk

AMENDMENT TO
CERTIFICATE OF ADJUDICATION

CERTIFICATE NO. 12-4161A			TYPE: AMENDMENT
Name:	City of Abilene	Address:	P. O. Box 60 Abilene, Texas 79604
Filed:	October 9, 1989	Granted:	January 23, 1991
Purposes:	Municipal, Industrial & Irrigation	County:	Jones
Watercourse:	Elm Creek, tributary of Clear Fork Brazos River, tributary of Brazos River	Watershed:	Brazos River Basin

WHEREAS, Certificate of Adjudication No. 12-4161 was issued to the City of Abilene on April 1, 1986, and authorized the certificate owner, to maintain an existing dam and reservoir on Elm Creek known as Fort Phantom Hill Reservoir and divert and use not to exceed 20,690 acre-feet of water per annum from the reservoir at a maximum rate of 69.52 cfs for municipal purposes and to divert and use not to exceed 10,000 acre-feet of water per annum from the reservoir for industrial purposes; and

WHEREAS, SPECIAL CONDITION 5.C. in the certificate indicates that the owner may not divert water from the reservoir for industrial purposes until such time as owner applies for and is granted an authorized rate of diversion for industrial purposes; and

WHEREAS, SPECIAL CONDITION 5.B. in the certificate indicates that the combined total amount of water diverted from Fort Phantom Hill Reservoir per annum for municipal purposes under Certificate of Adjudication No. 12-4161 and the City of Abilene's Certificate No. 12-4165 shall not exceed 20,690 acre-feet; and

WHEREAS, the City of Abilene has requested an amendment to Certificate No. 12-4161 to:

a. Reallocate the amount of water authorized for diversion and use from Fort Phantom Hill Reservoir as follows:

25,690 acre-feet per annum for municipal purposes;
4,000 acre-feet per annum for industrial purposes; and
1,000 acre-feet per annum for irrigation of approximately 400 acres of land within the environs of the City.

b. Delete Special Condition 5.C. and indicate that the maximum diversion rate of 69.52 cfs now authorized for municipal purposes be authorized as a combined maximum diversion rate for municipal, industrial and irrigation purposes; and

c. Delete Special Condition 5.B. in the certificate. The City believes that this Special Condition "...represents an error inadvertently made in the preparation..." of the certificate inasmuch as the condition was not included in Permit No. 1249, as amended, the predecessor water right to Certificate No. 12-4161, or in the adjudication of Permit No. 1249, as amended; and

WHEREAS, the applicant has agreed to a ten-year term being placed on the reallocation request of water; and

WHEREAS, the Texas Water Commission finds that jurisdiction over the application is established; and

WHEREAS, the Commission has complied with the requirements of the Texas Water Code and Rules of the Texas Water Commission in issuing this amendment.

NOW, THEREFORE, this amendment to Certificate No. 12-4161, which represents all authorizations included under the certificate, as amended, is issued to the City of Abilene, subject to the following provisions:

1. IMPOUNDMENT

Owner is authorized to maintain an existing dam and reservoir on Elm Creek, known as Fort Phantom Hill Reservoir, and impound therein not to exceed 73,960 acre-feet of water of which 6500 acre-feet is authorized under Certificate No. 12-4151 issued to the West Texas Utilities Company. The dam is located in the W. A. Farris Survey No. 4, Abstract No. 177; the T & P RR Co. Survey No. 87, Abstract No. 366 and the J. B. Garrett Survey No. 32, Abstract No. 808, Jones County, Texas.

2. USE

a. Owner is authorized to divert and use not to exceed 20,690 acre-feet of water per annum from the aforesaid reservoir for municipal purposes.

b. Owner is authorized to divert and use not to exceed 10,000 acre-feet of water per annum from the aforesaid reservoir for industrial purposes.

c. Owner is authorized to temporarily convert the use of 5000 of the 10,000 acre-feet of water authorized under Paragraph 2.b. above from industrial to municipal purposes.

d. Owner is authorized to temporarily convert the use of 1000 of the 10,000 acre-feet of water authorized under Paragraph 2.b. above from industrial to irrigation purposes within the environs of the City.

3. DIVERSION

a. At a point on the perimeter of the aforesaid reservoir in the W. Pendarvis Survey No. 65, Abstract No. 285, Jones County, Texas for municipal purposes.

b. Combined maximum diversion rate: 69.52 cfs (31,200 gpm) for municipal, industrial and irrigation purposes.

4. PRIORITY

The time priority of owner's right is March 25, 1937.

5. SPECIAL CONDITIONS

a. Owner shall maintain a suitable outlet in the aforesaid dam authorized herein to allow the free passage of water that owner is not entitled to divert or impound.

b. The authority to divert and use 5000 acre-feet of water authorized under Paragraph 2.c. for municipal purposes shall expire and become null and void on December 1, 2000, after which date the use of such water will revert to industrial purposes.

c. The authority to divert and use 1000 acre-feet of water authorized under Paragraph 2.d. for irrigation purposes shall expire and become null and void on December 1, 2000, after which date the use of such water will revert to industrial purposes.

This amendment is issued subject to all terms, conditions and provisions contained in Certificate No. 12-4161, except as specifically amended herein.

This amendment is issued subject to all superior and senior water rights in the Brazos River Basin.

Certificate owner agrees to be bound by the terms, conditions and provisions contained herein and such agreement is a condition precedent to the granting of this amendment.

All other matters requested in the application which are not specifically granted by this amendment are denied.

Certificate owner shall use those practices, techniques and technologies that will reduce the loss or waste of water and improve the efficiency and use of water so that only so much water as can be beneficially used will be diverted. Furthermore, diversion and use of water for irrigation purposes will occur only when reasonably necessary because of prevailing climatic conditions and subject to the terms and conditions of this amendment.

This amendment is issued subject to the Rules of the Texas Water Commission and to the right of continuing supervision of State water resources exercised by the Commission.

TEXAS WATER COMMISSION

B. J. Wynne, III, Chairman

DATE ISSUED: FEB 12 1991

ATTEST:

Gloria A. Vasquez, Chief Clerk

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

AMENDMENT TO CERTIFICATE OF ADJUDICATION

APPLICATION NO. 12-4161B CERTIFICATE NO. 12-4161B TYPE §11.122

Owner:	City of Abilene	Address:	P.O. Box 60 Abilene, Texas 79604
Filed:	May 10, 2001	Granted:	MAY 10 2002
Purpose:	Municipal, Industrial, Agriculture	County:	Jones
Watercourse:	Elm Creek, tributary of Clear Fork Brazos River, tributary of Brazos River	Watershed:	Brazos River Basin

WHEREAS, Certificate of Adjudication No. 12-4161, as amended, authorizes Owner to maintain an existing dam and reservoir on Elm Creek, known as Fort Phantom Reservoir, and impound therein not to exceed 73,960 acre-feet of water, 6,500 acre-feet of which is authorized under Certificate of Adjudication No. 12-4151, issued to the West Texas Utilities Company.

WHEREAS, Certificate of Adjudication No. 12-4161, as amended, also authorizes Owner to divert and use not to exceed 20,690 acre-feet of water per annum from the perimeter of the aforesaid reservoir for municipal purposes; to divert and use not to exceed 10,000 acre-feet of water per annum from the aforesaid reservoir for industrial purposes at a maximum combined diversion rate of 69.52 cfs (31,200 gpm); to temporarily convert the use of 5,000 of the aforesaid 10,000 acre-feet of water per annum from industrial to municipal purposes; and to temporarily convert the use of 1,000 the aforesaid 10,000 acre-feet of water per annum from industrial to agricultural use for irrigation of approximately 400 acres within the environs of the city; and

WHEREAS, a Special Condition 5.b & c in the amended certificate states that the authorization to reallocate 5,000 acre-feet of water for municipal purposes and 1,000 acre-feet of water for agricultural purposes will expire and become null and void on December 1, 2000.

WHEREAS, the applicant seeks an amendment to Certificate of Adjudication No. 12-4161, as amended, to extend or delete the term for the reallocation of water and agricultural use.

WHEREAS, the Texas Natural Resource Conservation Commission finds that jurisdiction over the application is established; and

WHEREAS, no person protested the granting of this application; and

NOW, THEREFORE, this amendment to Certificate of Adjudication 12-4161, which represents all authorizations included under the certificate, as amended, is issued to the City of Abilene, subject to the following conditions:

1. USE:

In lieu of previous authorizations:

a. Owner is authorized to divert and use not to exceed ~~25,650~~ 25,690 acre-feet per annum from the perimeter of the aforesaid reservoir for municipal purposes.

b. Owner is authorized to divert and use not to exceed 4,000 acre-feet of water per annum from the perimeter of the aforesaid reservoir for industrial purposes.

c. Owner is authorized to divert and use not to exceed 1,000 acre-feet of water per annum from the aforesaid reservoir for agricultural purposes to irrigate approximately 400 acres of within the environs of the city.

2. DIVERSION:

a. At a point on the perimeter of the aforesaid reservoir in the W. Pendarvis Survey No. 65, Abstract No. 285, Jones County, Texas.

b. Combined maximum diversion rate: 69.52 cfs (31,200 gpm) for municipal, industrial and agricultural purposes.

3. CONSERVATION:

Owner shall implement a conservation plan that provides for the utilization of water conservation practices, techniques and technologies that reduce or maintain the consumption of water, prevent or reduce the loss or waste of water, maintain or improve the efficiency in the use of water, increase the recycling and reuse of water, or prevent the pollution of water, so that a water supply is made available for future or alternative uses. Such plans shall include a requirement that in every wholesale water contract entered into, on or after the effective date of this amendment, including any contract extension or renewal, that each successive wholesale customer develop and implement conservation measures. If the customer intends to resell the water, then the contract for resale of the water must have water conservation requirements so that each successive wholesale customer in the resale of the water be required to implement water conservation measures.

This amendment is issued subject to all terms, conditions and provisions contained in Certificate of Adjudication No. 12-4161, as amended, except as specifically amended herein.

Owner agrees to be bound by the terms, conditions and provisions contained herein and such agreement is a condition precedent to the granting of this amendment. All other matters requested in the application which are not specifically granted by this amendment are denied.

This amendment is issued subject to the Rules of the Texas Natural Resource Conservation Commission and to the right of continuing supervision of State water resources exercised by the Commission.

TEXAS NATURAL RESOURCE
CONSERVATION COMMISSION

For the Commission

Date issued: MAY 10 2002

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

AMENDMENT TO
CERTIFICATE OF ADJUDICATION

CERTIFICATE NO. 12-4161C		TYPE §§ 11.122, 11.042, 11.046	
Owner:	City of Abilene	Address:	P.O. Box 60 Abilene, Texas 79604
Filed:	October 14, 2004	Granted:	June 22, 2011
Purpose:	Agricultural, Industrial, and Municipal	Counties:	Jones, Shackelford, Haskell, Stephens Throckmorton, and Taylor
Watercourses:	Freewater Creek, Deadman Creek, Cedar Creek, Elm Creek, Clear Fork Brazos River and Brazos River	Watershed:	Brazos River Basin

WHEREAS, Certificate of Adjudication No. 12-4161 authorizes the City of Abilene (hereinafter, the City, Applicant, or Owner) to maintain an existing dam and reservoir on Elm Creek (Lake Fort Phantom Hill) and impound therein not to exceed 73,960 acre-feet of water; and

WHEREAS, the Owner is further authorized to divert and use 25,650 acre-feet of water per year for municipal purposes, 4,000 acre-feet of water per year for industrial purposes, and 1,000 acre-feet of water per year for agricultural purposes from the perimeter of the said reservoir at a maximum combined diversion rate of 69.52 cfs (31,200 gpm); and

WHEREAS, Certificate of Adjudication No. 12-4161B contains a typographical error in Use Paragraph l.a. which states the Owner is authorized to divert and use not to exceed 25,650 acre-feet for municipal purposes. As reflected in the other sections of the certificate, the Owner is actually authorized to divert and use 25,690 acre-feet of water per year for municipal purposes. The Applicant has requested that the diversion amount be corrected in this certificate under Texas Administrative Code Section 50.145(b); and

WHEREAS, the Applicant seeks to amend Certificate of Adjudication No. 12-4161 for authorization to use the bed and banks of several watercourses to transport the historical and future City return flows, up to 24,640 acre-feet per year (an average annual flow of 22 MGD) from two outfalls of the City's Hamby Wastewater Treatment Facility (WWTF) and from the discharge of return flows previously diverted from Diversion Point No. 3, to subsequently divert such flows from four diversion points, and to use such flows for agricultural, industrial, and municipal purposes within the City's corporate boundaries, extra-territorial jurisdiction, and water Certificate of Convenience and Necessity service areas, as such areas may be changed or amended from time to time in the future; and

WHEREAS, the return flow discharged from the Hamby WWTF, authorized by Texas Pollutant Discharge Elimination System (TPDES) Permit No. 10334-004, results from the City's use of water pursuant to rights it holds in Certificates of Adjudication Nos. 12-4139, 12-4150, 12-4161, 12-4165, contract water from the West Central Texas Municipal Water District (WCTMWD), and developed water resulting from the City's use of water purchased from the Colorado River Municipal Water District out of O.H. Ivie Reservoir in the Colorado River Basin; and

WHEREAS, the Applicant seeks authorization to divert up to the maximum amount of the City return flows that are currently authorized for discharge, 24,640 acre-feet per year (an average annual flow of 22 MGD) less the 4,330 acre-feet of return flows per year authorized to be reused by the City pursuant to Permit No. 4266 (for a total of 20,310 acre-feet per year); and, at such time as the Water Supply Agreement between the City and the Brazos River Authority expires and Permit No. 4266 becomes void, the City seeks authorization to divert up to the maximum amount of the City return flows authorized for discharge, including the 4,330 acre-feet per year of return flows contemplated in Permit No. 4266, for a total of 24,640 acre-feet per year; and

WHEREAS, the Applicant indicates 20,160 acre-feet per year (flow of 18 MGD) of its return flows are discharged at Outfall 001 and conveyed down the bed and banks of Freewater Creek, thence to Deadman Creek, thence to the Clear Fork Brazos River, and thence to the Brazos River, through Jones, Shackelford, Haskell, Throckmorton, and Stephens Counties, for approximately 53 river miles to Diversion Point No. 2 or approximately 134 river miles to Diversion Point No. 3; and

WHEREAS, the Applicant indicates 4,480 acre-feet per year (flow of 4 MGD) of its return flows are discharged at Outfall 002 and conveyed down the bed and banks of Lake Kirby (located on Cedar Creek), thence to Cedar Creek, thence to Elm Creek, thence to Lake Fort Phantom Hill (located on Elm Creek), thence to the Clear Fork Brazos River, and thence to the Brazos River, through Taylor, Jones, Shackelford, Haskell, Throckmorton, and Stephens Counties for approximately 17 river miles to Diversion Point No. 1, approximately 73 river miles to Diversion Point No. 2, or approximately 154 river miles to Diversion Point No. 3; and

WHEREAS, the Applicant indicates return flows diverted from Diversion Point No. 3 will be discharged into Hubbard Creek Reservoir authorized by Certificate of Adjudication No. 12-4213, conveyed through the bed and banks of the reservoir, and subsequently diverted from the perimeter of Hubbard Creek Reservoir (Diversion Point No. 4); and

WHEREAS, the outfalls are located as follows:

Outfall 001 is located at Latitude 32.5613°N, Longitude 99.6223°W, also bearing southeast approximately 1/16 mile from the northwest corner of the Texas and Pacific Railroad Survey, Block 14, Section 53, Abstract 453, Jones County;

Outfall 002 is located at Latitude 32.3855°N, Longitude 99.7310°W, also bearing southeast approximately 1 mile from the center of Section 9 of the Lunatic Asylum Survey, Taylor County; and

WHEREAS, in addition to the two outfall points, the Applicant will discharge the return flows diverted from Diversion Point No. 3 into Hubbard Creek Reservoir authorized by Certificate of Adjudication No. 12-4213, at a point located at Latitude 32.8517°N, Longitude

99.0042°W, also, bearing S 45° E, 2,000 feet from the NW corner of the J. Michamps Survey, Abstract No. 108 in Stephens County, Texas; and

WHEREAS, the City's return flows will be diverted at the following locations:

Diversion Point No. 1 (Existing Lake Fort Phantom Hill Diversion) from Lake Fort Phantom Hill located on Elm Creek at Latitude 32.5613°N, Longitude 99.6883°W, also bearing west south west approximately 1.5 miles from the northeast corner of the C. Abbott Survey No. 71, Abstract No. 6, Jones County;

Diversion Point No. 2 (Cedar Ridge Reservoir Site) from the Clear Fork Brazos River was originally located at Latitude 33.0234°N, Longitude 99.4052°W, also originally located at the approximate intersection of the westernmost northwest corner of the N. Thompson Survey, Abstract No. 255 with the south line of the A.B. and M. Survey, Block 2, Section 5, Abstract 4, Throckmorton County; due to a change in the location of the proposed Cedar Ridge Reservoir, Diversion Point No. 2 will be located on the perimeter of the Cedar Ridge Reservoir, and the dam for such project will be located at Latitude 32.9627°N, Longitude 99.4599°W, also bearing approximately 0.3 miles WSW of the NE corner of the B&B Survey No. 17, Abstract No. 176, Throckmorton County;

Diversion Point No. 3 (U.S. Highway 183 crossing of the Clear Fork Brazos River) from the Clear Fork Brazos River at Latitude 32.9267°N, Longitude 99.0086°W, also located at the approximate intersection of the southeast corner of the Texas Emigration and Land Company Section 663, Abstract 487 with the northeast corner of the Texas Emigration and Land Company Section 493, Abstract 485, Stephens County;

Diversion Point No. 4 from the perimeter of Hubbard Creek Reservoir; and

WHEREAS, the Applicant indicates that the average annual channel loss rate from Outfall 002 to Diversion Point No. 1 is 14%, from Outfall 001 to Diversion Point No. 2 is 35%, and from Outfall 001 to Diversion Point No. 3 is 60% of the discharged amount; and

WHEREAS, the Applicant proposes to divert at a rate of 69.52 cfs (31,200 gpm) from Diversion Point No. 1 and at a combined rate of 37.1 cfs (16,650 gpm), being the peak 2-hour discharge that is allowed by TPDES Permit No. 10334-004, from Diversion Point Nos. 2 and 3; and

WHEREAS, the Cedar Ridge Reservoir site, at which Diversion Point No. 2 would be located, is a proposed reservoir site for which the City does not yet have storage capacity authorization. The Applicant indicates that when the reservoir is permitted under a separate application and constructed, City return flows may be captured in and diverted from the reservoir and returned to the City for its reuse; and

WHEREAS, the Applicant indicates that return flows diverted from Diversion Point No. 3 would be piped directly into Hubbard Creek Reservoir, owned and operated by WCTMWD, thence commingled with other waters in that reservoir and then diverted and piped to the City through existing diversion and transmission infrastructure to City-owned water treatment plant(s) for treatment and subsequent use; and

WHEREAS, the Texas Commission on Environmental Quality (TCEQ or Commission) finds that jurisdiction over the application is established; and

WHEREAS, the Applicant submitted the *Abilene Indirect Reuse Accounting Plan 4161C* on April 8, 2011; and

WHEREAS, review of the *Abilene Indirect Reuse Accounting Plan 4161C* dated April 8, 2011 has been conducted and said plan was approved by the Executive Director; and

WHEREAS, all requests for a contested case hearing were received and were subsequently withdrawn; and

WHEREAS, the Executive Director recommends special conditions be included in the amendment; and

WHEREAS, the Commission has complied with the requirements of the Texas Water Code and Rules of the TCEQ in issuing this amendment; and

NOW, THEREFORE, this amendment to Certificate of Adjudication No. 12-4161, designated Certificate of Adjudication No. 12-4161C, is issued to the City subject to the following terms and conditions:

1. USE

A. In lieu of Use Paragraph l.a. included in Certificate of Adjudication No. 12-4161B for authorization to divert and use not to exceed 25,650 acre-feet of water per year for municipal purposes, the authorization is hereby corrected to authorize the Owner the right to divert and use 25,690 acre-feet of water per year for municipal purposes.

B. In addition to the authorization included in 12-4161, as amended, the Owner is authorized to use the bed and banks of Freewater Creek, Deadman Creek, Lake Kirby, Cedar Creek, Elm Creek, Lake Fort Phantom Hill, Hubbard Creek Reservoir, and the Clear Fork Brazos River, in the Brazos River Basin to convey historical and future City return flows of up to 24,640 acre-feet per year, and to divert and reuse up to 24,640 acre-feet per year, less channel losses, for agricultural, industrial, and municipal purposes within the City's corporate boundaries, extraterritorial jurisdiction, and water Certificate of Convenience and Necessity service areas, as such areas may be changed or amended from time to time in the future.

2. DISCHARGE

A. TPDES Permit No. 10334-004 authorizes the Owner to discharge return flows at the following locations:

1. Outfall 001 — discharges up to 20,160 acre-feet of water per year (flow of 18 MGD) into Freewater Creek, thence to Deadman Creek, thence to the Clear Fork Brazos River, and thence to the Brazos River. Outfall 001 is located at Latitude 32.5613°N, Longitude 99.6223°W, also bearing southeast approximately 1/16 mile from the northwest corner of the Texas and Pacific Railroad Survey, Block 14, Section 53, Abstract 453, Jones County.

2. Outfall 002 — discharges up to 4,480 acre-feet of water per year (flow of 4 MGD) into Lake Kirby, thence to Cedar Creek, thence to Elm Creek, thence to Lake Fort Phantom Hill, thence to the Clear Fork Brazos River, and thence to the Brazos River. Outfall 002 is located at Latitude 32.3855° N, Longitude 99.7310°W, also bearing SE approximately 1 mile from the center of Section 9 of the Lunatic Asylum Survey, Taylor County.

B. In addition, the Owner is authorized to discharge return flows diverted at Diversion Point No. 3 into Hubbard Creek Reservoir at a point located at Latitude 32.8517°N, Longitude 99. 0042°W, also bearing S 45° E 2,000 feet from the NW corner of the J. Michamps Survey, Abstract No. 108 in Stephens County, Texas.

3. DIVERSION

Owner is authorized to divert the return flows authorized in Use Paragraph 1. B. at the following points and rates:

A. Diversion Point No. 1 (Existing Lake Fort Phantom Hill Diversion) from Lake Fort Phantom Hill located on Elm Creek at Latitude 32.5613°N, Longitude 99.6883°W, also bearing west south west approximately 1.5 miles from the northeast corner of the C. Abbott Survey No. 71, Abstract No. 6, Jones County.

B. Diversion Point No. 2 (proposed Cedar Ridge Reservoir) from the perimeter of the reservoir located on the Clear Fork Brazos River.

C. Diversion Point No. 3 (U.S. Highway 183 crossing of the Clear Fork Brazos River) from the Clear Fork Brazos River at Latitude 32.9267°N, Longitude 99.0086°W, also located at the approximate intersection of the southeast corner of the Texas Emigration and Land Company Section 663, Abstract 487 with the northeast corner of the Texas Emigration and Land Company Section 493, Abstract 485, Stephens County.

D. Diversion Point No. 4 (Hubbard Creek Reservoir) Owner is authorized to divert return flows discharged into Hubbard Creek Reservoir, at a rate not to exceed its discharge rate from the perimeter of Hubbard Creek Reservoir.

E. Owner is authorized to divert the return flows authorized herein at a maximum rate of 69.52 cfs (31,200 gpm) from Diversion Point No. 1 in combination with the existing diversion authorizations in this certificate.

F. Owner is authorized to divert at a maximum combined rate of 37.1 cfs (16,650 gpm) from Diversion Point Nos. 2 and 3.

4. CONSERVATION

Owner shall implement water conservation plans that provide for the utilization of reasonable practices, techniques, and technologies, for each category of authorized use, that reduce or maintain the consumption of water, prevent or reduce the loss or waste of water, maintain or improve the efficiency in the use of water, increase the recycling and reuse of water, and prevent the pollution of water, so that a water supply is made available for future or alternative uses. The practices, techniques, and technologies used should be designed to achieve a level of efficiency of use for each category of authorized use that is equal to or greater than the level provided for in Owner's most recent water conservation plans on file with the Commission as of the date of the issuance of this amendment. Such plans shall include a requirement in every wholesale water contract entered into, on or after the effective date of this amendment, including any contract extension or renewal, that each successive wholesale customer develop and implement conservation measures meeting the requirements of this provision. If the customer intends to resell the water, then the contract for resale of the water must have water conservation requirements so that each successive wholesale customer in the resale of the water is required to implement water conservation measures meeting the requirements of this provision.

5. TIME PRIORITY

A. The priority date for the diversion of 9,034.5 acre-feet per year of historically discharged return flows less that amount of return flows diverted under Permit No. 4266 is October 14, 2004 and subject to call by senior and superior water rights. If Permit No. 4266 becomes void, the full amount of 9,034.5 shall have a priority date of October 14, 2004 and be subject to call by senior and superior water rights.

B. The priority date for the diversion of an additional 15,605.5 acre-feet of future return flows authorized by TPDES Permit No. 10334-004, is October 14, 2004 but is not subject to call by senior water rights or subject to instream flow limitations.

6. SPECIAL CONDITIONS

A. In order to provide sufficient flows for the instream uses of the Clear Fork Brazos River, diversions of the City's historical return flows at Diversion Point No. 3, shall be limited to times when streamflow equals or exceeds the following values, as measured at USGS Gaging Station 08085500, Clear Fork Brazos at Fort Griffin Texas:

Recommended Monthly values (cfs)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9.6	11.2	15.6	14.4	32.4	39	8.4	3.9	9.6	8.8	10	9.2

In addition, for any day that historical return flows are diverted pursuant to this amendment at Diversion Point No. 3, diversions at that point pursuant to this amendment, calculated as a daily average, shall be at least 0.5 cfs less than the daily average of flows at that USGS gaging station for the corresponding day. This special condition is subject to adjustment and amendment by the Commission at any time, if the Commission determines, through an expedited public review process, that such adjustment is appropriate to achieve compliance with applicable environmental flow standards in accordance with Texas Water Code § 11.147(e-1).

B. Prior to diversions at the proposed Cedar Ridge Reservoir (Diversion Point No. 2), the Owner shall apply for and obtain the appropriate state and federal permits for said reservoir. Diversions from Diversion Point No. 2 shall not occur until the reservoir has been permitted and constructed, and any applicable flow conditions for diversions of the City's historical return flows authorized in Use Paragraph 1.B will be imposed at that time.

C. At Diversion Point No. 3, the Owner shall implement measures to minimize impacts to aquatic resources due to entrainment and impingement by installing screens at the diversion facilities with a screen opening of no larger than 0.75 inches, and ensuring a maximum flow through screen velocity of 0.5 feet per second or less.

D. Owner shall only divert and use the return flows authorized by this amendment in accordance with the most recently approved *Abilene Indirect Reuse Accounting Plan 4161C*. Owner shall maintain said plan in electronic format and make the data available to the Executive Director upon request. Any modifications to *Abilene Indirect Reuse Accounting Plan 4161C* shall be approved by the Executive Director. Any modification to the plan that changes the terms of this certificate, must be in the form of an amendment to the certificate. Should the Owner fail to

maintain the accounting plan or notify the Executive Director of any modifications to the plan, Owner shall immediately cease diversion and use of the return flows authorized in Paragraph 1. Use and Paragraph 3. Diversion, and either apply to amend the certificate, or voluntarily forfeit this amendment. If Owner fails to amend the accounting plan or forfeit this amendment, the Commission shall be notified immediately by the Owner upon modification of the accounting plan and provided with copies of the appropriate documents effectuating such changes.

E. The diversions authorized by this amendment are dependent upon potentially interruptible return flows or discharges and are conditioned on the availability of those discharges. Owner shall only divert the return flows that are actually discharged, as calculated on a daily basis and adjusted for channel losses, and if there is a permanent reduction in available return flows, Owner shall immediately seek an amendment to the certificate to reflect the reductions. The right to divert the discharged return flows hereunder is subject to revocation and Owner is subject to enforcement if this condition is violated.

F. Prior to diversion of return flows in excess of the current amount authorized by TPDES Permit 10334-004, Owner shall apply for an amendment to the certificate and be granted the right to reuse those return flows. In addition, Owner must amend the accounting plan to include future return flows prior to diverting said return flows.

G. The Owner's right to divert 4,330 acre-feet of the historical City return flows pursuant to Paragraph 1.B. herein is dependent on Permit 4266, as amended, becoming void.

This amendment is issued subject to all terms, conditions and provisions contained in Certificate of Adjudication No. 12-4161, as amended, except as specifically amended herein.

Owner agrees to be bound by the terms, conditions and provisions contained herein and such agreement is a condition precedent to the granting of this amendment.

All other matters requested in the application which are not specifically granted by this amendment are denied.

This amendment is issued subject to the Rules of the TCEQ and to the right of continuing supervision of State water resources exercised by the Commission.

For the Commission

Date issued: **June 22, 2011**

Lloyd Gosselink
ATTORNEYS AT LAW

816 Congress Avenue, Suite 1900
Austin, Texas 78701
Telephone: (512) 322-5800
Facsimile: (512) 472-0532
www.lglawfirm.com

Mr. Rochelle's Direct Line: (512) 322-5810
[redacted]

RECEIVED
AUG 18 2011
WATER RIGHTS PERMITTING

August 17, 2011

VIA HAND DELIVERY

Ms. Kellye Rila (MC 160)
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78767-3087

Re: Cedar Ridge Reservoir (450-25)

Dear Kellye:

On behalf of my client, the City of Abilene, enclosed please find one (1) original and seven (7) copies of an Application to Appropriate State Water in connection with the proposed Cedar Ridge Reservoir project on the Clear Fork Brazos River. Please file-stamp one copy of the application and return it to my messenger. Also enclosed please find my firm check in the amount of $100.00, payable toward the filing fees associated with this application.

Thank you for your attention to this matter. If you have any questions concerning this matter, or I may be of service to you or your staff, please do not hesitate to contact me at your convenience.

Sincerely,

Michelle M. Dye
for
Martin C. Rochelle

MCR/ldp
1299259v2

cc: Mr. Tommy O'Brien
Mr. Scott Hibbs
Mr. Ken Choffel
Ms. Michelle Smith

TCEQ 23-AUG-11 10:01 AM

TCEQ - A/R RECEIPT REPORT BY ACCOUNT NUMBER

Fee Description	Fee Code / Account# / Account Name	Ref#1 / Ref#2 / Paid In By	Check Number / Card Auth. / User Data	CC Type / Tran Code / Rec Code	Slip Key / Document#	Tran Date	Tran Amount
WTR USE PERMITS	WUP	R132834	17024		BS00018432	23-AUG-11	-$100.00
	WUP	12747	082211	N	D1804535		
	WATER USE PERMITS	LLOYD GOSSELINK ROCHELLE & TOWNSEND PC	JMGEBROF	CK			

Total (Fee Code): -$100.00

Grand Total: -$6,660.00

APPLICATION TO APPROPRIATE STATE WATER FOR CEDAR RIDGE RESERVOIR ON THE CLEAR FORK BRAZOS RIVER

THE CITY OF ABILENE, TEXAS

Table of Contents

Application Form – TCEQ Application For Permit To Appropriate State Water

Attachment A – City Council Resolution Authorizing the Filing of the Application

Attachment B – Copy of Notices Mailed Pursuant to Texas Water Code § 11.124(f)

Attachment C – Documentation of Water Conservation Plan

Attachment D – Supplemental Application, Engineering and Environmental Information Document for Cedar Ridge Reservoir

Attachment E – USGS Topographic Map

APPLICATION FORM

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY APPLICATION FOR PERMIT TO APPROPRIATE STATE WATER

Appl. 12897

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
APPLICATION FOR PERMIT TO APPROPRIATE STATE WATER
(SECTION 11.121, 11.042, 11.085 **OR** 11.143, TEXAS WATER CODE)
TAC CHAPTERS 30, 50, 281, 287, 288, 295, 297 AND 299
Water Supply Division, Water Rights Permitting MC-160
P.O. Box 13087
Austin, Texas 78711-3087
Telephone (512) 239-4691, FAX (512) 239-4770
(if including a check, mail directly to P.O. Box 13088, Austin, TX 78711-3088)

Notice: This form will not be processed until all delinquent fees and/or penalties owed to the TCEQ or the Office of the Attorney General on behalf of the TCEQ are paid in accordance with the Delinquent Fee and Penalty Protocol.

1. Applicant Information.

A. Applicant Name(s): **The City of Abilene**

Mailing Address: **Post Office Box 60**

Abilene, Texas 79604

Telephone Number: **(325) 676-6201** Fax Number: **(325) 676-6229**

Email Address: [redacted]

B. Customer Reference Number (if issued): **CN 600242671**

Note: If you do not have a Customer Reference Number, complete Section II of the Core Data Form (TCEQ-10400) and submit it with this application.

C. Fees and Penalties

Applicant owes fees or penalties?

☐ Yes ☑ No

If yes, provide the amount and the nature of the fee or penalty as well as any identifying number:

D. Lienholder Information

Provide this information on the holder of any liens on any land to which the water right would be appurtenant):

Not Applicable.

2. Dam (structure), Reservoir and Watercourse Data.

*** See attached "Supplemental Application, Engineering and Environmental Information Document for Cedar Ridge Reservoir" report.**

A. Type of Storage Reservoir (indicate by checking (√) all applicable)

☑ on-channel ☐ off-channel ☐ existing structure ☑ proposed structure* ☐ exempt structure**

*Applicant shall provide a copy of the notice that was mailed to each member of the governing body of each county and municipality in which the reservoir, or any part of the reservoir, will be located as well as copies of the certified mailing cards.

**TWC Section 11.143 for uses of water for other than domestic, livestock, or fish and wildlife from an existing, exempt reservoir with a capacity of 200 acre-feet or less. Please complete Paragraph 6 below if proceeding under TWC 11.143.

Date of Construction: **Commencing within two (2) years of permit issuance.**

B. Location of Structure No. **01**

1) Watercourse: **Clear Fork Brazos River**

2) Location from County Seat: **22.3** miles in a **Southwest** direction from **Throckmorton**, **Throckmorton** County, Texas.

Location from nearby town (if other than County Seat): **14.7** miles in a **Northeast** direction From **Lueders**, a nearby town

shown on county highway map. **See Figure 1-1 in the attached "Supplemental Application, Engineering and Environmental Information Document for Cedar Ridge Reservoir" report.**

3) Zip Code: **79533**

4) The dam will be/is located in the **B&B** Original Survey No. **17**, Abstract No. **176 (Section 17)** in **Throckmorton** County, Texas; and the Original Survey No. **18**, Abstract No. **1158 (Section18)** in **Throckmorton** County, Texas.

5) Station **0+00** on the centerline of the dam is **80** ° **West** (bearing), **3,727** feet (distance) from the **NE** corner of **B&B** Original Survey No. **17**, Abstract No. **176 (Section 17)**, in **Throckmorton** County, Texas, also being at Latitude **32.962906** °N, Longitude **- 99.467445**°W. **(by GIS)**

Provide the Latitude and Longitude coordinates in decimal degrees, to at least six decimal places, and indicate the method used to calculate the diversion point location.

C. Reservoir:

1) Acre-feet of water impounded by structure at normal maximum operating level: **227,127**

2) Surface area in acres of reservoir at normal maximum operating level: **6,635**

D. Drainage Area

The drainage area above the dam is **1,745,920** acres or **2,728** square miles.

E. Other

1) If this is a U.S. Natural Resources Conservation Service (NRCS) (formerly Soil Conservation Service (SCS)) floodwater-retarding structure, provide the Site No. **Not Applicable.** and watershed project name **Not Applicable.**.

2) Do you request authorization to close the "ports" or "windows" in the service spillway?

☐ Yes ☑ No

3. **Appropriation/Diversion Request (total amount of water needed, including maximum projected uses and accounting for evaporative losses for off-channel storage, if applicable).**

A. Appropriated water will be used as follows:

	Purpose*	Place of Use	Acre-feet per year
1)	**Municipal; Domestic; Agricultural; Livestock; Industrial; Steam Electric; Mining; and Recreation**	**The City's existing and future wholesale and retail service areas.**	**34,400**

*If agricultural use, list crops(s) to be irrigated:

Not applicable, pursuant to Texas Administrative Code, Chapter 30, Sections 295.31 and 295.32.

B. Lands to be irrigated (if applicable): **Not Applicable.**

1) Applicant proposes to irrigate a total of _ acres in any one year. This acreage is all of or part of a larger tract(s) which is described in a supplement attached to this application and contains a total of ___ acres in _ County, Texas. A copy of the deed(s) describing the overall tract(s) with the recording information from the county records is attached.

2) Location of land to be irrigated: In the Original Survey No. _, Abstract No. _.

C. Diversion Point No. **1.**

1) Watercourse: **Clear Fork Brazos River** .

2) Location of point of diversion

Applicant proposes to divert water from any point(s) on the perimeter of the proposed Cedar Ridge Reservoir. Additionally, pursuant to the authorization contained in Certificate of Adjudication No. 12-4161C, Applicant will divert historical and future return flows from Cedar Ridge Reservoir.

at Latitude _°N, Longitude __°W,
Provide Latitude and Longitude coordinates in decimal degrees, to at least six decimal places, and indicate the method used to calculate the diversion point location..

also bearing _°_, _feet (distance) from the _ corner of the _Original Survey No. _, Abstract No._____,County, Texas.

3) Location from County Seat: _ miles in a _ direction from _, _ County, Texas.
Location from nearby town (if other than County Seat): _ miles in a direction from _, a nearby town shown on county highway map.

4) Zip Code:

5) The diversion will be (check (√) all appropriate boxes and if applicable, indicate whether existing or proposed):

	Directly from stream	Existing	Proposed
√	From an on-channel reservoir		√
	From stream to an off-channel reservoir		
	From a stream to an on-channel reservoir		
	From an off-channel reservoir		
	Other method (explain fully, use additional sheets if necessary)		

6) Rate of Diversion (Check (√) applicable provision):

√ 1. Diversion Facility:

A. **42,636** Maximum gpm (gallons per minute)

B. **A minimum of 3** Number of pumps

C. **Vertical Turbine** Type of pump

D. **14,212** gpm, Pump capacity of each pump

E. Portable pump _ Yes or **X** No.

___2. If by gravity:

A. _ Headgate _____ Diversion Dam _____ Maximum gpm

B. _ Other method (explain fully - use additional sheets if necessary)

7) The drainage area above the diversion point is **1,745,920** acres or **2,728** square miles.

Diversion Point No. **2.**

1) Watercourse: **Lake Fort Phantom Hill** .

2) Location of point of diversion

Applicant proposes to divert water that is discharged from the pipeline delivering water from Cedar Ridge Reservoir into Lake Fort Phantom Hill from any point(s) on the perimeter of Lake Fort Phantom Hill. Such diversions from Lake Fort Phantom Hill shall include up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project.

at Latitude _°N, Longitude __°W,

Provide Latitude and Longitude coordinates in decimal degrees, to at least six decimal places, and indicate the method used to calculate the diversion point location..

also bearing _°_, _feet

(distance) from the _ corner of the _Original

Survey No. _, Abstract No._____,County, Texas.

3) Location from County Seat: _ miles in a _ direction from

_, _ County, Texas.

Location from nearby town (if other than County Seat): _ miles in a

direction from _, a nearby town shown on county

highway map.

4) Zip Code:

5) The diversion will be (check (√) all appropriate boxes and if applicable, indicate whether existing or proposed):

	Directly from stream	Existing	Proposed
√	From an on-channel reservoir	√	
	From stream to an off-channel reservoir		
	From a stream to an on-channel reservoir		
	From an off-channel reservoir		
	Other method (explain fully, use additional sheets if necessary)		

6) Rate of Diversion (Check (√) applicable provision):

_√_1. Diversion Facility:

A. **42,636** Maximum gpm (gallons per minute)

B. **A minimum of 3** Number of pumps

C. **Vertical Turbine** Type of pump

D. **14,212** gpm, Pump capacity of each pump

E. Portable pump _ Yes or **X** No.

___2. If by gravity:

A. _ Headgate _____ Diversion Dam _____ Maximum gpm

B. _ Other method (explain fully - use additional sheets if necessary)

7) The drainage area above the diversion point is **300,800** acres or **470** square miles.

D. Return Water or Return Flow **(location and quantity information, provide Latitude and Longitude coordinates in decimal degrees to at least six decimal places and indicate the method used to calculate the diversion point location):**

All wastewater resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project are proposed to be taken to the City's Hamby Wastewater Treatment Facility and resulting return flows will be discharged pursuant to TPDES Permit No. WQ0010334004 at two

outfalls described below. Pursuant to Certificate of Adjudication No. 12-4161C, the City has the authorization to appropriate the return flows discharged from the Hamby Wastewater Treatment Facility, including future return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project. Additionally, the City may construct new wastewater treatment facilities from which return flows resulting from water supplies made available by the Cedar Ridge Reservoir project will be discharged.

Outfall No. 001

Water which is diverted but not consumed as a result of the above stated use, will be returned to Freewater Creek, tributary of Deadman Creek, tributary of Clear Fork Brazos River, tributary of Brazos River, Brazos River Basin, at a point which is at Latitude 32.561417 °N, Longitude - 99.622666 °W, also, bearing 18° Southeast (direction), 330 feet (distance) from the Northwest corner of the Texas and Pacific Railroad (Block 14, Section 53) Original Survey No. 53, Abstract No. 453, in Jones County, Texas.

Zip Code: 79601

Estimated **annual** amount of return flow to said stream will be 20,160 acre-feet, **and this volume of return flows is currently authorized pursuant to Certificate of Adjudication No. 12-4161C and includes future return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project. As the City grows, its return flows to said stream may increase, as well.**

Outfall No. 002

Water which is diverted but not consumed as a result of the above stated use, will be returned to Lake Kirby on Cedar Creek, tributary of Elm Creek, tributary of Clear Fork Brazos River, tributary of Brazos River, Brazos River Basin, at a point which is at Latitude 32.385633 °N, Longitude - 99.731366 °W, also, bearing 80° Southeast (direction), 5,280 feet (distance) from the Center of Section 9 of the Lunatic Asylum Original Survey No. 9, Abstract No. 1032, in Taylor County, Texas.

Zip Code: 79602

Estimated **annual** amount of return flow to said stream will be 4,480 acre-feet, **and this volume of return flows is currently authorized pursuant to Certificate of Adjudication No. 12-4161C and includes future return flows resulting from the use of water supplies made available by the Cedar Ridge Reservoir project. As the City grows, its return flows to said stream may increase, as well.**

E. Surplus Water **(provide Latitude and Longitude coordinates in decimal degrees to at least six decimal places and indicate the method used to calculate the diversion point location): Not Applicable.**

Water which is diverted but not used beneficially will be returned to _, tributary of _, _ Basin at a point which is at Latitude _°N, Longitude _°W, also

bearing _°_ (direction), _feet

(distance) from the _ corner of the _ Original Survey

No. _, Abstract No. _, in _ County, Texas.

Zip Code:

4. Discharge Point Information (if applicable, provide Latitude and Longitude coordinates in decimal degrees to at least six decimal places and indicate the method used to calculate the diversion point location).

The Applicant proposes to deliver water diverted from Cedar Ridge Reservoir directly into the City's raw water system for subsequent treatment and use, and/or to discharge such water into Lake Fort Phantom Hill for subsequent diversion, as indicated herein. Such discharges into Lake Fort Phantom Hill shall include up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project.

Discharge Point No. or Name: **Lake Fort Phantom Hill Discharge Point**

A. Select the appropriate box for the source of water being discharged:

☐ Treated effluent

☐ Groundwater

☒ Other **Up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project.**

B. Location of discharge point will be/is at Latitude _° N, Longitude _°W,

also bearing _°_, _feet from the _ corner of the

Original Survey No. ___, Abstract No. _, in

_County, Texas.

What method was used to determine the Latitude and Longitude for the discharge point? (*i.e.*, GPS Unit, USGS 7.5 Topographic Map, etc.)

Water diverted from Cedar Ridge Reservoir and proposed to be discharged into Lake Fort Phantom Hill, will be discharged anywhere along the perimeter of Lake Fort Phantom Hill, for subsequent diversion and use.

C. Location from County Seat: _ miles in a _direction from _,

_ County, Texas.

Location from nearby town (if other than County Seat): __ miles in a

direction from _____, a nearby town shown on county highway map.

D. Zip Code:

E. Water will be discharged into **Lake Fort Phantom Hill** stream/**reservoir**,

(tributaries) **on Elm Creek, tributary of Clear Fork Brazos River, tributary of Brazos River**,

Brazos River, Basin.

F. Water will be discharged at a maximum rate of **95** cfs (**42,636** gpm).

G. The amount of water that will be discharged is **up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project**.

H. The purpose of use for the water being discharged will be **for the purposes specified in Section 3.A., above** .

I. Additional information required:

For groundwater **Not Applicable.**

1) Provide water quality analysis and 24 hour pump test for the well if one has been conducted.
2) Locate and label the groundwater well(s) on a USGS 7.5 Minute Topographic Map
3) Provide a copy of the groundwater well permit if it is located in a Groundwater Conservation District.
4) What aquifer the water is being pumped from?

For treated effluent **See Certificate of Adjudication No. 12-4161C.**

1) What is the TPDES Permit Number? Provide a copy of the permit.
2) Provide the monthly discharge data for the past 5 years.
3) What % of treated water was groundwater, surface water?
4) If any original water is surface water, provide the base water right number.

5. General Information.

A. The proposed **X** or existing _ works will be located on the land of **the City of Abilene** , whose mailing address is **Post Office Box 60, Abilene, Texas, 79604**

B. If an application for the appropriation is granted, either in whole or in part, construction works will begin within **two (2) years** after such permit is issued. The proposed work will be completed within **ten (10) years** from the date the permit is issued.

C. A Water Conservation Plan is attached? √ Yes _ No.

D. ____Interbasin transfer is not requested.

√* Applicant requests authorization to transfer **up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application** from the **Brazos River** Basin to the **Colorado River** Basin of which **up to 34,400** acre-feet of water will be used for **municipal, domestic, industrial, agricultural, livestock, steam-electric, mining, and recreation** purposes.

***Applicant requests an exempt interbasin transfer pursuant to Texas Water Code § 11.085(v)(4) to use water diverted from Cedar Ridge Reservoir within Scurry, Mitchell, Nolan, Taylor, Callahan, Eastland, Comanche and Brown Counties.**

E. __√__ Bed and Banks request to transfer **__up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project__** within the bed and banks of **__Lake Fort Phantom Hill__**, tributary of **__Elm Creek, tributary of Clear Fork Brazos River, tributary of Brazos River, Brazos River Basin__**.

F. Is this project located within 200 river miles of the coast? _ Yes __√__ No _Unknown

5. Maps, plats, plans, and drawings accompany this application as required by applicable TAC Sections.

__√__ Yes _ No. Attach additional sheets.

6. The dam(s) and reservoir(s) shown on the attached application was (were) constructed for domestic and livestock purposes and I/we elect to seek a permit under Section 11.143 of the Texas Water Code.

7. Provide information describing how this application addresses a water supply need in a manner that is consistent with the state water plan or the applicable approved regional water plan for any area in which the proposed appropriation is located or, in the alternative, describe conditions that warrant a waiver of this requirement.

__The proposed Cedar Ridge Reservoir is identified in the 2011 Brazos G Water Plan and 2007 State Water Plan as a recommended water management strategy to serve the future needs of the City of Abilene and the surrounding region. Additionally, pursuant to Senate Bill 3, the site for the proposed Cedar Ridge Reservoir is identified as "unique" for the construction of a reservoir.__

Applicant Name (Sign) Applicant Name (Sign)

Larry D. Gilley, City Manager

Applicant Name (Printed) Applicant Name (Printed)

SWORN TO AND SUBSCRIBED before me this 12th day of August, 2011.

AUDRIA HAMMOND
Notary Public, State of Texas
My Commission Exp 05-03-14

Notary Public for the State of Texas

Supplemental Dam/Reservoir Information Sheet

Dam (structure), Reservoir and Watercourse Data

A. Type of Storage Reservoir (indicate by checking (√) all applicable)

☑ on-channel ☐ off-channel ☐ existing structure ☑ proposed structure* ☐ exempt structure**

*Applicant shall provide a copy of the notice that was mailed to each member of the governing body of each county and municipality in which the reservoir, or any part of the reservoir, will be located as well as copies of the certified mailing cards.

**TWC Section 11.143 for uses of water for other than domestic, livestock, or fish and wildlife from an existing, exempt reservoir with a capacity of 200 acre-feet or less. Please complete Paragraph 6 below if proceeding under TWC 11.143.

Date of Construction **Commencing within two (2) years of permit issuance**

B. Location of Structure No. 1.

1) Watercourse: **Clear Fork Brazos River**

2) Location from County Seat: **22.3** miles in a **Southwest** direction from **Throckmorton**, **Throckmorton** County, Texas.

Location from nearby town (if other than County Seat): **14.7** miles in a **Northeast** direction From **Lueders**, a nearby town shown on county highway map.

3) Zip Code: **79533**

4) The dam will be/is located in the **B&B** Original Survey No. **17**, Abstract No. **176 (Section 17)** in **Throckmorton** County, Texas; and Original Survey No. **18**, Abstract No. **1158 (Section 18)** in **Throckmorton** County, Texas.

5) Station **0+00** on the centerline of the dam is **80** ° **West** (bearing), **3,727** feet (distance) from the **Northeast** corner of **B&B** Original Survey No. **17**, Abstract No. **176 (Section17)**, in **Throckmorton** County, Texas, also being at Latitude **32.962906** °N, Longitude **- 99.467445** °W. (by GIS)

Provide Latitude and Longitude coordinates in decimal degrees to at least six decimal places and indicate the method used to calculate the diversion point location

C. Reservoir:

1) Acre-feet of water impounded by structure at normal maximum operating level: **227,127**

2) Surface area in acres of reservoir at normal maximum operating level: **6,635**

D. The drainage area above the dam is **1,745,920** acres or **2,728** square miles.

E. Other: **Not Applicable.**

1) If this is a U.S. Natural Resources Conservation Service (NRCS) (formerly Soil Conservation Service (SCS)) floodwater-retarding structure, provide the Site No. _____ and watershed project name

2) Do you request authorization to close the "ports" or "windows" in the service spillway?

☐ Yes ☐ No

Supplemental Diversion Point Information Sheet

Diversion Point No. __1__. (Provide a completed *Supplemental Diversion Point Information Sheet* for additional diversions)

1) Watercourse: **Clear Fork Brazos River**

2) Location of point of diversion

Applicant proposes to divert from any point(s) on the perimeter of the proposed Cedar Ridge Reservoir.

at Latitude ___°N, Longitude ___°W,

also, bearing _°_, _feet (distance) from the _corner of the

_ Original Survey No. _, Abstract No. _, in

_ County, Texas. **Provide Latitude and Longitude coordinates in decimal degrees, to at least six decimal places, and indicate the method used to calculate the diversion point location.**

3) Location from County Seat: _ miles in a _direction from _,

_ County, Texas.

Location from nearby town (if other than County Seat): __ miles in a

direction from _____, a nearby town shown on county highway map.

4) Zip Code:

5) The diversion will be (check (√) all appropriate boxes and if applicable, indicate whether existing or proposed):

	Directly from stream	Existing	Proposed
√	From an on-channel reservoir		√
	From stream to an off-channel reservoir		
	From a stream to an on-channel reservoir		
	From an off-channel reservoir		
	Other method (explain fully, use additional sheets if necessary)		

6) Rate of Diversion (Check (√) applicable provision):

__√__1. Diversion Facility:

A. __**42,636**__ Maximum gpm (gallons per minute)

1) **A minimum of 3** Number of pumps

2) **Vertical Turbine** Type of pump

3) **14,212** gpm, Pump capacity of each pump

4) Portable pump _ Yes or **X** No

___2. If by gravity:

A.__ Headgate _ Diversion Dam _ Maximum gpm

B.__ Other method (explain fully - use additional sheets if necessary)

7) The drainage area above the diversion point is **1,745,920** acres or **2,728** square miles.

Supplemental Diversion Point Information Sheet

Diversion Point No. **2**.

1) Watercourse: **Lake Fort Phantom Hill**

2) Location of point of diversion

Applicant proposes to divert water that is discharged from the pipeline delivering water from Cedar Ridge Reservoir into Lake Fort Phantom Hill from any point(s) on the perimeter of Lake Fort Phantom Hill. Such diversions from Lake Fort Phantom Hill shall include up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project.

at Latitude ___°N, Longitude ___°W,

also, bearing _°_, _feet (distance) from the _corner of the

_ Original Survey No. _, Abstract No. _, in

_ County, Texas. **Provide Latitude and Longitude coordinates in decimal degrees, to at least six decimal places, and indicate the method used to calculate the diversion point location.**

3) Location from County Seat: _ miles in a _direction from _,

_ County, Texas.

Location from nearby town (if other than County Seat): __ miles in a

direction from _____, a nearby town shown on county highway map.

4) Zip Code:

5) The diversion will be (check (√) all appropriate boxes and if applicable, indicate whether existing or proposed):

	Directly from stream	Existing	Proposed
√	From an on-channel reservoir	√	
	From stream to an off-channel reservoir		
	From a stream to an on-channel reservoir		
	From an off-channel reservoir		
	Other method (explain fully, use additional sheets if necessary)		

6) Rate of Diversion (Check (√) applicable provision):

__√__ 1. Diversion Facility:

A. **42,636** Maximum gpm (gallons per minute)

1) **A minimum of 3** Number of pumps
2) **Vertical Turbine** Type of pump
3) **14, 212** gpm, Pump capacity of each pump
4) Portable pump _ Yes or **X** No

___2. If by gravity:

A.__ Headgate _ Diversion Dam _ Maximum gpm

B.__ Other method (explain fully - use additional sheets if necessary)

7) The drainage area above the diversion point is **300,800** acres or **470** square miles.

Supplemental Discharge Point Information Sheet

Discharge Point No. or Name: **Lake Fort Phantom Hill Discharge Point**

The Applicant proposes to deliver water diverted from Cedar Ridge Reservoir directly into the City's raw water system for subsequent treatment and use, and/or to discharge such water into Lake Fort Phantom Hill for subsequent diversion. Such discharges into Lake Fort Phantom Hill shall include up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project.

1) Select the appropriate box for the source of water being discharged:

☐ Treated effluent

☐ Groundwater

☒ Other **Up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project.**

2) Location of discharge point will be/is at Latitude _° N, Longitude _°W,

also bearing _°_, _feet from the _ corner of the

Original Survey No. __, Abstract No. _, in _County, Texas.

Provide Latitude and Longitude coordinates in decimal degrees, to at least six decimal places and indicate the method was used to determine the Latitude and Longitude for the discharge point? (*i.e.*, GPS Unit, USGS 7.5 Topographic Map, etc.)

Water diverted from Cedar Ridge Reservoir and proposed to be discharged into Lake Fort Phantom Hill, will be discharged anywhere along the perimeter of Lake Fort Phantom Hill, for subsequent diversion and use.

3) Location from County Seat: _ miles in a _direction from _,

_ County, Texas.

Location from nearby town (if other than County Seat): __ miles in a

direction from _____, a nearby town shown on county highway map.

4) Zip Code:

5) Water will be discharged into **Lake Fort Phantom Hill** stream/**reservoir**,

(tributaries) **on Elm Creek, tributary of Clear Fork Brazos River, tributary of Brazos River** ___,

Brazos River Basin.

6) Water will be discharged at a maximum rate of **95** cfs (**42,636** gpm).

7) The amount of water that will be discharged is **up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project.**

8) The purpose of use for the water being discharged will be **for the purposes specified in Section**

3.A of this Application.

9) Additional information required:

For groundwater **Not Applicable.**

1. Provide water quality analysis and 24 hour pump test for the well if one has been conducted.
2. Locate and label the groundwater well(s) on a USGS 7.5 Minute Topographic Map
3. Provide a copy of the groundwater well permit if it is located in a Groundwater Conservation District.
4. What aquifer the water is being pumped from?

For treated effluent **See Certificate of Adjudication No. 12-4161C.**

1. What is the TPDES Permit Number? Provide a copy of the permit.
2. Provide the monthly discharge data for the past 5 years.
3. What % of treated water was groundwater, surface water?
4. If any original water is surface water, provide the base water right number.

Supplemental Environmental Information Sheet

Water right projects have the potential to alter environmental conditions in the state's rivers and streams through flow modification, sediment load alteration, loss of wetlands, and removal of riparian vegetation. The Resource Protection Team assess the effects issuance or amendment of a water right may have on existing instream uses. Instream uses include, but are not limited to, water quality, fish and wildlife habitat, recreation, and freshwater inflows to bays and estuaries.

The following items are suggested guidelines for data to be submitted depending on the nature of the particular application. Please note that *not* all the information identified below is required for the water right application to be considered administratively complete. However, depending on the magnitude and scope of the proposed project, failure to provide requested information for technical review may result in delayed processing times or a recommendation of denial of the application.

ITEMS TO BE PROVIDED FOR ALL APPLICATIONS:

1. USGS 7.5 minute topographic map with all diversion points, discharge points, reservoirs, and/or land to be irrigated clearly indicated. **See Attachment D, Section 4, Figures 4-1 and 4-2, and Attachment E.**

2. Photographs of the stream at the project area (i.e., diversion point/dam location) including upstream and downstream views. Photographs should be in color and reflect the existing conditions of the stream and the riparian vegetation. Each photograph should include a description of what is depicted as well as be referenced to the USGS topographic map indicating the location and direction of the shot. **See Attachment D, Appendix D.**

3. Brief description of the affected stream or water body at the project location including:
   See Attachment D, Section 6.
   a) Average and maximum channel width and depth;
   b) Flow characteristics of the stream (i.e., is the stream perennial, intermittent with pools, or intermittent?);
   c) Description of land uses upstream within the watershed, if known.

4. Any known recreation or other public uses of the affected stream or water body.
   See Attachment D, Section 6.

ADDITIONAL ITEMS TO BE PROVIDED IF AN EXISTING DAM AND RESERVOIR ARE SOUGHT TO BE PERMITTED: Not Applicable.

1. Date dam constructed.

2. Will the reservoir be maintained at normal pool elevation with an alternate source of water? If so, identify the source of water. If groundwater will be used, see below.

3. Does the dam have an operational low flow outlet or other means to pass state water?

MINIMAL ADDITIONAL ITEMS TO BE PROVIDED IF A DAM AND RESERVOIR ARE PROPOSED TO BE CONSTRUCTED:

1. In addition to indicating the location of the project location on the USGS topographic map, please identify the area of lake inundation at normal pool level.
   See Attachment D, Section 4, Figures 4-1 and 4-2.

2. Provide a brief description of the area to be affected by the proposed dam and reservoir.
See Attachment D, Section 4 and Section 6.

3. The local U.S. Army Corps of Engineers (USACE) district should be notified of the proposed project. If the USACE determines that a 404 permit is required, provide the project number and name of the USACE Project Manager.
Project No. SWF-2010-00191 (Project Manager Fred Land).

4. Will the reservoir be maintained at normal pool elevation with an alternate source of water? If so, identify the source of water. If groundwater will be used, see below.
Not Applicable.

5. Will the dam have a low flow outlet or other means to pass state water?
See Attachment D, Section 4.

POSSIBLE ADDITIONAL ITEMS TO BE PROVIDED IF A DAM AND RESERVOIR ARE PROPOSED TO BE CONSTRUCTED:

1. A quantitative or qualitative evaluation of existing aquatic, riparian, wetland, and terrestrial habitats that will be subject to impact by the proposed reservoir project, preferably performed by a qualified third party. Acceptable evaluation procedures to be used may include, but are not limited to, USFWS's Habitat Evaluation Procedures or TPWD's Wildlife Habitat Appraisal Procedure. Any habitat evaluation should include an assessment of the effects of the project on habitats in the river segment downstream.
See Attachment D, Section 6.

2. Description of the alternatives that were examined to meet the water needs that the proposed project is intended to fulfill. Were other site locations examined that may result in less environmental impact? How was the size of the proposed reservoir determined? Would a smaller reservoir be adequate to meet the projected water needs? Habitat mitigation shall be considered only after the complete sequencing (avoidance, minimization or modification, and compensation/replacement) process has been performed.
See Attachment D, Section 2 and Section 6.

3. Should habitat losses be found to be unavoidable, a mitigation plan should be developed that will compensate for lost or altered ecosystem functions and values imposed by the proposed project. This plan should address both the direct and indirect impacts to aquatic, riparian, and terrestrial habitats, as well as short- and long-term effects that may result from the proposed project. Habitat mitigation plans shall be ensured through binding legal contracts or conservation easements and shall include goals and schedules for completion of those goals. Mitigation areas shall be managed in perpetuity by a party approved by the Commission to maintain the habitat functions and values that will be affected by the proposed project.
See Attachment D, Section 6.

ADDITIONAL ITEMS TO BE PROVIDED IF GROUNDWATER WILL BE USED:

Not Applicable.

Information regarding the groundwater wells to be used in this project and groundwater quality data from each well to be used. Well information should include the following:

a) Depth of well;
b) Name of aquifer from which water is withdrawn;

c) Pumping capacity of well.

Water chemistry information should include but not be limited to the following parameters:

a) Chlorides;
b) Sulfates;
c) Total Dissolved Solids (TDS);
d) pH;
e) Temperature.

If data for on-site wells are unavailable, historical data collected from similar sized wells drawing water from the same aquifer may be provided. However, please note that on-site data may still be required when it becomes available.

Alternatives Analysis Worksheet for Wetland Impacts

See Attachment D, Section 2 and Section 6.

1. Alternatives
    1. How could you satisfy your needs in ways which do not affect wetlands?
    2. How could the project be re-designed to fit the site without affecting wetlands?
    3. How could the project be made smaller and still meet your needs?
    4. What other sites were considered?
        1. What geographic area was searched for alternative sites?
        2. How did you determine whether other non-wetland sites are available for development in the area?
    5. What are the consequences of not building the project?

2. Comparison of alternatives
    1. How do the costs for the alternatives considered above?
    2. Are there logistic (location, access, transportation, etc.) factors that limit the alternatives considered?
    3. Are there technological limitations for the alternatives considered?
    4. Are there other reasons certain alternatives are not feasible?

3. If you have not chosen an alternative which would avoid wetland impacts, explain:
    1. Why your alternative was not selected?
    2. What you plan to do to minimize adverse effects on the wetlands impacted?

4. Please provide a comparison of each criterion (from Part II) for each site evaluation in the alternatives analysis.

PERMIT APPLICATION COMPLETION CHECKLIST FOR HYDROLOGY, WATER CONSERVATION, AND DAM SAFETY

Name(s) of Applicant: **The City of Abilene, Texas**

Stream, Basin, and County: **Clear Fork Brazos River, Brazos River Basin, Throckmorton County, Texas**

USGS 7.5 minute topographic map with all diversion points, discharge points, reservoirs, and/or land to be irrigated clearly indicated: **See Attachment D, Section 4, Figures 4-1 and 4-2.**

Latitude and Longitude of all diversion points and/or reservoirs, including how the coordinates were determined: **Applicant proposes to divert raw water from any point(s) on the perimeter of the proposed Cedar Ridge Reservoir and to divert water that is discharged from the pipeline delivering raw water from Cedar Ridge Reservoir into Lake Fort Phantom Hill from any point(s) on the perimeter of Lake Fort Phantom Hill.**

Diversion amount: **34,400 acre-feet per annum of new water from Cedar Ridge Reservoir. The Applicant proposes to deliver water diverted from Cedar Ridge Reservoir directly into the City's raw water system for subsequent treatment and use, and/or to discharge such water into Lake Fort Phantom Hill for subsequent diversion. Such diversions from Cedar Ridge Reservoir and discharges into Lake Fort Phantom Hill shall include up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project. Applicant proposes to divert water that is discharged from the pipeline delivering water from Cedar Ridge Reservoir into Lake Fort Phantom Hill from any point(s) on the perimeter of Lake Fort Phantom Hill. Such diversions from Lake Fort Phantom Hill shall include up to 34,400 acre-feet of water proposed to be diverted from Cedar Ridge Reservoir pursuant to this Application, as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project.**

Diversion rate: **42,636 gpm from both Cedar Ridge Reservoir and Lake Fort Phantom Hill.**

Monthly Diversion Distribution (the amount of the total water that you plan to divert each month):

J	F	M	A	M	J	J	A	S	O	N	D
6.6%	6.4%	7.1%	7.7%	9.2%	10.0%	11.5%	10.4%	9.2%	7.9%	7.0%	6.8%

Reservoir capacity and surface area: **Reservoir impoundment at the conservation pool for Cedar Ridge Reservoir is approximately 227,127 acre-feet of water with a surface area of approximately 6,635 acres.**

Drainage area: **1,745,920 acres or 2,728 square miles for Cedar Ridge Reservoir. 300,800 acres or 470 square miles for Lake Fort Phantom Hill.**

Request to use the bed and banks of a watercourse and/or reservoir: **Applicant requests to use the bed and banks of Lake Fort Phantom Hill to convey up to 34,400 acre-feet of new water diverted from Cedar Ridge Reservoir as well as the historical and future City return flows diverted from Cedar Ridge Reservoir pursuant to Certificate of Adjudication No. 12-4161C and delivered to Lake Fort Phantom Hill to a diversion point(s) located on the perimeter of Lake Fort Phantom Hill.**

Other (copy of contract for water, alternate source of water, accounting plan, etc.)

WATER CONSERVATION PLAN

1. Plan and appropriate data form **See Attachment C.**

2. Please specify the quantitative goals as outlined on the data form **See Attachment C.**

DAM SAFETY

If a reservoir is requested in the application, the following information should be submitted: **See Attachment D, Section 4.**

1. Surface area and capacity of the reservoir

2. Plans (with engineer's seal) for the reservoir if the dam is over 6 feet high

3. Engineer's signed and sealed hazard classification

4. Statement from engineer that the structure complies with the Chapter 299 Rules and supporting documentation

ATTACHMENT A

CITY COUNCIL RESOLUTION AUTHORIZING THE FILING OF THE APPLICATION

RESOLUTION NO. 14-2011

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF ABILENE, TEXAS AUTHORIZING THE FILING AND PROSECUTION OF THE NECESSARY STATE AND FEDERAL PERMIT APPLICATIONS FOR THE CEDAR RIDGE RESERVOIR PROJECT.

WHEREAS, the City of Abilene, Texas (the "City") serves as a major water supplier for its citizens and for surrounding communities in and near Taylor and Jones Counties, Texas; and,

WHEREAS, the City projects that its water supply demands and that of this region of the state will continue to grow and may exceed available supplies in the near future; and,

WHEREAS, pursuant to the approved 2011 Region G Regional Water Plan (the "Plan") and the approved 2007 State Water Plan (the "State Plan"), the City is projected to need additional water supplies before 2060; and,

WHEREAS, the City desires to ensure that it has adequate water supplies to meet future demands and attract new business development to this region of the state; and,

WHEREAS, the Cedar Ridge Reservoir (the "Reservoir") is identified in the Plan and the State Plan as a recommended water management strategy for the City and this region of the state; and,

WHEREAS, the 2007 Texas Legislature designated the site of the Reservoir as unique for the construction of a reservoir in Senate Bill 3; and,

WHEREAS, the City has evaluated the economic feasibility of the Reservoir and determined that the Reservoir, if constructed, will provide a cost-effective supply of water for the City, its citizens, and its water supply customers; and,

WHEREAS, in order to pursue and accomplish construction of the Reservoir it is necessary for the City to secure state and federal authorizations appropriate for same, including applications to the Texas Commission on Environmental Quality ("TCEQ") under Chapter 11 of the Texas Water Code for a water rights permit and a Clean Water Act §401 water quality certification, as well as applications to the U.S. Army Corps of Engineers (the "Corps") for a Clean Water Act § 404 permit; and,

WHEREAS, the City Council wishes to authorize the City Manager or his designee to prepare, make, execute, file, prosecute and amend any and all applications to obtain the necessary water rights permit and Clean Water Act §401 certification and to negotiate, settle and compromise any challenges or disputes arising out of such applications, all as he shall deem to be in the best interests of the City; and,

WHEREAS, the City Council wishes to authorize the City Manager or his designee to prepare, make, execute, file, prosecute and amend any and all applications to obtain a Clean Water Act § 404 permit and any other federal environmental authorization related to the permit and required for the Reservoir, and to negotiate, settle and compromise any challenges or disputes arising out of such applications, all as he shall deem to be in the best interests of the City;

NOW THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF ABILENE, TEXAS:

PART 1: The City Manager or his designee is hereby authorized and directed to prepare, or cause to be prepared, and to make, execute, file, prosecute and amend any and all applications to obtain the necessary water rights and certifications under Chapter 11 of the Texas Water Code, and § 401 of the Clean Water Act required for the Reservoir and to negotiate, settle and compromise any challenges or disputes arising out of such applications.

PART 2: The City Manager or his designee is hereby authorized and directed to prepare, or cause to be prepared, and to make, execute, file, prosecute and amend any and all applications to obtain a Clean Water Act § 404 permit and any other federal environmental authorizations related to the permit and required for the Reservoir and to negotiate, settle and compromise any challenges or disputes arising out of such applications, all as he shall deem to be in the best interests of the City.

PART 3: The City Manager or his designee is hereby authorized and directed to make the expenditures necessary in order to prepare, make, execute, file, prosecute, amend, negotiate, settle and compromise the applications for the above permits and authorizations from state and federal agencies, including the TCEQ and the Corps, as may be required for the Reservoir.

PART 4: A certified copy of this resolution shall be provided to the TCEQ, the Corps, and to all persons interested in the subject matter hereof.

ADOPTED AND EFFECTIVE this 11 day of August, 2011.

ATTEST:

Danette Dunlap
City Secretary

Norm Archibald
Mayor

APPROVED:

T. Daniel Santee
City Attorney

ATTACHMENT B

COPY OF NOTICES MAILED PURSUANT TO TEXAS WATER CODE § 11.124(F)

CITY OF ABILENE

OFFICE OF CITY MANAGER

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Jones County
P O Box 148
Anson, Texas 79501
Attn: Honorable Dale Spurgin

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Judge Spurgin:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

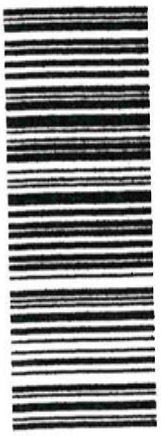
Sincerely,

Larry S. Gilley

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS, FOLD AT DOTTED LINE

CERTIFIED MAIL



7010 1870 0000 8747 8154

7010 1870 0000 8747 8154

U.S. Postal Service
CERTIFIED MAIL RECEIPT
(Domestic Mail Only: No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

Office of Appellate Law, SB

Postage	
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Cedar Ridge

Postmark Here

Sent To: Jones County
Honorable Dale Spurgin

Street, Apt. No., or PO Box No.: ~~P.O. Box 148~~
Anson, TX 79501

City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Jones County
Honorable Dale Spurgin
P.O. Box 148
Anson, TX 79501

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☑ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7010 1870 0000 8747 8154

S Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

CITY OF ABILENE

OFFICE OF CITY MANAGER

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Jones County
County Commissioner, Precinct 1
1001 Northwest Third Street
Hamlin, Texas 79520
Attn: Mr. James Clawson

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Clawson:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

CERTIFIED MAIL™

OF THE RETURN ADDRESS, FOLD AT DOTTED LINE

7010 1870 0000 8747 8161

7010 1870 0000 8747 8161

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com®

Notice of Application for Cedar Ridge OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. James Clawson
Street, Apt. No.; or PO Box No.: Jones County County Commissioner, Precinct 1 1001 Northwest Third Street
City, State, ZIP+4: Hamlin TX 79520

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

Article Addressed to:

Mr. James Clawson
County Commissioner, Precinct 1
1001 Northwest Third Street
Hamlin TX 79520

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

Article Number (Transfer from service label) 7010 1870 0000 8747 8161

Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

OFFICE OF CITY MANAGER

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Jones County
County Commissioner, Precinct 2
10980 Hwy. 6
Avoca, Texas 79503
Attn: Mr. Mike Polk

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Polk:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS. FOLD AT DOTTED LINE

CERTIFIED MAIL

7010 1870 0000 8747 8178

7010 1870 0000 8747 8178

U.S. Postal Service™

CERTIFIED MAIL™ RECEIPT

(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CEDAR RIDGE OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. Mike Polk
Jones County
County Commissioner, Precinct, 2

Street, Apt. No.; or PO Box No.: 10980 HWY 6

City, State, ZIP+4: Avoca, TX 79503

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Mike Polk
Jones County
County Commissioner, Precinct, 2
10980 HWY 6
Avoca, TX 79503

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☑ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7010 1870 0000 8747 8178

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

OFFICE OF CITY MANAGER

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Jones County
County Commissioner, Precinct 3
P O Box 148
Anson, Texas 79501
Attn: Mr. Gaite Taylor

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Taylor:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager



PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS, FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8185

7010 1870 0000 8747 8185

U.S. Postal Service™

CERTIFIED MAIL™ RECEIPT

(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CEDAR RIDGE OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Mr. Gaite Taylor
Jones County

Sent To: County Commissioner, Precinct 3

Street, Apt. No.; or PO Box No.: P.O. Box 148

City, State, ZIP+4: Anson, TX 79501

PS Form 3800, August 2006 — See Reverse for Instructions

NDER: *COMPLETE THIS SECTION*

Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
Print your name and address on the reverse so that we can return the card to you.
Attach this card to the back of the mailpiece, or on the front if space permits.

rticle Addressed to:

Mr. Gaite Taylor
Jones County
County Commissioner, Precinct 3
P.O. Box 148
Anson, TX 79501

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

icle Number
ansfer from service label) 7010 1870 0000 8747 8185

rm 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

OFFICE OF CITY MANAGER

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Jones County
County Commissioner, Precinct 4
P O Box 148
Anson, Texas 79501
Attn: Mr. Joe Whitehorn

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Whitehorn:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

CERTIFIED MAIL

7010 1870 0000 8747 8192

7010 1870 0000 8747 8192

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CHIEF JUSTICE

OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. Joe Whitehorn
Jones County
County Commissioner, Precinct 4
Street, Apt. No. or PO Box No.: P.O. Box 148
City, State, ZIP+4: Anson, TX 79501

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Joe Whitehorn
Jones County
County Commissioner, Precinct 4
P.O. Box 148
Anson, TX 79501

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1870 0000 8747 8192

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

OFFICE OF CITY MANAGER

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Shackelford County
P O Box 2797
Albany, Texas 76430
Attn: Honorable Ross Montgomery

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Judge Montgomery:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS. FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8208

7010 1870 0000 8747 8208

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com®

NOTICE OF APPLICATION FOR CEDAR RIDGE

OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To ~~Honorable Ross Montgomery~~
Shackelford County
Street, Apt. No. P.O. Box 2797
or PO Box No. Albany, TX 76430
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

NDER: *COMPLETE THIS SECTION*

Complete items 1, 2, and 3. Also complete
tem 4 if Restricted Delivery is desired.
Print your name and address on the reverse
so that we can return the card to you.
Attach this card to the back of the mailpiece,
or on the front if space permits.

rticle Addressed to:

Honorable Ross Montgomery
Shackelford County
P.O. Box 2797
Albany, TX 76430

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☑ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

Icle Number
ansfer from service label) 7010 1870 0000 8747 8208

rm 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

OFFICE OF CITY MANAGER

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Shackelford County
County Commissioner, Precinct 1
324 Eaheart
Albany, Texas 76430
Attn: Mr. David Everett

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Everett:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

OF THE RETURN ADDRESS, FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8215

7010 1870 0000 8747 8215

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com.

NOTICE OF APPLICATION FOR CEDAR RIDGE OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. David Everett
Shackelford County
County Commissioner, Precinct 1

Street, Apt. No. or PO Box No.: 324 Eaheart

City, State, ZIP+4: Albany, TX 76430

PS Form 3800, August 2006 — See Reverse for Instructions

DER: *COMPLETE THIS SECTION*

omplete items 1, 2, and 3. Also complete
m 4 if Restricted Delivery is desired.
int your name and address on the reverse
that we can return the card to you.
tach this card to the back of the mailpiece,
on the front if space permits.

ticle Addressed to:

Mr. David Everett
Shackelford County
County Commissioner, Precinct 1
324 Eaheart
Albany, TX 76430

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☑ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

ticle Number
ansfer from service label) 7010 1870 0000 8747 8215

orm 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

CITY OF ABILENE

OFFICE OF CITY MANAGER

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Shackelford County
County Commissioner, Precinct 2
P O Box 2081
Albany, Texas 76430
Attn: Mr. Larry Cauble

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Cauble:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

CERTIFIED MAIL

7010 1870 0000 8747 8222

7010 1870 0000 8747 8222

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com®

NOTICE OF APPLICATION FOR CHANGE

OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. Larry Cauble
Shackelford County
County Commissioner, Precinct 2

Street, Apt. No., or PO Box No.: P.O. Box 2081

City, State, ZIP+4: Albany, TX 76430

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Larry Cauble
Shackelford County
County Commissioner, Precinct 2
P.O. Box 2081
Albany, TX 76430

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☑ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7010 1870 0000 8747 8222

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

CITY OF ABILENE

OFFICE OF CITY MANAGER

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Shackelford County
County Commissioner, Precinct 3
251 FM 2408
Moran, Texas 76464
Attn: Mr. Jimmy Brooks

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Brooks:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager



U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CEDAR RIDGE

7010 1870 0000 8747 8239

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. Jimmy Brooks
Shackelford County
County Commissioner, Precinct 3

Street, Apt. No.; or PO Box No.: 251 FM 2408

City, State, ZIP+4: Moran, TX 76464

PS Form 3800, August 2006 — See Reverse for Instructions

DER: *COMPLETE THIS SECTION*

omplete items 1, 2, and 3. Also complete
m 4 if Restricted Delivery is desired.
int your name and address on the reverse
that we can return the card to you.
tach this card to the back of the mailpiece,
on the front if space permits.

ticle Addressed to:

Mr. Jimmy Brooks
Shackelford County
County Commissioner, Precinct 3
251 FM 2408
Moran, TX 76464

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☑ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

ticle Number
ansfer from service label) 7010 1870 0000 8747 8239

orm 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Shackelford County
County Commissioner, Precinct 4
425 CR 151
Abilene, Texas 79601
Attn: Mr. Stan West

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. West:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager



CERTIFIED MAIL

7010 1870 0000 8747 8246

7010 1870 0000 8747 8246

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CHARGE OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Mr. Stan West
Shackelford County
County Commissioner, Precinct 4
425 CR 151
Abilene, TX 79601

Sent To
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
Print your name and address on the reverse so that we can return the card to you.
Attach this card to the back of the mailpiece, or on the front if space permits.

Article Addressed to:

Mr. Stan West
Shackelford County
County Commissioner, Precinct 4
425 CR 151
Abilene, TX 79601

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

Article Number (Transfer from service label) 7010 1870 0000 8747 8246

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Haskell County
One Avenue D
Haskell, Texas 79521
Attn: Honorable David C. Davis

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Judge Davis:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

CERTIFIED MAIL

7010 1870 0000 8747 8253

7010 1870 0000 8747 8253

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CHANGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Honorable David C. Davis

Sent To: Haskell County

Street, Apt. No., or PO Box No.: One Avenue D

City, State, ZIP+4: Haskell, TX 79521

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Honorable David C. Davis
Haskell County
One Avenue D
Haskell, TX 79521

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

Article Number *(Transfer from service label)* 7010 1870 0000 8747 8253

S Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Haskell County
County Commissioner, Precinct 1
One Avenue D
Haskell, Texas 79521
Attn: Mr. John Scoggins

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Scoggins:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager



OF THE RETURN ADDRESS, FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8260

7010 1870 0000 8747 8260

U.S. Postal Service™

CERTIFIED MAIL™ RECEIPT

(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CEDAR RIDGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. John Scoggins
Haskell County
County Commissioner, Precinct 1

Street, Apt. No.; or PO Box No.: One Avenue D

City, State, ZIP+4: Haskell, TX 79521

PS Form 3800, August 2006 — See Reverse for Instructions

NDER: *COMPLETE THIS SECTION*

Complete items 1, 2, and 3. Also complete
tem 4 if Restricted Delivery is desired.
Print your name and address on the reverse
so that we can return the card to you.
Attach this card to the back of the mailpiece,
or on the front if space permits.

rticle Addressed to:

Mr. John Scoggins
Haskell County
County Commissioner, Precinct 1
One Avenue D
Haskell, TX 79521

COMPLETE THIS SECTION ON DELIVERY

A. Signature

X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

icle Number
ansfer from service label) 7010 1870 0000 8747 8260

rm 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Haskell County
County Commissioner, Precinct 2
One Avenue D
Haskell, Texas 79521
Attn: Mr. Tiffen Mayfield

Re: Notice of Application for the Cedar Ridge Reservoir

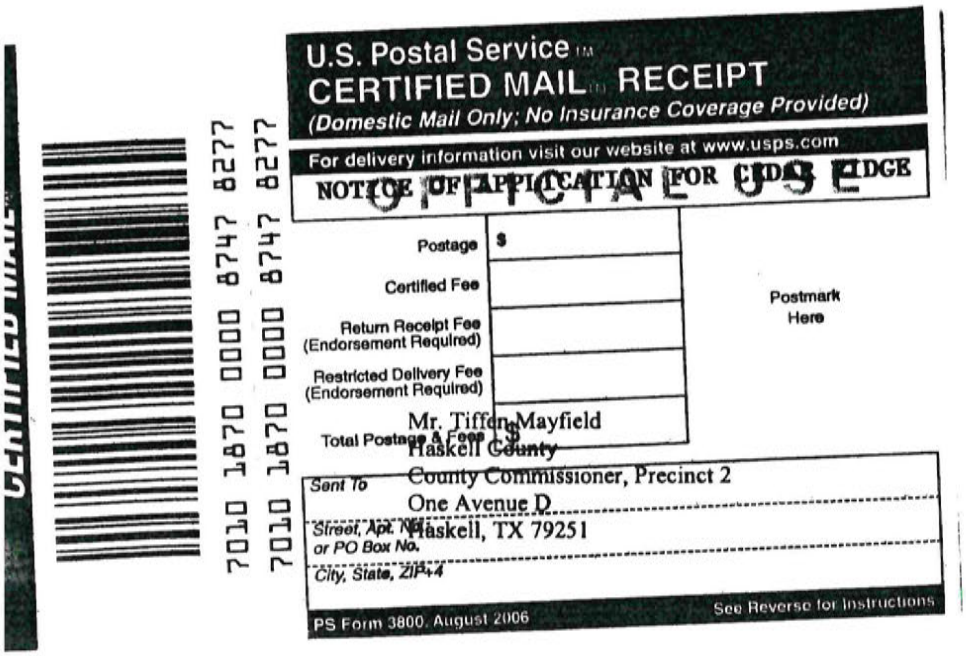
Dear Mr. Mayfield:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager



U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR JUDGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. Tiffen Mayfield
Haskell County
County Commissioner, Precinct 2
Street, Apt. No., or PO Box No.: One Avenue D
City, State, ZIP+4: Haskell, TX 79251

PS Form 3800, August 2006 — See Reverse for Instructions

7010 1870 0000 8747 8277

7010 1870 0000 8747 8277

SENDER: COMPLETE THIS SECTION

Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
Print your name and address on the reverse so that we can return the card to you.
Attach this card to the back of the mailpiece, or on the front if space permits.

Article Addressed to:

Mr. Tiffen Mayfield
Haskell County
County Commissioner, Precinct 2
One Avenue D
Haskell, TX 79251

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

Article Number (Transfer from service label) 7010 1870 0000 8747 8277

S Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Haskell County
County Commissioner, Precinct 3
One Avenue D
Haskell, Texas 79521
Attn: Mr. Kenny Thompson

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Thompson:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

CERTIFIED MAIL

7010 1870 0000 8747 8284

7010 1870 0000 8747 8284

U.S. Postal Service
CERTIFIED MAIL RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CEDAR RIDGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. Kenny Thompson
Haskell County
County Commissioner, Precinct 3

Street, Apt. No. or PO Box No.: One Avenue D

City, State, ZIP+4: Haskell, TX 79521

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Kenny Thompson
Haskell County
County Commissioner, Precinct 3
One Avenue D
Haskell, TX 79521

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☑ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1870 0000 8747 8284

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Haskell County
County Commissioner, Precinct 4
One Avenue D
Haskell, Texas 79521
Attn: Mr. Neal Kreger

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Kreger:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager



CERTIFIED MAIL™

7010 1870 0000 8747 8291

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com®
NOTICE OF APPLICATION FOR CEDAR RIDGE
OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. Neal Kreger
Haskell County
~~County Commissioner, Precinct 4~~
Street, Apt. No., or PO Box No.: One Avenue D
City, State, ZIP+4: Haskell, T 79521

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Neal Kreger
Haskell County
County Commissioner, Precinct 4
One Avenue D
Haskell, T 79521

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (*Printed Name*) C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
~~☑ Certified Mail~~ ☐ Express Mail
☐ Registered ☑ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (*Extra Fee*) ☐ Yes

2. Article Number (*Transfer from service label*) 7010 1870 0000 8747 8291

S Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Throckmorton County
P O Box 700
Throckmorton, Texas 76483
Attn: Honorable Trey Carrington

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Judge Carrington:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS, FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8307

7010 1870 0000 8747 8307

U.S. Postal Service™

CERTIFIED MAIL™ RECEIPT

(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CIDER EDGE

OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Honorable Trey Carrington

Sent To Throckmorton County

P.O. Box 700

Street, Apt. No. or PO Box No. Throckmorton, TX 76483

City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired. Print your name and address on the reverse so that we can return the card to you. Attach this card to the back of the mailpiece, or on the front if space permits.

Article Addressed to:

Honorable Trey Carrington
Throckmorton County
P.O. Box 700
Throckmorton, TX 76483

COMPLETE THIS SECTION ON DELIVERY

A. Signature

X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

Article Number
(Transfer from service label) 7010 1870 0000 8747 8307

Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Throckmorton County
County Commissioner, Precinct 1
P O Box 700
Throckmorton, Texas 76483
Attn: Mr. Casey Wells

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Wells:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS. FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8314

7010 1870 0000 8747 8314

U.S. Postal Service™

CERTIFIED MAIL™ RECEIPT

(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION - CEDAR RIDGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Mr. Casey Wells
Throckmorton County
County Commissioner, Precinct 1
P.O. Box 700
Throckmorton, TX 76483

Sent To

Street, Apt. No.; or PO Box No.

City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Casey Wells
Throckmorton County
County Commissioner, Precinct 1
P.O. Box 700
Throckmorton, TX 76483

COMPLETE THIS SECTION ON DELIVERY

A. Signature — X — ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* — C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7010 1870 0000 8747 8314

S Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Throckmorton County
County Commissioner, Precinct 2
P O Box 700
Throckmorton, Texas 76483
Attn: Mr. John Jones

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Jones:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS. FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8321

7010 1870 0000 8747 8321

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com®

NOTICE OF APPLICATION FOR CEDAR RIDGE USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. John Jones
Throckmorton County
County Commissioner, Precinct 2

Street, Apt. No., or PO Box No.: P.O. Box 700

City, State, ZIP+4: Throckmorton, TX 76483

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. John Jones
Throckmorton County
County Commissioner, Precinct 2
P.O. Box 700
Throckmorton, TX 76483

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1870 0000 8747 8321

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Throckmorton County
County Commissioner, Precinct 3
P O Box 700
Throckmorton, Texas 76483
Attn: Mr. Teddy Clark

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Clark:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager



CERTIFIED MAIL

7010 1870 0000 8747 8338

U.S. Postal Service
CERTIFIED MAIL RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CEDAR RIDGE OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees

Postmark Here

Sent To Mr. Teddy Clark
Throckmorton County
County Commissioner, Precinct 3
Street, Apt. No., or PO Box No. P.O. Box 700
City, State, ZIP+4 Throckmorton, TX 76483

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
Print your name and address on the reverse so that we can return the card to you.
Attach this card to the back of the mailpiece, or on the front if space permits.

Article Addressed to:

Mr. Teddy Clark
Throckmorton County
County Commissioner, Precinct 3
P.O. Box 700
Throckmorton, TX 76483

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

Article Number (Transfer from service label) 7010 1870 0000 8747 8338

Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

Throckmorton County
County Commissioner, Precinct 4
P O Box 700
Throckmorton, Texas 76483
Attn: Mr. Wilton Cantrell

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Cantrell:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS, FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8345

7010 1870 0000 8747 8345

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR CHANGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	Mr. Wilton Cantrell

Postmark Here

Sent To: Throckmorton County
Street, Apt. No.; or PO Box No.: County Commissioner, Precinct 4
City, State, ZIP+4: P.O. Box 700 Throckmorton, TX 76483

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Wilton Cantrell
Throckmorton County
County Commissioner, Precinct 4
P.O. Box 700
Throckmorton, TX 76483

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7010 1870 0000 8747 8345

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

City of Lueders
P O Box 277
Lueders, Texas 79533
Attn: Honorable Danny Dillard

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mayor Dillard:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry S. Gilley

Larry Gilley
City Manager



SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Honorable Danny Dillard
City of Lueders
P.O. Box 277
Lueders, TX 79533

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7010 1870 0000 8747 8352

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

City of Lueders
P O Box 277
Lueders, Texas 79533
Attn: Mr. John Neal, Council Member

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Neal:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS. FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8369

7010 1870 0000 8747 8369

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com®

NOTICE OF APPLICATION FOR CEDAR RIDGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. ~~John Neal, Council~~ Member
Street, Apt. No.; or PO Box No.: City of Lueders
City, State, ZIP+4: P.O. Box 277
Lueders, TX 79533

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. John Neal, Council Member
City of Lueders
P.O. Box 277
Lueders, TX 79533

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
~~☑ Certified Mail~~ ☐ Express Mail
☐ Registered ~~☑ Return Receipt for Merchandise~~
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7010 1870 0000 8747 8369

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

City of Lueders
P O Box 277
Lueders, Texas 79533
Attn: Mr. Pete Lopez, Council Member

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Lopez:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS, FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8376

7010 1870 0000 8747 8376

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com®

NOTICE OF APPLICATION FOR CHANGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. Pete Lopez, Council Member
Street, Apt. No.; or PO Box No.: City of Lueders P.O. Box 277
City, State, ZIP+4: Lueders, TX 79533

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Pete Lopez, Council Member
City of Lueders
P.O. Box 277
Lueders, TX 79533

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

Article Number *(Transfer from service label)* 7010 1870 0000 8747 8376

S Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

City of Lueders
P O Box 277
Lueders, Texas 79533
Attn: Ms. Karla Hicks, Council Member

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Ms. Hicks:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry L. Gilley

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS, FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8383

7010 1870 0000 8747 8383

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com

NOTICE OF APPLICATION FOR GAS EDGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Ms. Karla Hicks, Council Member
City of Lueders
Street, Apt. No.; or PO Box No.: P.O. Box 277
City, State, ZIP+4: Lueders, TX 79533

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
Print your name and address on the reverse so that we can return the card to you.
Attach this card to the back of the mailpiece, or on the front if space permits.

Article Addressed to:

Ms. Karla Hicks, Council Member
City of Lueders
P.O. Box 277
Lueders, TX 79533

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

Article Number (Transfer from service label) 7010 1870 0000 8747 8383

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

City of Lueders
P O Box 277
Lueders, Texas 79533
Attn: Ms. Lyndia Wills, Council Member

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Ms. Wills:

This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager

PLACE STICKER AT TOP OF ENVELOPE TO THE RIGHT OF THE RETURN ADDRESS, FOLD AT DOTTED LINE

CERTIFIED MAIL™

7010 1870 0000 8747 8390

7010 1870 0000 8747 8390

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com.

NOTICE OF APPLICATION FOR CEDAR RIDGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Ms. Lyndia Wills, Council Member
Street, Apt. No.; or PO Box No.: City of Lueders P.O. Box 277
City, State, ZIP+4: Lueders, TX 79533

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Ms. Lyndia Wills, Council Member
City of Lueders
P.O. Box 277
Lueders, TX 79533

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by *(Printed Name)* | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7010 1870 0000 8747 8390

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

CITY OF ABILENE

WATER DEPARTMENT

August 15, 2011

VIA CERTIFIED MAIL, RETURN RECEIPT REQUESTED

City of Lueders
P O Box 277
Lueders, Texas 79533
Attn: Mr. Steve Sweet, Council Member

Re: Notice of Application for the Cedar Ridge Reservoir

Dear Mr. Sweet:

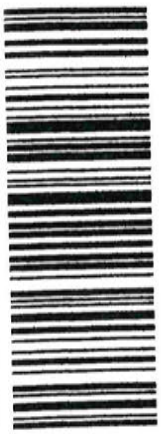
This letter is submitted pursuant to the requirements of Texas Water Code § 11.124(f) and 30 Texas Administrative Code § 295.42 to notify you that the City of Abilene is filing an application for a permit to appropriate state water (the "Application") with the Texas Commission on Environmental Quality ("TCEQ"). The Application seeks authorization from TCEQ to construct the Cedar Ridge Reservoir on the Clear Fork Brazos River in Throckmorton, Haskell, Shackelford and Jones Counties. At your request, the City will be pleased to provide you with a copy of the Application filed with TCEQ.

Should you have any questions about the Application or the project in general, please feel free to call at your convenience.

Sincerely,

Larry Gilley
City Manager





7010 1870 0000 8747 8406

7010 1870 0000 8747 8406

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com®

NOTICE OF APPLICATION FOR CEDAR RIDGE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Mr. Steve Sweet, Council Member
City of Lueders
Street, Apt. No. or PO Box No.: P.O. Box 277
City, State, ZIP+4: Lueders, TX 79533

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

Article Addressed to:

Mr. Steve Sweet, Council Member
City of Lueders
P.O. Box 277
Lueders, TX 79533

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

Article Number (Transfer from service label): 7010 1870 0000 8747 8406

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

ATTACHMENT C

DOCUMENTATION OF WATER CONSERVATION PLAN

CITY OF ABILENE

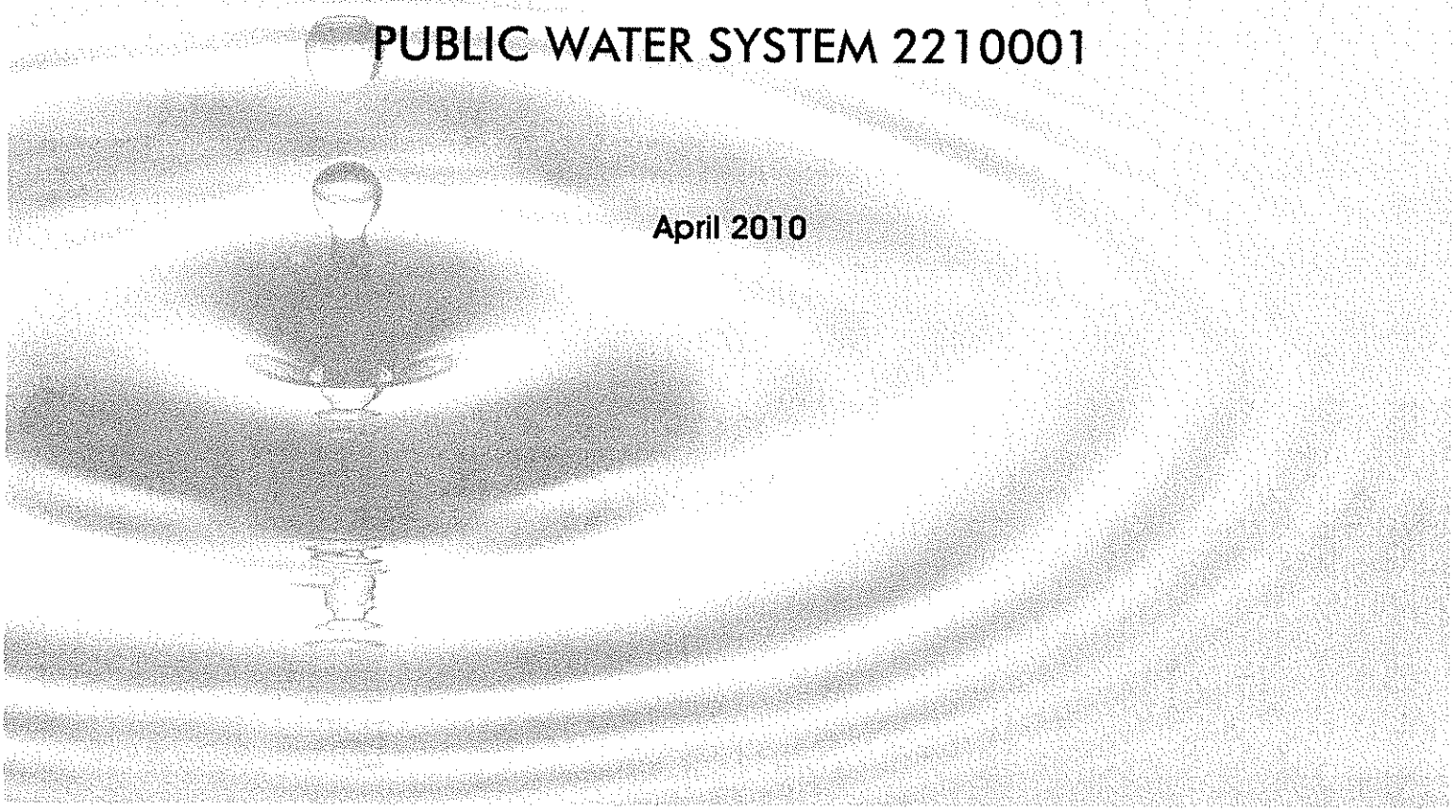
Water Conservation Plan

and

Drought Contingency Plan

("Water Conservation Plan Ordinance")

PUBLIC WATER SYSTEM 2210001



April 2010

ATTACHMENT C

DOCUMENTATION OF WATER CONSERVATION PLAN

DRAFT

WATER CONSERVATION PLAN

TABLE OF CONTENTS

Section I	Declaration of Policy, Purpose and Intent	1
Section II	Utility Profile Summary	1
Section III	Water Conservation Goals	6
Section IV	Metering Devices	7
Section V	Universal Metering	7
Section VI	Measures to Determine and Control Unaccounted-For Uses of Water	8
Section VII	Water Conservation Program	8
Section VIII	Public Involvement	9
Section IX	Water Rate Structure	10
Section X	Means of Implementation and Enforcement	10
Section XI	Additional Wholesale Water Contract Requirements	11
Section XII	Coordination With Brazos G Regional Water Planning Group	11
Section XIII	Revisions to the Water Conservation Plan	11
Section XIV	Severability	11

APPENDICES

Appendix A Service Area Maps

Appendix B Utility Profile & Water Conservation Plan Requirements for Municipal Water Use by Public Water Suppliers

Appendix C Profile & Water Conservation Plan Requirements for Wholesale Public Water Suppliers

Appendix D System Inventory and Water Conservation Plan for Agricultural Water Suppliers Providing Water to More Than One User

Appendix E Industrial/Mining Water Conservation Plan

Appendix F City of Abilene Reservoir Operation Plan

Appendix G Resolution Adopting the Water Conservation Plan (April 2010 Updates)

Appendix H Notification to Wholesale Purchasers (April 2010 Updates)

Appendix I City of Abilene Water Rate Structure

CITY OF ABILENE, TEXAS
WATER CONSERVATION PLAN

Section I. Declaration of Policy, Purpose and Intent

The purpose of the Water Conservation Plan (Plan) is to: promote the wise and responsible use of water by implementing structural programs that result in quantifiable water conservation results; develop, maintain, and enforce water conservation policies and ordinances; and support public education programs that educate customers about water and wastewater facilities operations, water quantity and quality, water conservation and non-point source protection.

Section II. Utility Profile Summary

The City of Abilene supplies treated potable water to municipal, industrial and wholesale users, limited amounts of raw water to some industrial and agricultural users, and treated wastewater for reuse to agricultural users and to irrigation users as reclaimed water. The City of Abilene holds Certificate of Convenience and Necessity (CCN) Number 11823. Abilene's municipal, industrial and agricultural use customers are located within Abilene's CCN area encompassing approximately 108 square miles and is depicted in the service area map in Appendix A.

Abilene's wholesale service area encompasses approximately 874 square miles situated outside of Abilene's CCN. Maps of the wholesale service area have been included in Appendix A. Since the City delivers water for municipal, wholesale, agricultural, and industrial users, detailed profiles for each user category have been provided in Appendix B, C, D and E respectively. The utility profiles are summarized as follows.

A. Population

Abilene's population in the year 2010 as determined by information supplied by the Brazos G Regional Water Planning Group is estimated to be 124,607 and is projected to reach 130,220 by 2020. Abilene supplies treated water to wholesale purchasers who in turn resell that water to their system users. Total population of wholesale users in the year 2010 is estimated to be 36,755, and is projected to reach 37,495 persons by the year 2020. Table 1 provides population figures for City of Abilene and Abilene's wholesale users for the previous five years.

Table 1: Population for City of Abilene and Wholesalers For Preceding Five Years

Year	Abilene Population	Wholesale Population
2004	119,398	35,938
2005	120,267	36,077
2006	121,135	36,216
2007	122,003	36,356
2008	122,871	36,497

Source: Brazos G Regional Water Planning Group

Table 2 depicts projected population figures for Abilene and Abilene's wholesale users through the year 2050.

Table 2: Projected Population for City of Abilene and Wholesalers		
Year	**Abilene Population**	**Wholesale Population**
2010	124,607	36,755
2020	130,220	37,495
2030	132,820	37,669
2040	133,514	37,569
2050	130,943	37,060
Source: Initially Prepared 2011 Brazos G Regional Water Plan		

B. Customer Data and Water Use Data

On average, the City of Abilene diverts approximately 23,600 acre-feet per year of raw water from its surface water sources to satisfy the demands of raw and treated water users. The City produces an average of 22,500 acre feet per year of treated surface water from its three surface water treatment plants. The raw water diverted by the City goes to some raw water industrial and irrigation users and in production of potable water at the City's treatment plants.

Abilene's water customers consist of a mixture of residential, commercial, industrial, wholesale, institutional and irrigation users. City of Abilene residential customers are supplied through approximately 34,200 connections with approximately 200 residential connections added each year. Abilene serves approximately 3,830 commercial connections with a net average gain of approximately 15 new commercial connections each year. Abilene serves approximately 21 industrial users with an average of three new industrial connections added each year. Wholesale customers are those entities that purchase treated potable water from Abilene for resale, and are summarized in Table 3.

Approximately 24 reclaimed water customers citywide and an additional 10 agricultural irrigators around the Hamby Water Reclamation Plant utilize treated wastewater for agricultural and irrigation use.

Abilene customers including residential, commercial, industrial, and institutional users use approximately 86% of the total water delivered from the City's potable water treatment works while wholesale customers use approximately14% of the total water delivered from the City's treatment works. Table 4 summarizes the expected water use figures for Abilene municipal and wholesale users over the next decade.

Table 3: City of Abilene Wholesale Purchasers	
Wholesale Customer	**Contracted Amount (ac-ft/yr)**
City of Baird	77
City of Merkel	353
City of Tye	184
City Clyde	307
City of Lawn	77
Blair WSC	77
Hamby WSC	308
Hawley WSC	307
S.U.N. WSC	230
Eula WSC	61
Potosi WSC	307
Steamboat Mountain WSC	307
View-Caps WSC	199
Dyess AFB	491
Total	**3,285**

Source: City of Abilene Records

Table 4: Projected Water Demand for the Coming Decade					
Year	**Abilene Population**	**Wholesale Population**	**Abilene Demand (ac-ft/yr)**	**Wholesale Demand (ac-ft/yr)**	**Total Demand (ac-ft/yr)**
2010	124,607	36,755	22,891	3,427	26,318
2011	125,168	36,829	22,950	3,427	26,377
2012	125,730	36,903	23,010	3,427	26,437
2013	126,291	36,977	23,069	3,427	26,496
2014	126,852	37,052	23,129	3,427	26,556
2015	127,414	37,126	23,188	3,427	26,615
2016	127,975	37,201	23,247	3,427	26,674
2017	128,536	37,276	23,307	3,427	26,734
2018	129,097	37,351	23,366	3,427	26,793
2019	129,659	37,426	23,426	3,427	26,853

Source: Initially Prepared 2011 Brazos G Regional Water Plan

C. Water Supply System

1. Water Sources

Abilene's water sources are presented in Table 5. Information provided is for 2010 as presented in the Initially Prepared 2011 Brazos G Regional Water Plan.

Table 5: Water Sources

Source	Amount (ac-ft/yr)
Lake Fort Phantom Hill	9,316
Hubbard Creek Reservoir [1]	20,086
Lake O.H. Ivie [2]	6,720

[1] Delivered under contract from the West Central Texas MWD.

[2] Delivered under contract from the Colorado River MWD. Amount limited to current treatment capacity of 6 MGD.

Raw surface water is supplied to Abilene's treatment works from several sources. The City of Abilene owns and holds surface water rights to 30,690 acre feet per year (ac-ft/yr) from Lake Fort Phantom Hill, of which 25,690 ac-ft/yr are for municipal purposes, 4,000 ac-ft/yr are for industrial purposes, and 1,000 ac-ft/yr are for irrigation. The Clear Fork Diversion, owned and operated by Abilene, allows a maximum of 30,000 ac-ft/yr to be diverted from the Clear Fork of the Brazos to Lake Fort Phantom Hill.

The City owns and is allocated use of 1,675 ac-ft/yr of water for municipal purposes from Lake Abilene. Lake Abilene, however, is not considered a dependable supply by the City and is currently not used. The City also holds surface water rights to 3,880 ac-ft/yr from Lake Kirby, also owned by Abilene, for multiple use purposes and for storage/diversion of reclaimed water used for irrigation purposes. Hubbard Creek Reservoir, owned and operated by the West Central Texas Municipal Water District provides by contract up to 25,500 ac-ft/yr (125% of Abilene's portion of the allocated safe yield of Hubbard Creek Reservoir, depending on the lake level) of raw surface water for use by the City. Abilene may utilize by contract up to 16.54% of the safe yield of Lake O.H. Ivie.

2. Water Treatment

A pump station located on the eastern bank of Lake Ft. Phantom Hill pumps raw surface water from Lake Ft. Phantom Hill to the Northeast Treatment Plant and the Grimes Treatment Plant. A raw water delivery system consisting of two parallel pipelines can provide up to 27 million gallons per day (MGD) from Hubbard Creek Reservoir to the Ft. Phantom Hill delivery system. Raw water is pumped approximately 50 miles from Lake

O.H. Ivie to the Hargesheimer Water Treatment Plant located on Highway 83/84 near Tuscola. A pump station on the banks of the Clear Fork of the Brazos River, near Lake Ft. Phantom Hill provides diversion pumping of up to 30,000 ac-ft/yr into Lake Ft. Phantom Hill under selected volume and quality conditions.

The City's Water Treatment System consists of three treatment plants having a maximum treatment capacity of 51 MGD and combined treated water storage of 20.76 million gallons (MG). The Northeast Water Treatment Plant on East Lake Road has a capacity of 25 MGD and treats raw water drawn from Lake Ft. Phantom Hill and Hubbard Creek Reservoir. The Grimes Water Treatment Plant on East Highway 80 has a treatment capacity of 20 MGD and treats water drawn from Lake Ft. Phantom Hill and Hubbard Creek Reservoir. The Hargesheimer Water Treatment Plant located on Highway 83/84 near Tuscola has a micro-filtration capacity of 8.95 MGD, and a reverse osmosis/ blended capacity of 6.0 MGD, and treats raw water drawn from Lake O.H. Ivie.

3. Water Distribution

The City of Abilene's water distribution system provides economical and compatible facilities that are capable of furnishing sufficient water at suitable pressures to both Abilene retail and wholesale purchasers. The system consists of nearly 750 miles of underground water mains, twelve pumping stations, seven ground storage tanks, eight elevated storage tanks, over 12,000 valves, over 2,700 fire hydrants, and over 38,400 meters.

After the water is processed at the treatment plants, it is pumped into the distribution system and stored in ground and elevated storage tanks with a combined volume of 19.25 million gallons. The distribution network is laid out in a continuous looped system to circulate water and maintain constant system pressure. Pumping stations are located strategically throughout the system to pump water, maintain uniform pressure and maintain storage tank levels.

Treated water from the Abilene treatment plants enters the wholesalers' systems through metered interconnections. According to TCEQ's records as available through the Texas Water Utility Database (TWUD), production capacity of the wholesale purchasers' systems amount to approximately 17.5 MGD. Based on TWUD records, ground storage capacity within the wholesalers' systems is approximately 5.5 million gallons while total elevated storage volume is approximately 3.3 million gallons.

D. Wastewater System

1. Wastewater Collection

Abilene's wastewater collection system consists of a network of approximately 653 miles of sewers, five lift stations, and approximately 5,100 manholes serving the cities of Abilene, Tuscola, Tye and the Hawley ISD. Sewage flows by gravity, aided when necessary by lift stations, through the collection system into the Buck Creek Pump Station, which has a rated pumping capacity of approximately 24 MGD. An emergency storage basin at this facility has a capacity of approximately 23 million gallons. Sewage is metered at Buck Creek and then pumped five miles to the wastewater treatment plant. Collected wastewater is treated at the City of Abilene's Hamby Wastewater Reclamation Plant which is operated under permit number 10334-004. The operator in responsible charge of the Hamby Plant is employed by the City of Abilene.

2. Wastewater Treatment

When wastewater reaches the Hamby treatment facilities northeast of town, it undergoes full biological treatment that includes grit removal, sedimentation, activated sludge process, filtration, chlorine disinfection, and disinfectant removal. Wastewater quality is protected against industrial pollution through an Industrial Pre-Treatment Program. Industrial users are required to treat wastewater to specific standards before it is released into the municipal sanitary sewer system. Irrigators in and around the City reuse some of the treated effluent. The remainder is discharged to Deadman Creek by way of Freewater Creek or is discharged to Lake Kirby by way of the City's reclaimed water system. Sewage biosolids are disposed of in a sludge disposal unit.

Section III. Water Conservation Goals

A. Municipal Use Goals

Water users (all City of Abilene water users such as residential, commercial, and industrial) located within the City of Abilene's Certificate of Convenience and Necessity (CCN) coverage area historically use (when not under water use restrictions) approximately 149 gallons of water per capita per day (gpcd). The 5-year goal for water use reduction by City of Abilene users is to maintain per capita water use at or below 162 gpcd by the end of 2015. The 10-year goal is to maintain per capita use at or below 161 gpcd by the end of 2020. These goals are set in accordance with Brazos G Regional Water Planning Group projections.

B. Wholesale Use Goals

Wholesale water users served by the City of Abilene, located outside the City of Abilene's CCN coverage area, historically use (when not under water use restrictions) approximately 83 gpcd of water supplied by Abilene. The 5 and 10-year goals for wholesale users supplied by the City of Abilene is to reduce per capita use by 1 gallon per day per user to 82 gpcd by the end of 2015 and 2020. These goals are set in accordance with Brazos G Regional Water Planning Group projections.

C. Industrial Use Goals

The 5- and 10-year target for industrial water savings is to maintain source water diversion for wash-down, dust control and sanitary/domestic uses by current industrial users at not more than 350 acre-feet per year through the end of 2015 and 2020. The 5 and 10-year goals represent an annual water savings of approximately 12-20 acre-feet per year over present industrial water use rates, and were developed considering Abilene's current industrial user base and projected industrial water use for the coming decade.

D. Agricultural Use Goals

The 5-year and 10-year target for water savings is to maintain the irrigation requirement at or below the area agronomic standard of 24-inches per acre per year. It should be noted that occasionally the City may allow the agronomic standard rate to be exceeded in order to flush the crop root zone to improve plant productivity, livelihood, growth enhancement and overall reduction in crop water demand.

Section IV. Metering Devices

It is Abilene's policy to purchase meters that meet at least the minimum standards developed by the American Water Works Association. All metering devices used to meter water diverted from the source of supply are accurate to within plus or minus 5% to measure and account for water diverted from the source of supply. All service connections in the distribution system are metered. Aged meters are systematically replaced to assure reliability of meter performance. The City has established the following meter maintenance and replacement programs:

Meter Type	Calibration Period and Replacement
Master Meters	Annually and replaced as needed
1-1/2 inch and larger	Annually and replaced as needed
1-1/2 inch and smaller	Every 10 years and replaced as needed

The wholesale water purchasers are responsible for metering device installation, maintenance and calibration for meters located within their service areas.

Section V. Universal Metering

It is Abilene's policy to individually meter all water usage, except for fire protection and fire hydrant flushing to maintain a safe potable water distribution system, including all new construction within the City's CCN coverage area. Combined with an aggressive leak detection and repair program, electronic data collection devices, and a computerized billing system, Abilene's universal metering program has resulted in a water delivery accuracy rate well within industry operating standards.

Section VI. Measures to Determine and Control Unaccounted-For Uses of Water

The record management system utilized by the City of Abilene segregates water sales and users into user classes of residential, commercial, public/institutional, and industrial. It is Abilene's policy to investigate customer complaints of low pressure and possible leaks. Abilene visually inspects suspected leaks and makes quick and timely repairs to those leaks when detected. Abilene utilizes a record management system which records water pumped, water delivered, water sales and water losses to track water transmission, distribution, and delivery to customers. This information is used to evaluate the integrity of the water delivery system from source to end user to control and minimize unaccounted-for uses of water.

Section VII. Water Conservation Program

The City of Abilene's Water Conservation Program utilizes Supply Management Methods and Demand Management Methods to work towards optimizing use of Abilene's water resources.

A. Supply Management Program Elements consist of:

1. Coordinated use of water supplies to ensure the City withdraws water from its water supply reservoirs in a manner that ensures maximum dependable yield and efficiency of operation.
2. Watershed management to ensure diversion channels to Lake Ft. Phantom Hill are clean, relatively straight, and obstruction-free to increase captured water flow while minimizing flooding potential in populated areas, and reducing siltation entering Lake Ft. Phantom Hill.
3. Metering all service connections to ensure maximum return for delivered water while minimizing unaccounted-for water loss.
4. Leak detection and repair to minimize unaccounted-for water loss.
5. Treated wastewater reuse and recycling to lessen the demand for raw water used to produce potable water, and for raw water pumping for irrigation uses.

B. Demand Management Program Elements consist of:

1. Water pricing as a mechanism for encouraging water customers to conserve.
2. Regulations for conserving water via the Water Conservation Plan and Drought Contingency Plan adopted by the City.
3. Plumbing Code for the City of Abilene requires maximum standard plumbing fixture capacities not be exceeded. Abilene supports a Low-Income Housing Retrofit Program and City Building Retrofit program to determine the feasibility of retrofitting fixtures in selected structures.
4. Continuing education programs to increase public awareness of supply, treatment and conveyance systems in Abilene, to increase public awareness of the benefits and need for conservation, and to make information about practical cost-effective methods and technologies to achieve conservation readily available.

Section VIII. Public Involvement

Public involvement in the formation of Abilene's Water Conservation Plan formally began in February 1985 with the appointment of a Water Conservation Advisory Committee to assist the Water Utilities staff in the preparation of the Water Conservation Plan. Since that time public involvement has been an ongoing and integral part of Abilene's water conservation programs. A public information and education program developed and implemented by the City is an important component in the City's water conservation strategy. Water Utilities education programs have three principal objectives including:

- Increase public awareness of supply, treatment, and conveyance systems in Abilene.
- Increase public awareness of the needs for and benefits of conservation.
- Make available information about practical cost effective methods and technologies to achieve conservation.

A variety of communication and marketing techniques are being utilized including: printed marketing materials; electronic information and marketing materials via Abilene's internet website; billboard advertising; newspaper supplements; presentations at neighborhood, civic, social, and professional organizations; public service announcements; special promotions sponsored by local media; and public school programs.

A. Schools

Water and conservation curriculum has been introduced into area public schools. City of Abilene staff have conducted workshops to train area educators in teaching methods and provide materials relating to water issues. Presentations are made directly to classes of all ages, including university level. Presentations are supported by a variety of printed materials. Tours of the water treatment plants are often used by area teachers as an education tool.

B. Landscaping

Implementation of the Xeriscape Program began in 1986 with the creation of a Xeriscape Advisory Committee composed of representatives of the landscape industry, business and residential communities. The committee assisted in the development of an informational brochure and plant list.

An aggressive ongoing public information campaign called "Project Xeriscape" which began in 1989, has included public service announcements, workshops, displays, landscape competition, a coloring contest for children, and distribution of materials. The campaign received state-wide recognition at the State Conference of the Texas Section American Water Works Association in 1990. The City's website offers extensive and useful information regarding xeriscaping and water conservation landscaping measures.

C. Commercial/Industrial Conservation

The Water Utilities Department works with area businesses to keep water bills as low as possible by conserving water use. Seasonal written contracts, industrial inspections, and individual responses to

public inquiries about water and waste help to focus conservation efforts towards the commercial sector needs.

D. Agricultural Conservation

In order to lessen the demand on the City's raw water sources the City relies on reuse of treated wastewater for supply to irrigators located within the City's service area. It is the City's policy to assist irrigators where feasible and practical to utilize reclaimed wastewater as their irrigation supply water. The City strives to work closely with local irrigation water users to ensure effective use of the City's water resources through improved irrigation systems, promoting healthy vegetation, and improved farming practices.

E. Local Media

The Water Utilities Department has prepared several public service announcements which are periodically aired on local television stations addressing the education program objectives. The Water Utilities Department routinely presents information on local public broadcasting systems addressing the objectives described above.

Section IX. Water Rate Structure

In 1984, the City of Abilene adopted a non-promotional, inverted rate structure. Under this rate structure the billing rate increases as individual water consumption increases. This rate structure promotes conservation and shifts the cost of supplying water to those consumers using it most. A copy of the City's current water rates is provided in Appendix I.

Section X. Means of Implementation and Enforcement

This Water Conservation Plan has been adopted by the City. A copy of the resolution adopting this Plan is included in Appendix G.

A. Enforcement Within Abilene's CCN Area

The Plan is enforced within the Abilene CCN coverage area by providing service taps only to customers complying with adopted ordinances, maintaining a non-declining rate structure, discontinuing service to those customers who do not pay their water bills until payment is made, and certifying new construction only after verifying it conforms to adopted ordinances and plumbing codes.

B. Enforcement for Abilene's Wholesale Purchasers

Wholesale customers will receive written notification of Plan adoption and any subsequent Amendments. Adoption of this Plan by the City of Abilene per 30 Texas Administrative Code (TAC) Rule §288.5 obligates wholesale customers as defined in 30 TAC Rule §288.1 to implement water conservation measures. A copy of the notification letter to wholesale users has been included in Appendix H.

Section XI. Additional Wholesale Water Contract Requirements

It is Abilene's policy to include in every wholesale water supply contract entered into or renewed after official adoption of the Plan, including any contract extension, that each successive wholesale customer develop and implement a water conservation plan or water conservation measures using applicable elements in 30 TAC 288. If the wholesale customer intends to resell the water, then the contract between Abilene and the wholesale customer must provide that the contract for the resale of the water must have water conservation requirements so that each successive customer in the resale of the water will be required to implement water conservation measures in accordance with 30 TAC 288.

Section XII. Coordination with Brazos G Regional Water Planning Group

All of the customers served by the City of Abilene are located within the Brazos G Regional Water Planning Area. Abilene has provided a copy of this Plan to the Brazos G Regional Water Planning Group.

Section XIII. Revisions to the Water Conservation Plan

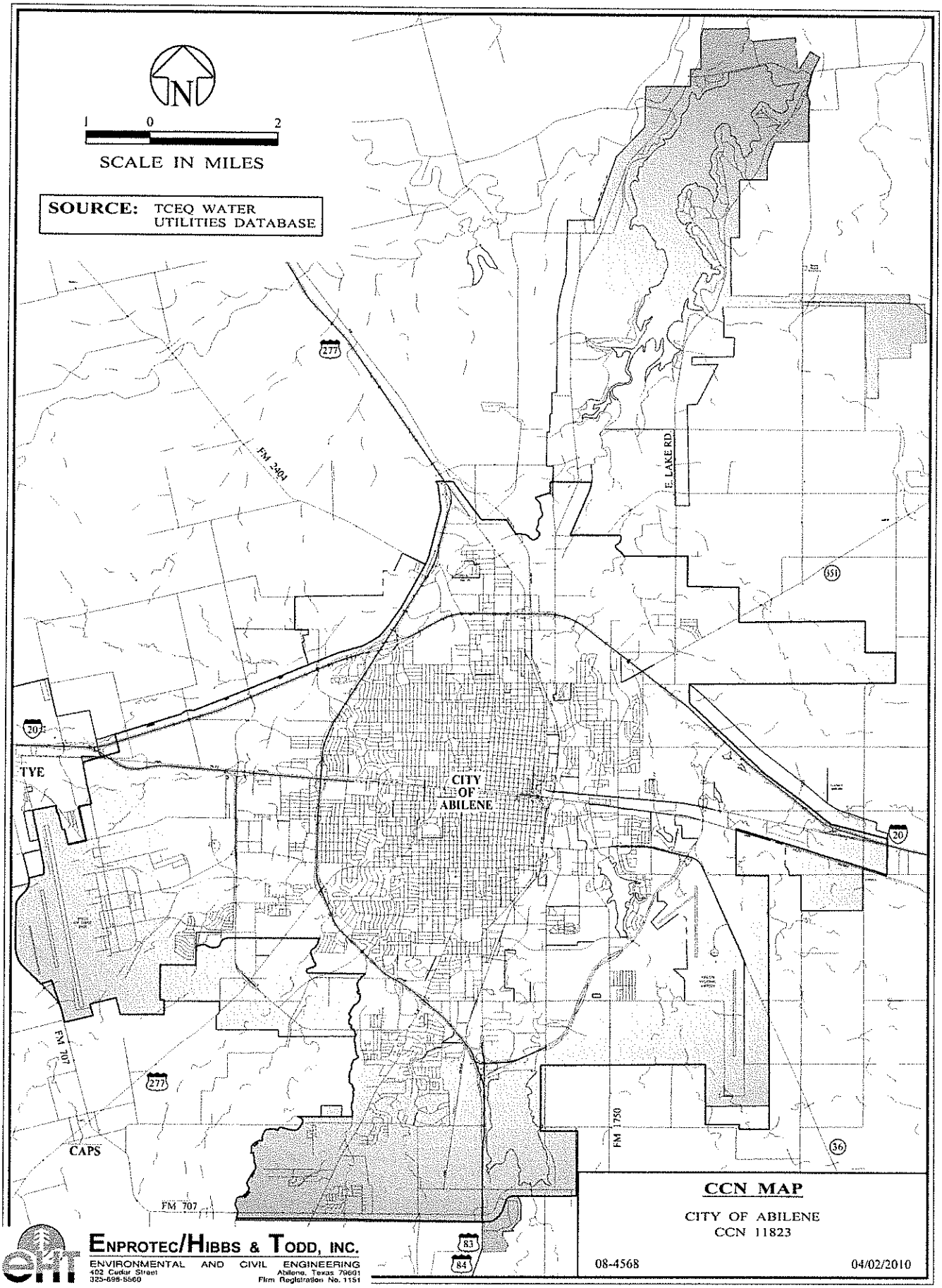
The City of Abilene will review and update this water conservation plan, as appropriate, based on new or updated information, such as the adoption or revision of the regional water plan. As a minimum the Plan will be updated every five (5) years.

Section XIV. Severability

It is hereby to be the intention of Abilene that the sections, paragraphs, sentences, clauses, and phrases of this Plan are severable and if, any phrase, clause, sentence, paragraph or section shall be declared unconstitutional by the valid judgment or decree of any court of competent jurisdiction, such unconstitutionality shall not affect any of the remaining phrases, clauses, sentences, paragraphs or sections of this Plan, since the same would not have been enacted by Abilene without the incorporation into this Plan of any such unconstitutional phrase, clause, sentence, paragraph or section.

Appendix A

Service Area Maps

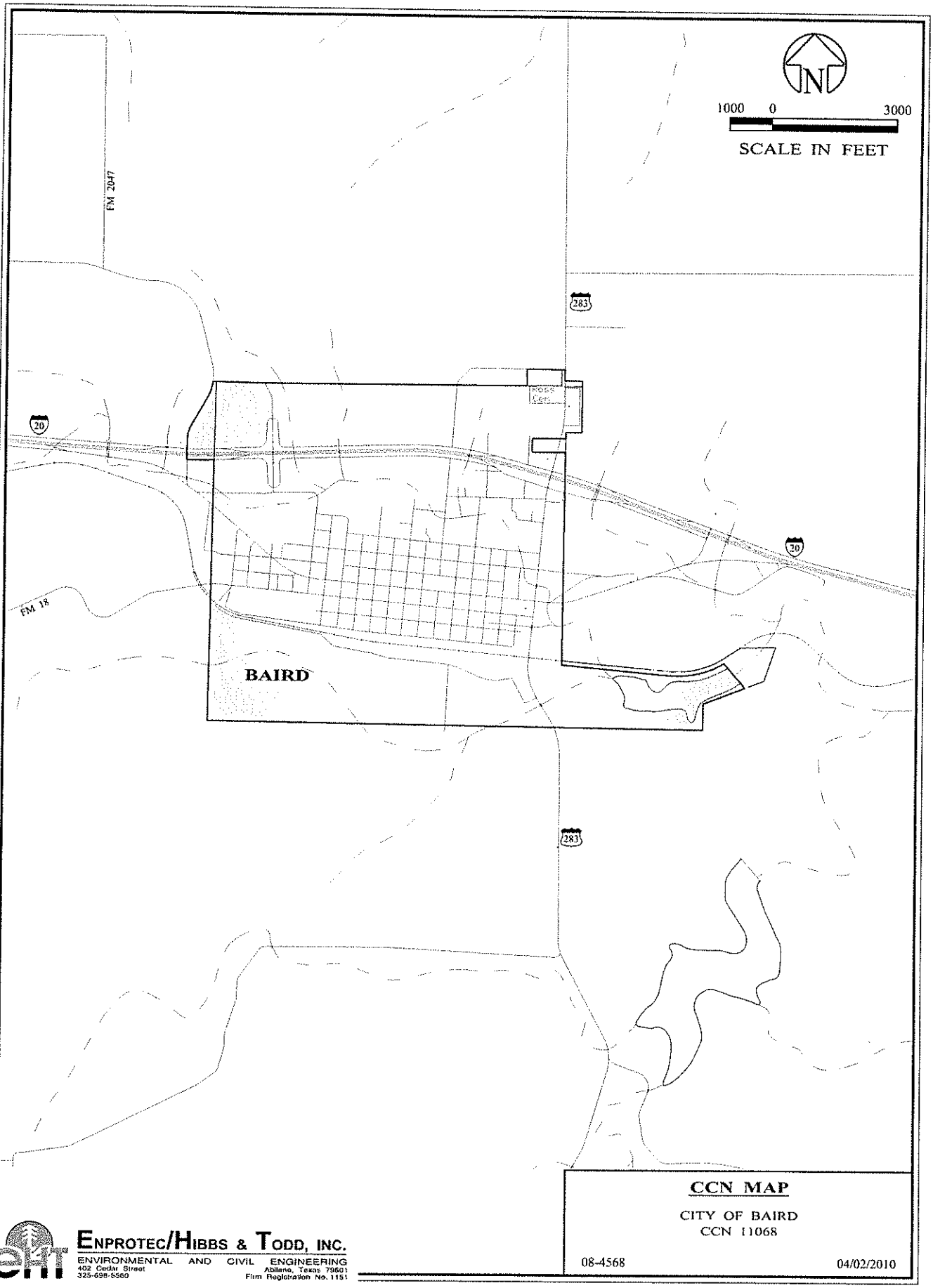


CCN MAP

CITY OF ABILENE
CCN 11823

08-4568 04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
325-698-5560
Abilene, Texas 79601
Firm Registration No. 1151

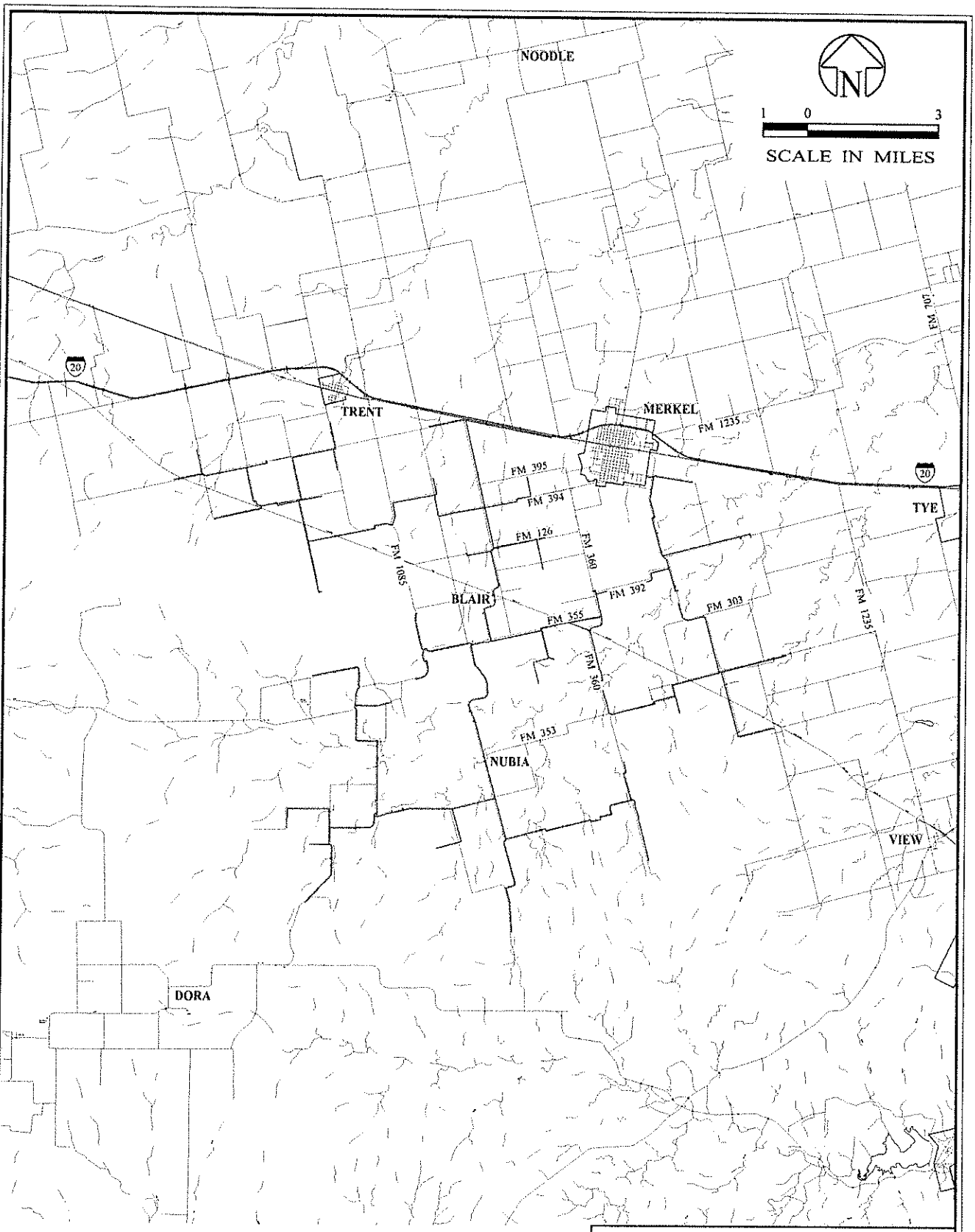


CCN MAP

CITY OF BAIRD
CCN 11068

08-4568 04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
325-698-5560
Abilene, Texas 79601
Firm Registration No. 1151



LEGEND

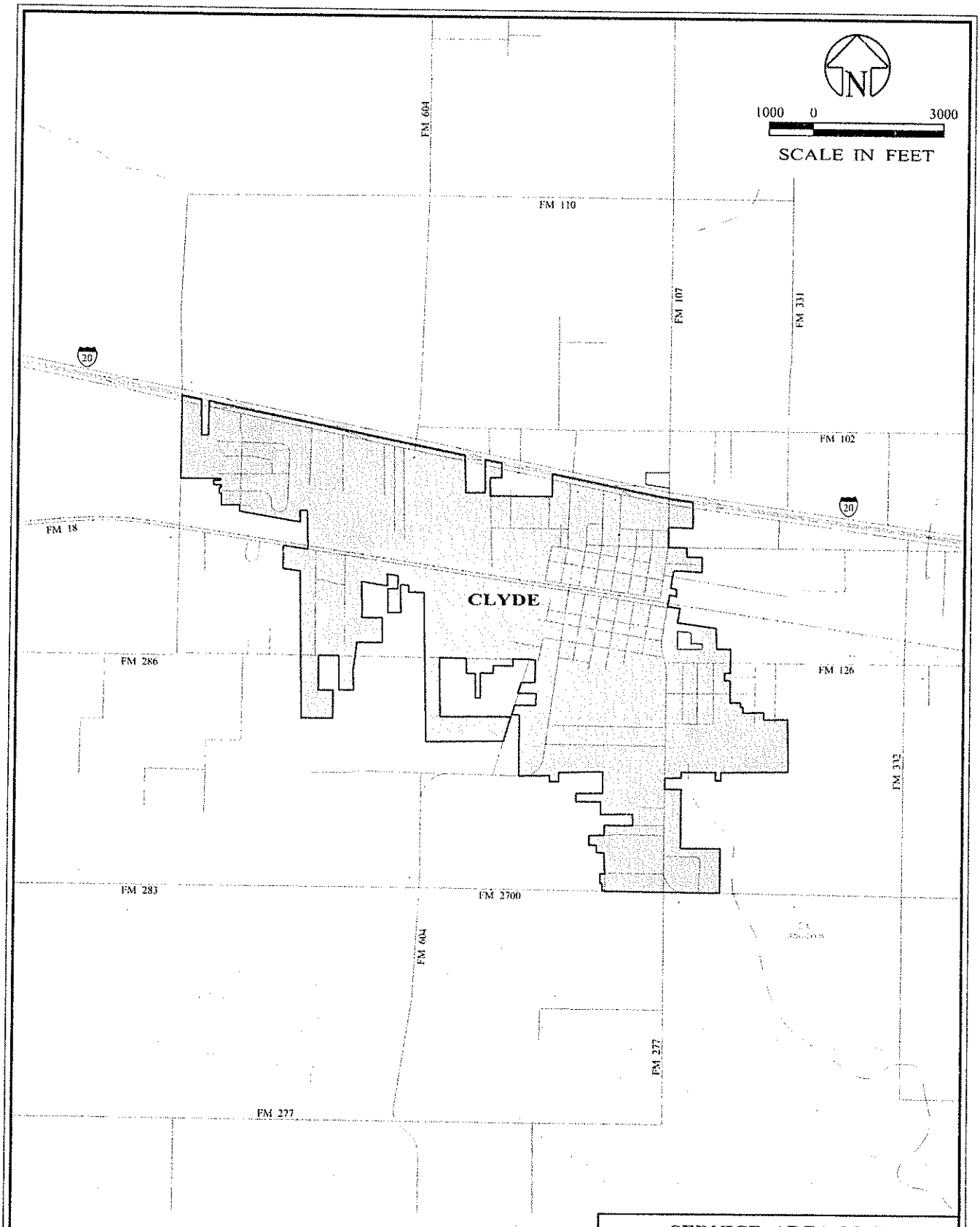
——— FACILITIES CCN

CCN MAP

BLAIR
WATER SUPPLY CORPORATION
CCN 11532

08-4568 04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street Abilene, Texas 79601
325-698-5560 Firm Registration No. 1151



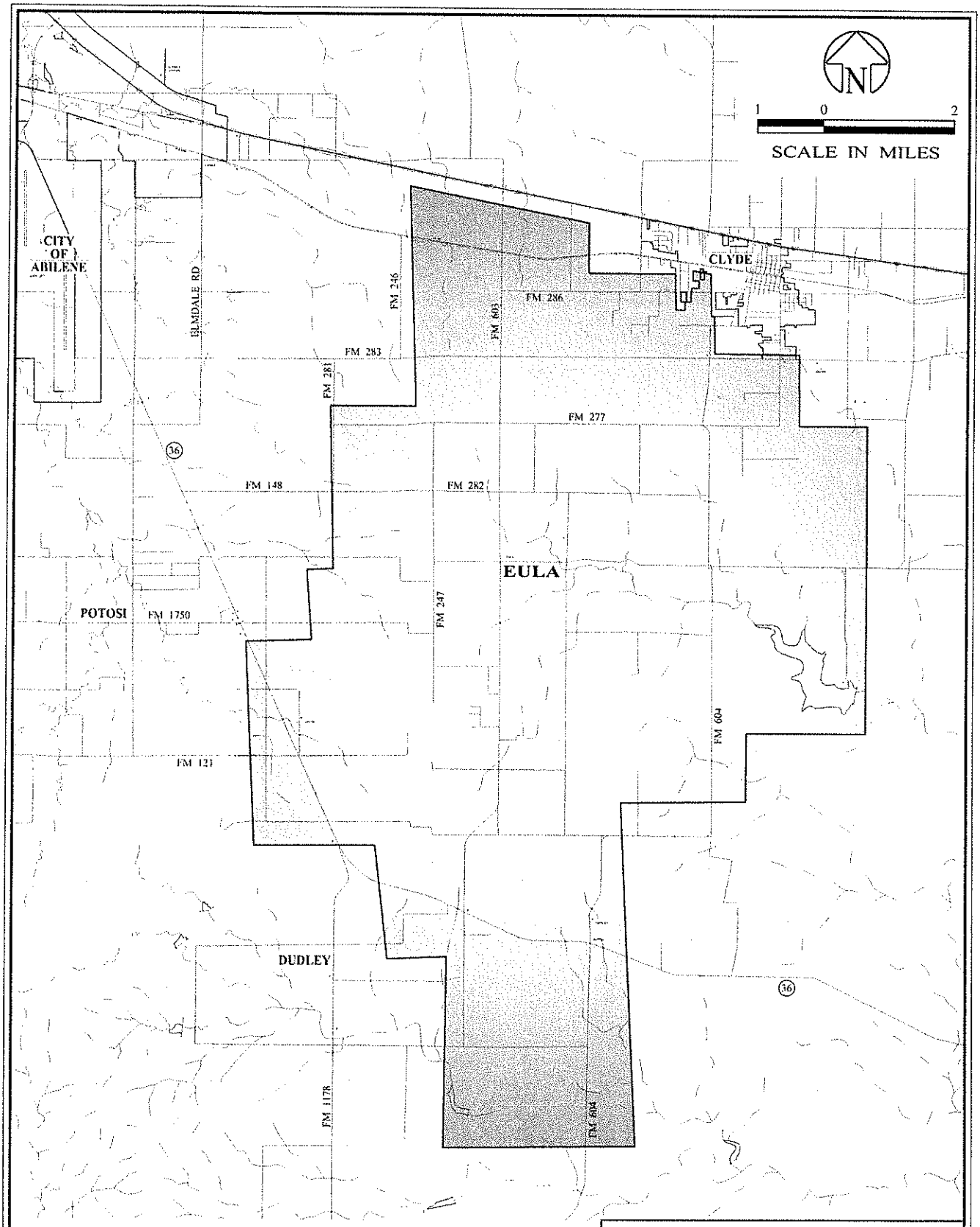
SERVICE AREA MAP

CITY OF CLYDE
P0595

08-4568

04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
325-698-5560
Abilene, Texas 79601
Firm Registration No. 1151

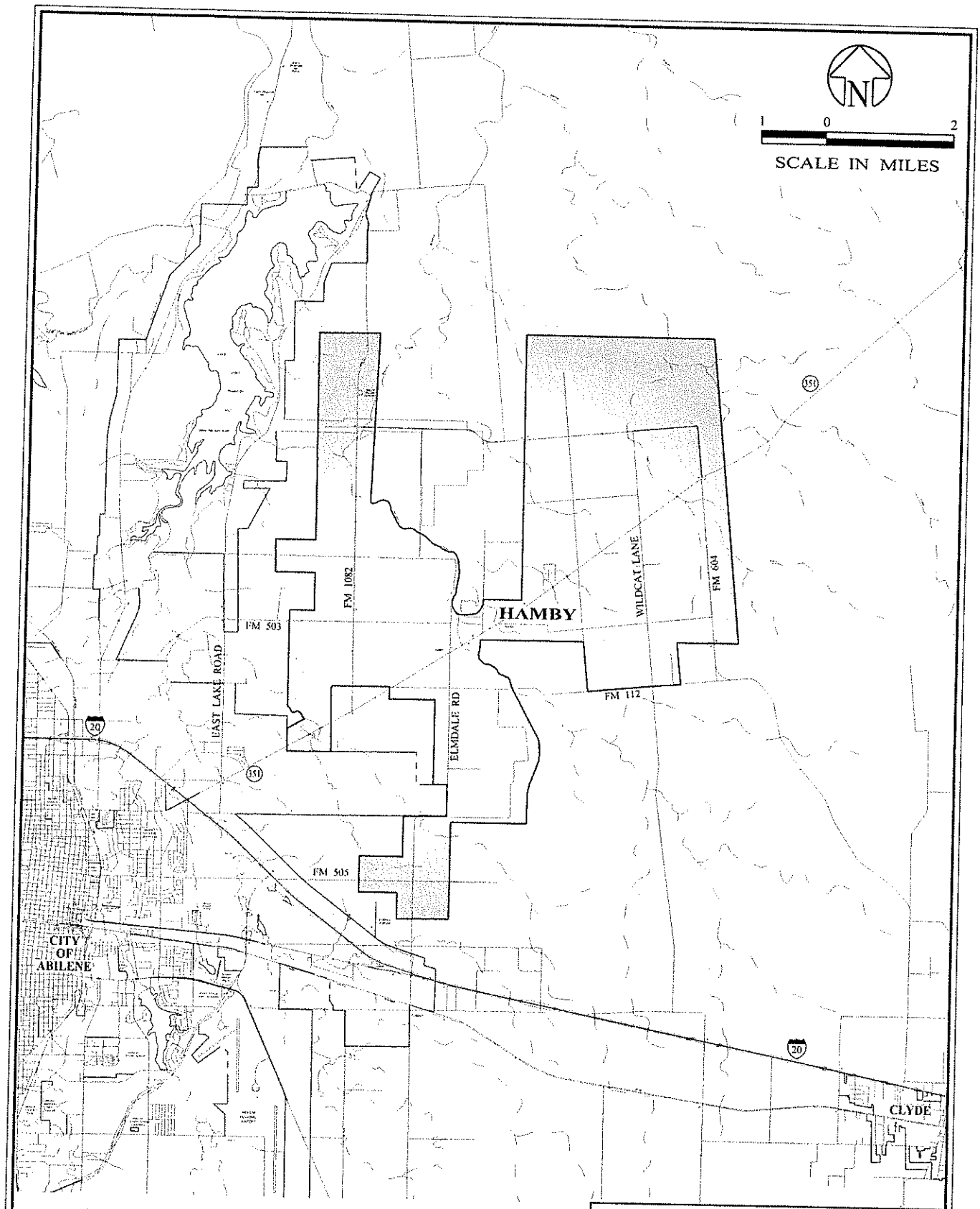


CCN MAP

EULA
WATER SUPPLY CORPORATION
CCN 10443

08-4568 04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
325-698-5560
Abilene, Texas 79601
Firm Registration No. 1151



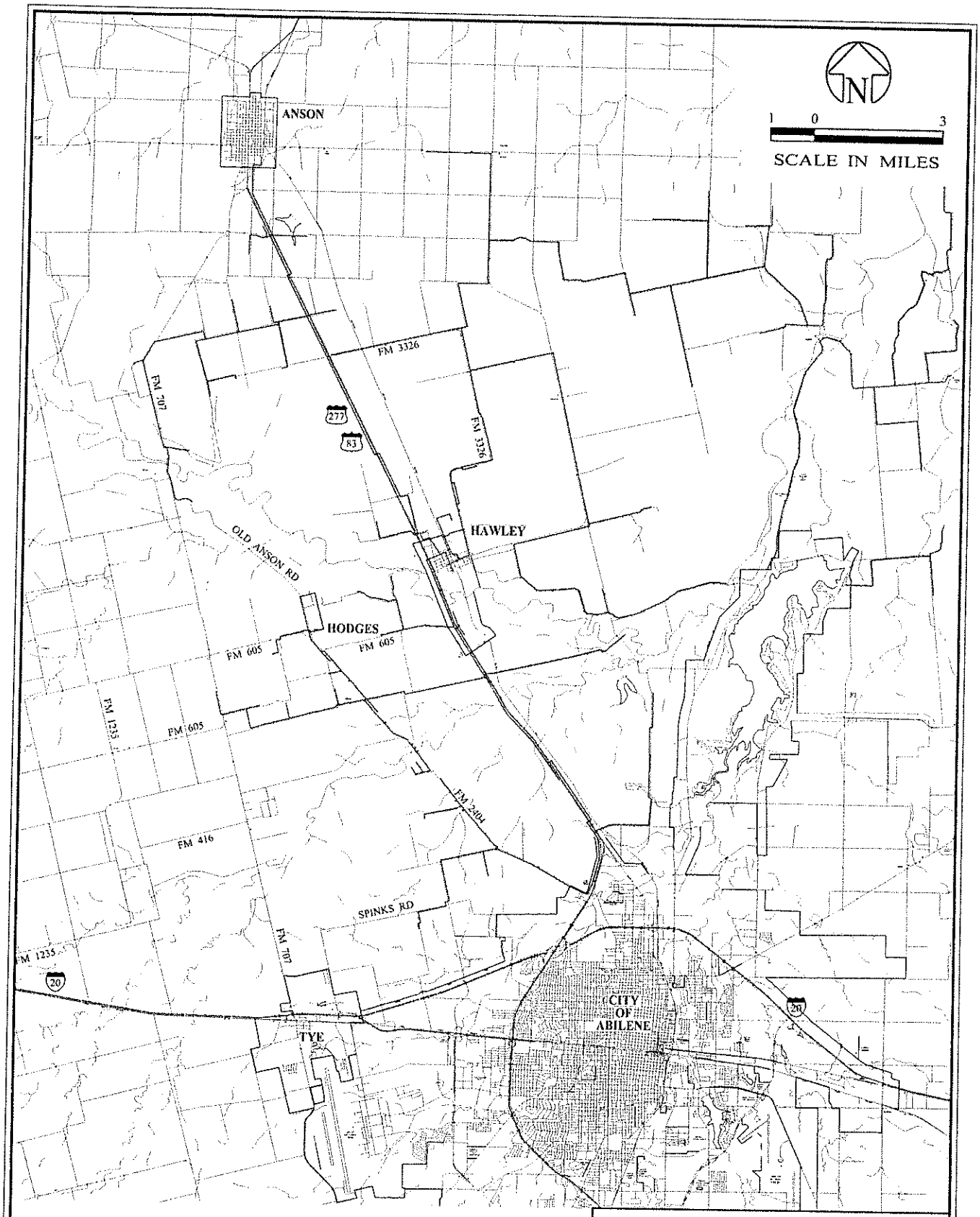
CCN MAP

HAMBY
WATER SUPPLY CORPORATION
CCN 10226

08-4568

04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
325-698-5560
Abilene, Texas 79601
Firm Registration No. 1151



LEGEND

——— FACILITIES CCN

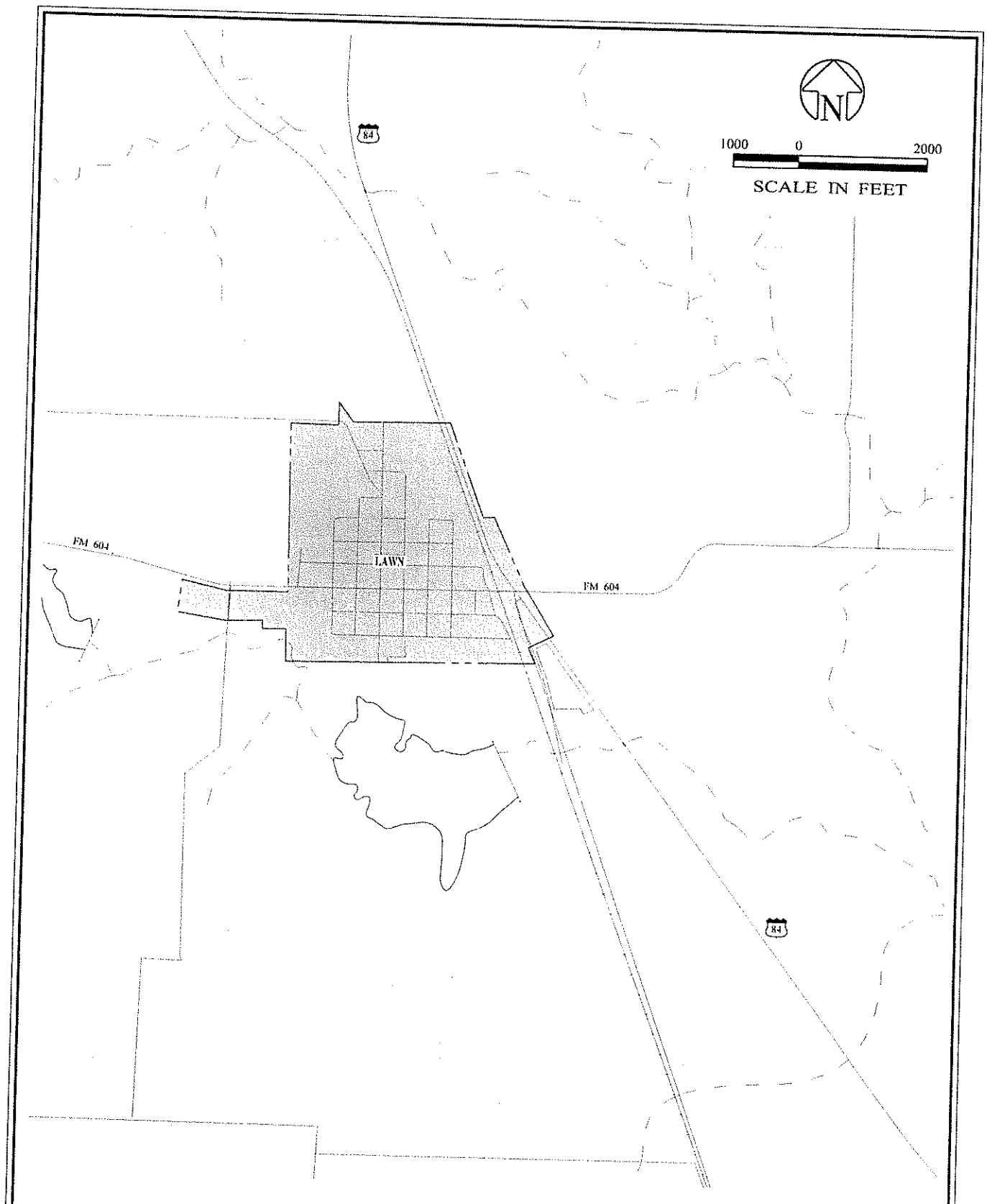
CCN MAP

HAWLEY
WATER SUPPLY CORPORATION
CCN 10952

08-4568

04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
325-698-5560
Abilene, Texas 79601
Firm Registration No. 1191



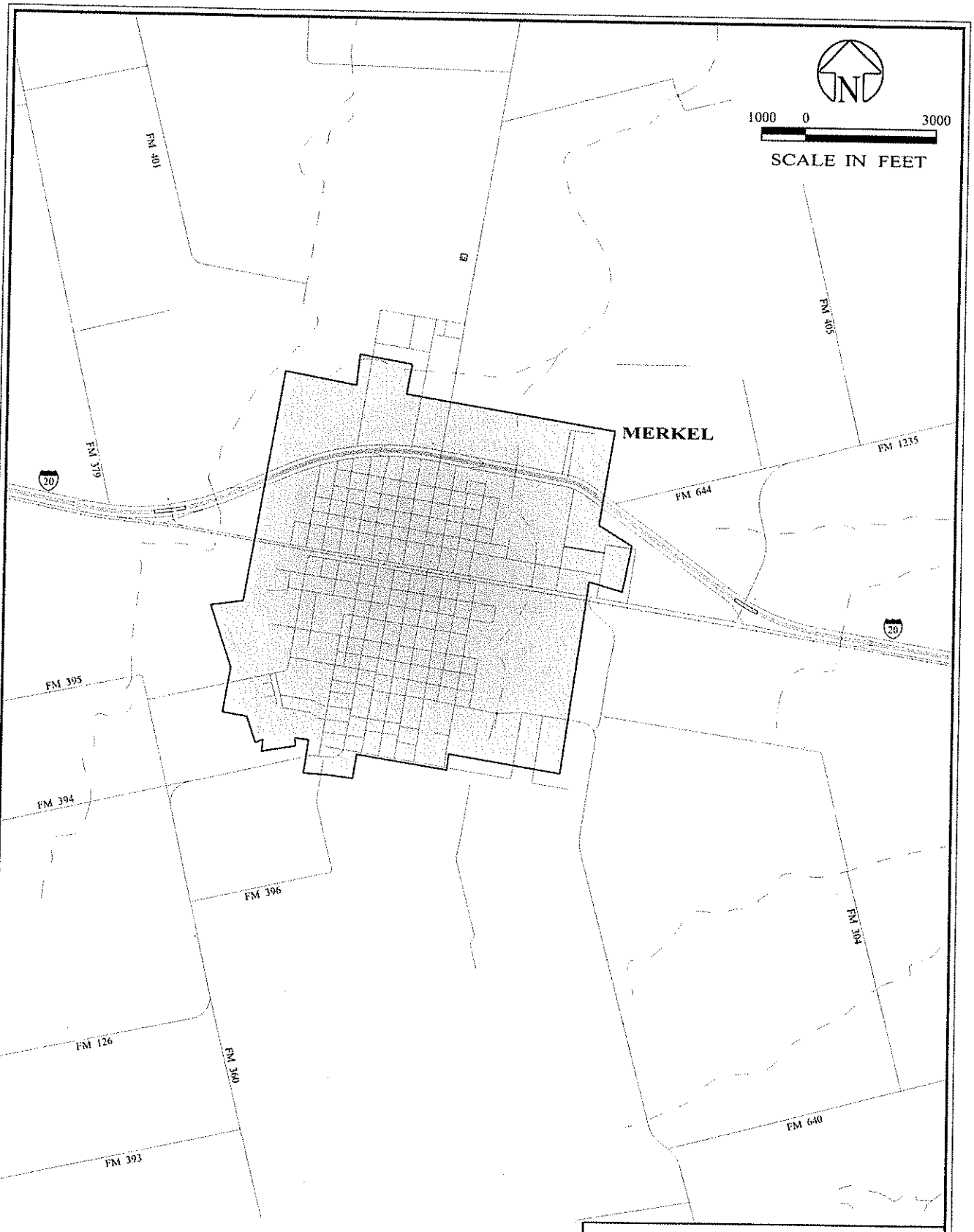
SERVICE AREA MAP

LAWN
WATER SUPPLY CORPORATION
P0704

08-4568

04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
325-698-5560
Abilene, Texas 79601
Firm Registration No. 1151

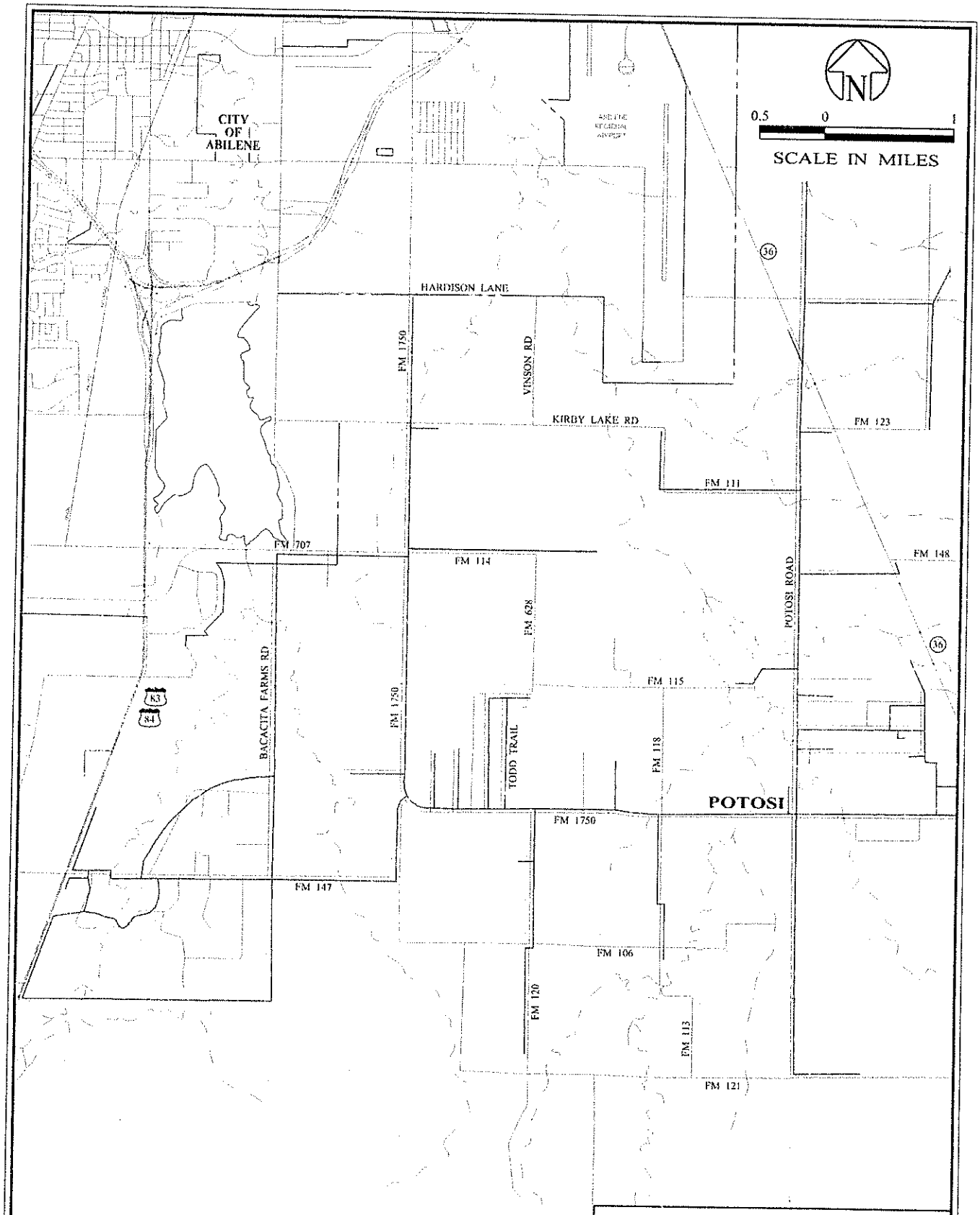


CCN MAP

CITY OF MERKEL
CCN 11454

08-4568 04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
Abilene, Texas 79601
325-698-5560
Firm Registration No. 1151



LEGEND

——— FACILITIES CCN

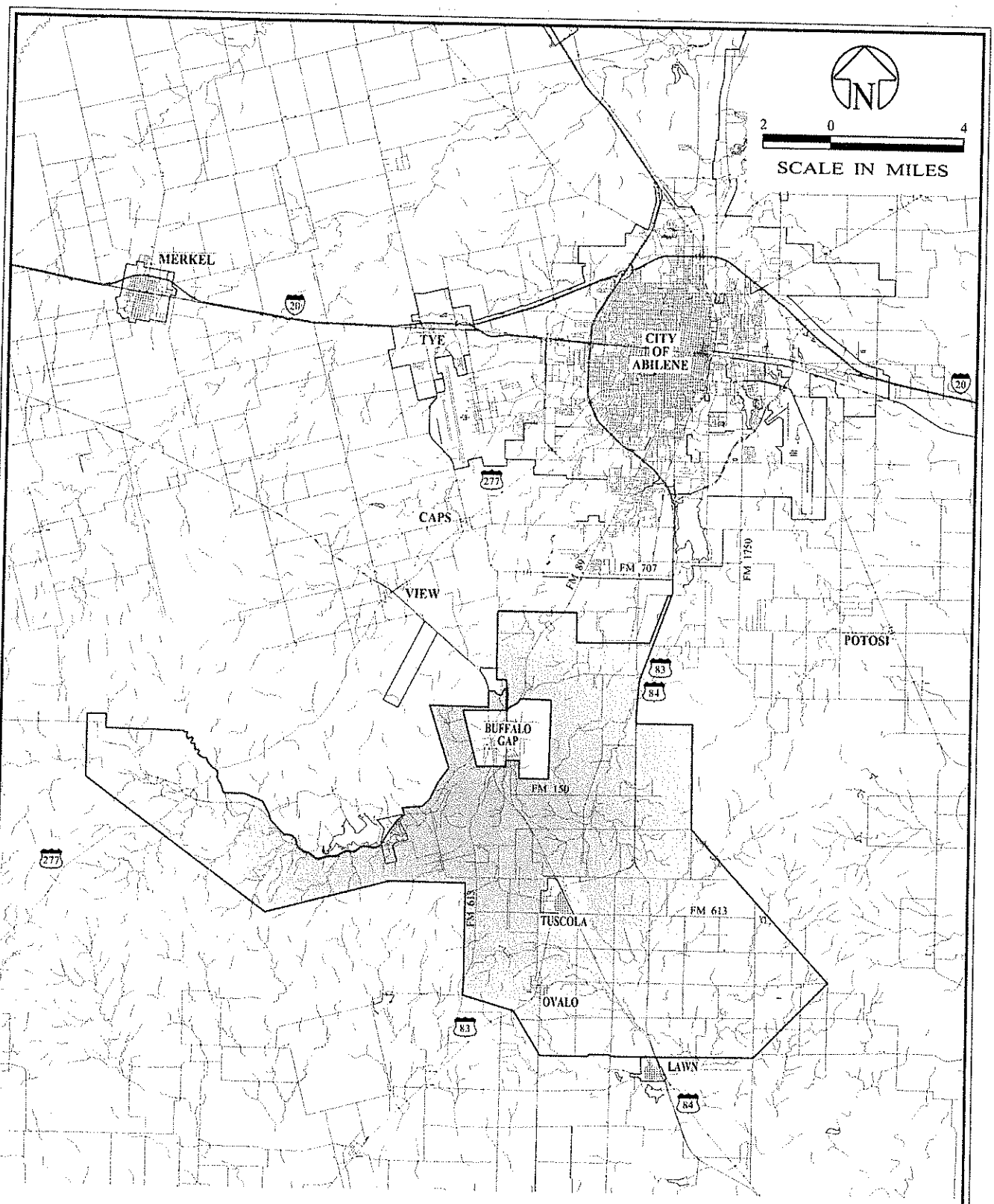
CCN MAP

POTOSI
WATER SUPPLY CORPORATION
CCN 10738

08-4568

04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
Abilene, Texas 79601
325-698-5560
Firm Registration No. 1191

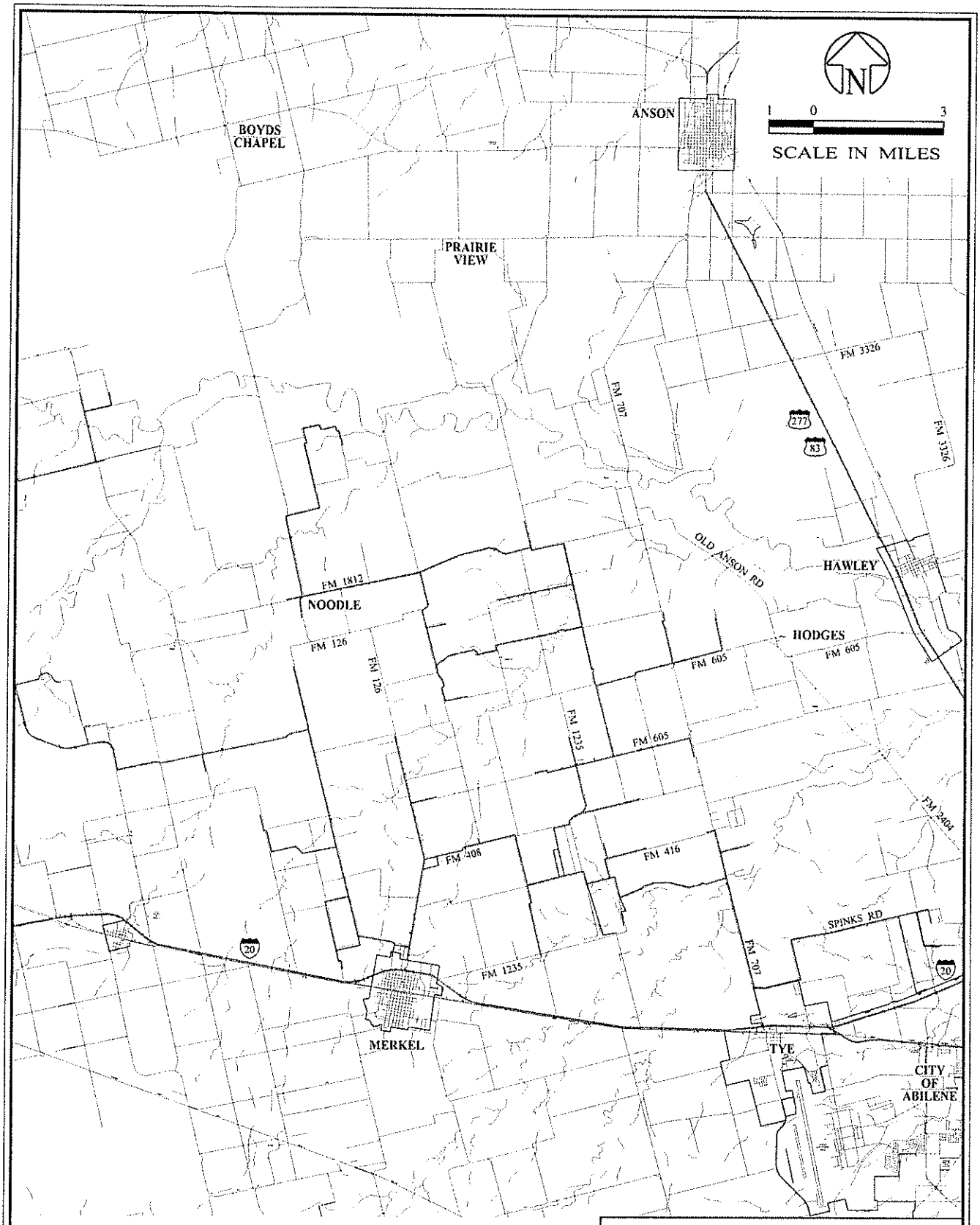


CCN MAP

STEAMBOAT MOUNTAIN
WATER SUPPLY CORPORATION
CCN 11370

08-4568 04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
Abilene, Texas 79601
325-698-5560
Firm Registration No. 1151



LEGEND

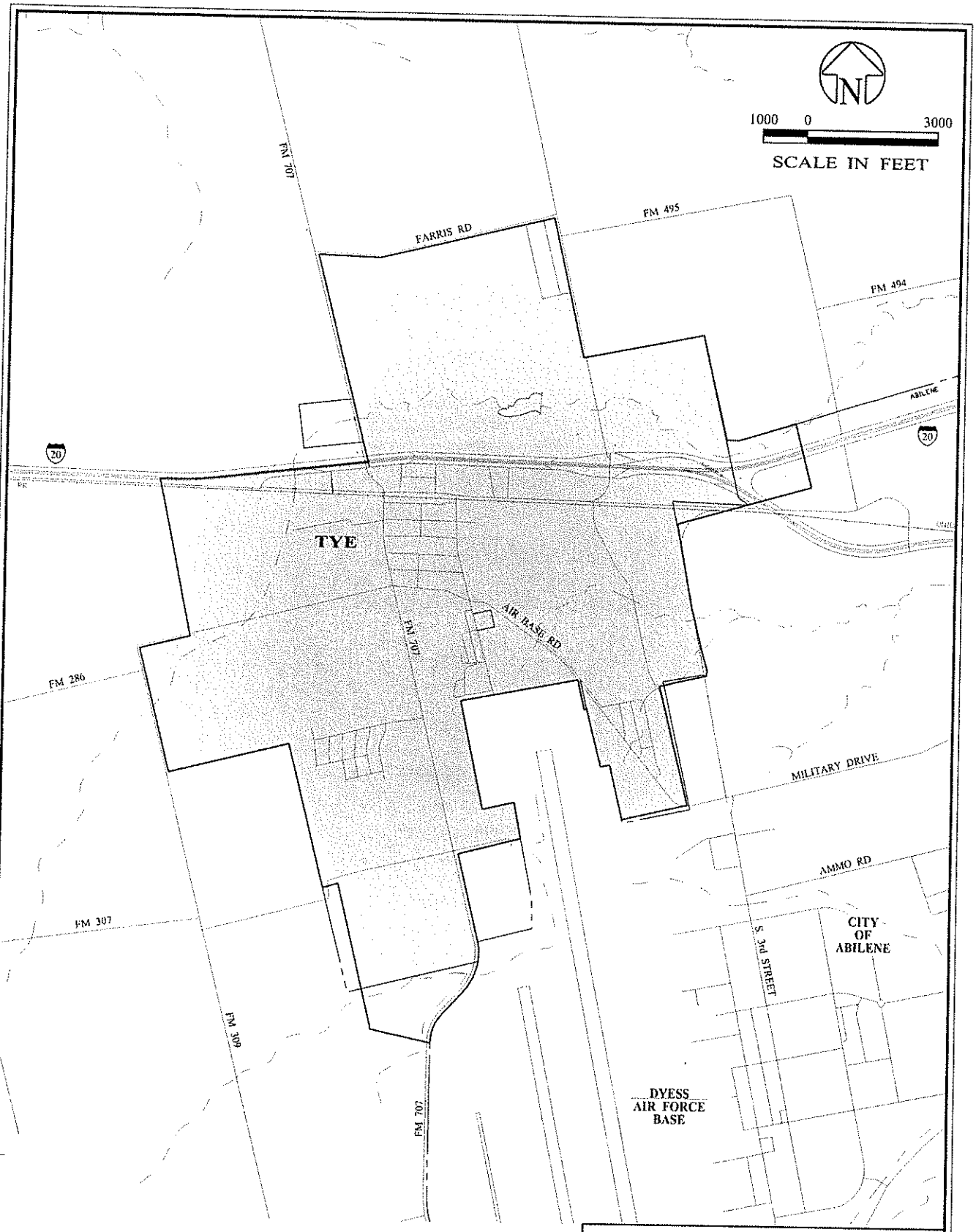
——— FACILITIES CCN

CCN MAP

S.U.N.
WATER SUPPLY CORPORATION
CCN 11139

08-4568 04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
325-698-5560
Abilene, Texas 79601
Firm Registration No. 1151



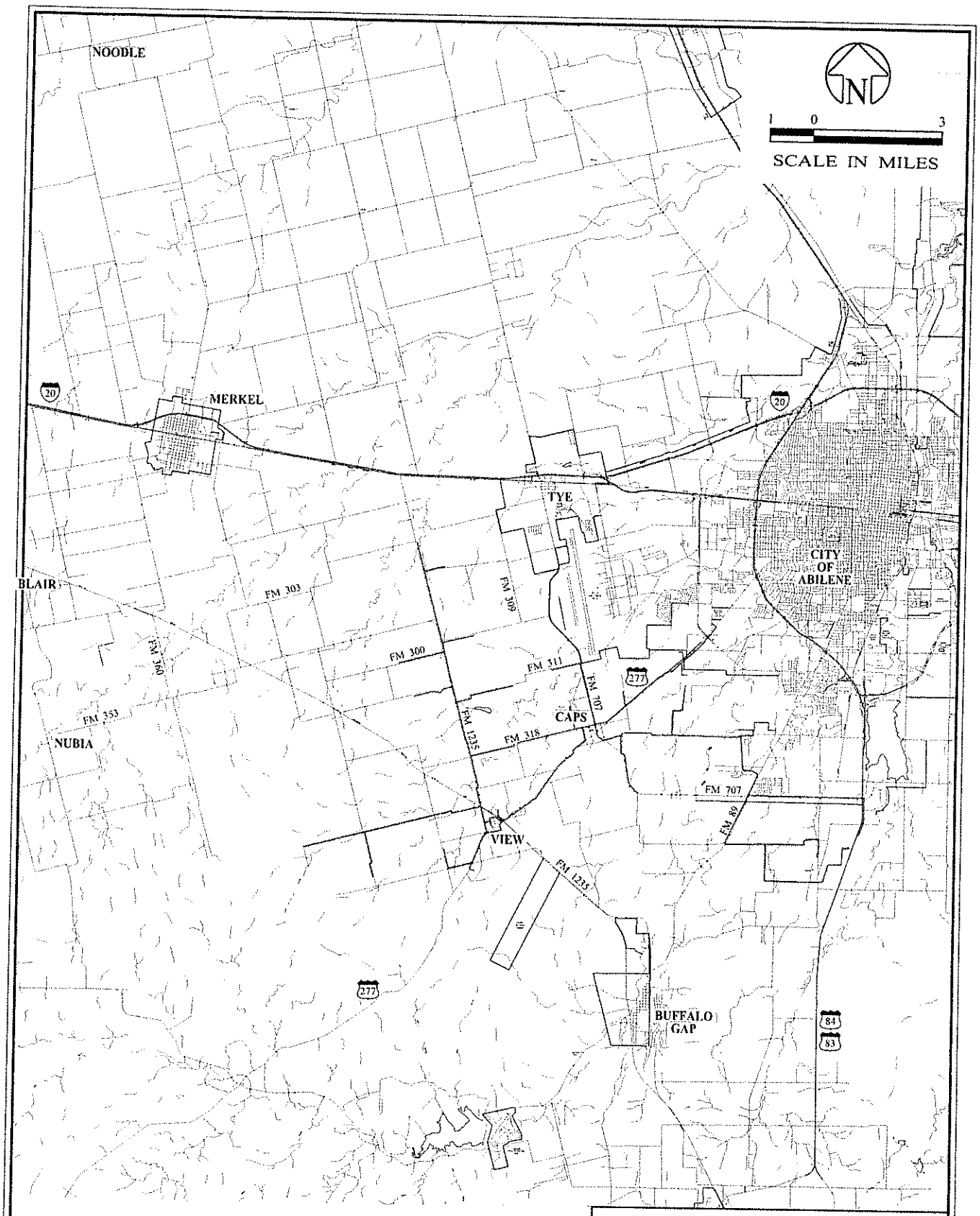
SERVICE AREA MAP

CITY OF TYE
P0841

08-4568

04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
325-698-5560
Abilene, Texas 79601
Firm Registration No. 1151



LEGEND

——— FACILITIES CCN

CCN MAP

VIEW CAPS
WATER SUPPLY CORPORATION
CCN 10241

08-4568

04/02/2010

ENPROTEC/HIBBS & TODD, INC.
ENVIRONMENTAL AND CIVIL ENGINEERING
402 Cedar Street
325-698-5560
Abilene, Texas 79601
Firm Registration No. 1151

Appendix B

Utility Profile & Water Conservation Plan Requirements for Municipal Water Use by Public Water Suppliers

Texas Commission on Environmental Quality

UTILITY PROFILE & WATER CONSERVATION PLAN REQUIREMENTS FOR MUNICIPAL WATER USE BY PUBLIC WATER SUPPLIERS

This form is provided to assist entities in water conservation plan development for municipal water use by a retail public water supplier. Information from this form should be included within a water conservation plan for municipal use. If you need assistance in completing this form or in developing your plan, please contact the conservation staff of the Resource Protection Team in the Water Supply Division at (512) 239-4691.

Date: April 2010

Name of Entity: City of Abilene

Address & Zip: P.O. Box 60, Abilene, TX 79604-0060

Telephone Number: (325) 676-6000 **Fax:** (325) 676-6229

Form Completed By: Scott F. Hibbs, P.E.

Title: Principal Engineer; Enprotec/Hibbs & Todd, Inc.

Signature Date: 4/2/10

STATE OF TEXAS
SCOTT F. HIBBS
63462
REGISTERED PROFESSIONAL ENGINEER

Form Verified By: Tommy O'Brien, P.E.

Title: Director of Abilene Water Utilities

Signature Tommy O'Brien, P.E. Date: 4-2-10

UTILITY PROFILE

I. POPULATION AND CUSTOMER DATA

A. Population and Service Area Data

1. Attach a copy of your service-area map and, if applicable, a copy of your Certificate of Convenience and Necessity (CCN). *(See Appendix A)*

2. Service area size (square miles): Approximately 108 square miles

3. Current population of service area: 124,607 persons within City's CCN

4. Current population served:

   a. water 124,607 persons within City's CCN

   b. wastewater 119,623 persons within City's CCN

5. Population served by water utility for the previous five years:

Year	Population
2004	119,398
2005	120,267
2006	121,135
2007	122,003
2008	122,871

6. Projected population for service area in the following decades:

Year	Population
2010	124,607
2020	130,220
2030	132,820
2040	133,514
2050	130,943

7. List source/method for the calculation of current and projected population:

   Brazos G Regional Water Planning Group (current)
   Initially Prepared 2011Brazos G Regional Water Plan (projected)

B. Active Connections

1. Current number of active connections. Check whether multi-family service is counted as Residential _____ or Commercial _X_ .

Treated water users	Metered	Not-metered	Total
Residential	34,172	0	34,172
Commercial	3,831	0	3,831
Industrial	46	0	46
Wholesale	32	0	32
Public/Institutional	331	0	331
Total	38,412	0	38,412

Source: City of Abilene Records

2. List the net number of new connections per year for most recent three years:

	2006	2007	2008
Residential	163	332	123
Commercial	14	-15	45
Industrial	0	7	1
Other	75	79	-9

Source: City of Abilene Records

C. High Volume Customers

List annual water use for the five highest volume customers
(indicate if treated or raw water delivery)

	Customer	Use (1,000 gal/yr)	Treated/Raw
(1)	TDCJID	238,904	Treated
(2)	Dyess AFB	207,190	Treated
(3)	Potosi WSC	198,001	Treated
(4)	Steamboat Mountain WSC	178,900	Treated
(5)	City of Merkel	125,243	Treated

Source: City of Abilene Records

II. WATER USE DATA FOR SERVICE AREA

A. Water Accounting Data

1. Amount of water use for previous five years (in 1,000 gal)

City of Abilene Total Raw Water Diverted for Treatment 2004-2008 (1,000 gal)

Raw to WTP	2004	2005	2006	2007	2008
January	517,936	502,216	599,401	522,910	573,907
February	460,014	440,540	502,379	490,892	549,687
March	503,529	504,919	583,885	582,014	538,049
April	562,099	611,803	701,335	581,750	612,829
May	633,324	639,107	780,205	552,666	740,611
June	673,055	746,620	845,475	593,671	818,674
July	760,180	808,654	1,016,388	647,983	971,612
August	671,108	701,906	1,010,464	732,829	804,612
September	665,896	749,767	686,065	680,280	681,089
October	550,632	639,036	671,329	716,580	655,275
November	484,921	574,066	613,976	602,358	602,735
December	509,935	576,336	547,164	543,350	572,865
a) Total Raw to WTP	6,992,629	7,494,970	8,558,066	7,247,283	8,121,945
b) Total Treated from WTP	6,822,260	7,223,594	8,093,202	6,963,459	7,673,495
c) Production Loss at WTP (a-b)	170,369	271,376	464,864	283,824	448,450

Source: City of Abilene Records

2. Amount of water (in 1,000 gallons) delivered (sold) as recorded by the following account types for the past five years.

Year	Treated Residential	Treated Commercial	Treated Industrial	Treated Wholesale	Treated Public/ Institutional/ Other	Total Treated Sales	Raw Water	Wastewater Reuse
2004	2,859,547	1,963,286	380,548	882,791	474,724	6,560,896	3,036	451,500
2005	3,356,018	1,701,976	420,020	877,646	492,570	6,848,230	6,898	775,900
2006	3,681,397	1,776,457	379,179	1,028,772	506,479	7,372,284	7,969	1,341,100
2007	2,660,941	1,526,014	254,116	954,743	476,385	5,872,199	1,659	526,000
2008	3,091,783	1,614,347	260,573	1,035,345	701,226	6,703,274	2,763	742,000

Source: City of Abilene Records

3. List previous five years records for water loss (the difference between water diverted (or treated) and water delivered (or sold))

Year	Amount Diverted (1,000 gal)	Production Loss (1,000 gal)	Line Flushing [1] (1,000 gal)	Treated Sales (1,000 gal)	Amount of Loss (1,000 gal)	% Loss
2004	6,992,629	170,369	47,000	6,560,896	204,864	3%
2005	7,494,970	271,376	57,000	6,848,230	318,864	4%
2006	8,558,066	464,864	59,000	7,372,284	664,418	8%
2007	7,247,283	283,824	410,000	5,872,199	681,260	9%
2008	8,121,945	448,450	210,000	6,703,274	760,221	9%

Source: City of Abilene Records

[1] Line flushing volumes are opinions of probable flushing volumes necessary to properly maintain a safe potable water distribution system. The substantial increase of the opinion of volume for 2007 and 2008 are the result of the City's effort to adequately flush the entire distribution system as a result of the city-wide boil water notice issued in August 2007.

4. Municipal water use for previous five years:

Year	Population	Total Water Diverted (1,000 gal)	Total Water Diverted for Abilene Users (1,000 gal)	Abilene Retail Per Capita Use (GPCD)
2004	119,398	6,992,629	6,051,747	138
2005	120,267	7,494,970	6,534,440	149
2006	121,135	8,558,066	7,363,823	167
2007	122,003	7,247,283	6,068,969	136
2008	122,871	8,121,945	6,867,481	153

Source: Brazos G Regional Water Planning Group and City of Abilene Records

B. Projected Water Demands (If applicable, attach projected water supply demands for the next ten years.)

Year	Retail Demand (ac-ft/yr)	Wholesale Demand (ac-ft/yr)	Total Demand (ac-ft/yr)
2010	22,891	3,427	26,318
2011	22,950	3,427	26,377
2012	23,010	3,427	26,437
2013	23,069	3,427	26,496
2014	23,129	3,427	26,556
2015	23,188	3,427	26,615
2016	23,247	3,427	26,674
2017	23,307	3,427	26,734
2018	23,366	3,427	26,793
2019	23,426	3,427	26,853

Source: Initially Prepared 2011Brazos G Regional Water Plan

III. WATER SUPPLY SYSTEM DATA

A. Water Supply Sources

List all current water supply sources and the amounts authorized with each: Current raw water supply sources used to produce potable water include:

Source	Amount (ac-ft/yr)
Lake Fort Phantom Hill [2]	9,316
Hubbard Creek Reservoir [3]	20,086
Lake O.H. Ivie [4]	6,720

[2] Amount obtained from Initially Prepared 2011 Brazos G Regional Water Plan.
[3] Delivered under contract from the West Central Texas MWD. Amount obtained from Initially Prepared 2011 Brazos G Regional Water Plan.
[4] Delivered under contract from the Colorado River MWD. Amount limited to current treatment capacity of 6 MGD.

B. Treatment and Distribution System

1.	Rated daily capacity of system:		51 MGD
2.	Storage Capacity:	Elevated:	6.45 MG
		Ground:	33.56 MG

Source: City of Abilene Records

3. If surface water, do you recycle filter backwash to the head of the plant?
   Yes _X_ Approximately 0.4 MGD.

Source: City of Abilene Records

4. Please attach a description of the water system. Include the number of treatment plants, wells, and storage tanks. If possible, include a sketch of the system layout.

   A pump station located on the eastern bank of Lake Ft. Phantom pumps raw surface water from Lake Ft. Phantom to the Northeast Treatment Plant and the Grimes Treatment Plant. A raw water delivery system consisting of two parallel pipelines can provide up to 27 million gallons per day (MGD) from Hubbard Creek Reservoir to the Ft. Phantom delivery system. Raw water is pumped approximately 50 miles from Lake O.H. Ivie to the Hargesheimer Water Treatment Plant located on Highway 83/84 near Tuscola. A pump station on the banks of the Clear Fork of the Brazos River, near Lake Ft. Phantom provides diversion pumping for up to 30,000 ac-ft/yr into Lake Ft. Phantom under selected volume and quality conditions.

   The City's Water Treatment System consists of three treatment plants having a maximum treatment capacity of 51 MGD and combined treated water storage of 20.76 million gallons (MG). The Northeast Water Treatment Plant on East Lake Road has a capacity of 25 MGD and treats raw water drawn from Lake Ft. Phantom and Hubbard Creek Reservoir. The Grimes Water Treatment Plant on East Highway 80 has a treatment capacity of 20 MGD and treats water drawn from Lake Ft. Phantom and Hubbard Creek Reservoir. The Hargesheimer Water Treatment Plant located on Highway 83/84 near Tuscola has a micro-filtration capacity of 8.95 MGD, and a reverse osmosis/ blended capacity of 6.0 MGD, and treats raw water drawn from Lake O.H. Ivie.

   The City of Abilene's water distribution system provides economical and compatible facilities that are capable of furnishing sufficient water at suitable pressures to both Abilene retail and wholesale purchasers. The system consists of nearly 750 miles of underground water mains, twelve pumping stations, seven ground storage tanks, eight elevated storage tanks, over 12,000 valves, over 2,700 fire hydrants, and over 38,400 meters.

After the water is processed at the treatment plants, it is pumped into the distribution system and stored in ground and elevated storage tanks with a combined volume of 19.25 million gallons. The distribution network is laid out in a continuous looped system to circulate water and maintain constant system pressure. Pumping stations are located strategically throughout the system to pump water, maintain uniform pressure and maintain storage tank levels.

Treated water from the Abilene treatment plants enters the wholesalers' systems through metered interconnections. According to TCEQ's records as available through the Texas Water Utility Database (TWUD), production capacity of the wholesale purchasers' systems amount to approximately 17.5 MGD. Based on TWUD records, ground storage capacity within the wholesalers' systems is approximately 5.5 million gallons while total elevated storage volume is approximately 3.3 million gallons.

IV. WASTEWATER SYSTEM DATA

A. Wastewater System Data

1. Design capacity of wastewater treatment plant(s): 22 MGD

   Source: City of Abilene Records

2. Is treated effluent used for irrigation on-site _X_, off-site _X_, plant washdown _X_, or chlorination/dechlorination _X_?
   If yes, approximately _35_ million gallons per month.

3. Briefly describe the wastewater system(s) of the area serviced by the water utility. Describe how treated wastewater is disposed of. Where applicable, identify treatment plant(s) with the TCEQ name and number, the operator, owner, and, if wastewater is discharged, the receiving stream. If possible, attach a sketch or map which locates the plant(s) and discharge points or disposal sites.

   Abilene's wastewater collection system consists of a network of approximately 653 miles of sewer lines, five lift stations, and 5,100 manholes serving the cities of Abilene, Tuscola, Tye and the Hawley ISD. Sewage flows by gravity, aided when necessary by lift stations, through the collection system into the Buck Creek Pump Station, which has a rated pumping capacity of approximately 24 MGD. An emergency storage basin at this facility has a capacity of approximately 23 million gallons. Sewage is metered at Buck Creek and then pumped five miles to the wastewater treatment plant. Collected wastewater is treated at the City of Abilene's Hamby Wastewater Reclamation Plant which is operated under permit number 10334-004. The

operator in responsible charge of the Hamby Plant is employed by the City of Abilene

Raw sewage undergoes full biological treatment that includes grit removal, sedimentation, activated sludge process, filtration, chlorine disinfection, and disinfectant removal. Wastewater quality is protected against industrial pollution through an Industrial Pre-Treatment Program. Industrial users are required to treat wastewater to specific standards before it is released into the municipal sanitary sewer system. Irrigators in and around the City reuse some of the treated effluent, while the remainder is discharged to Deadman Creek by way of Freewater Creek, discharged to Lake Kirby by way of the City's reclaimed water system, or is used for irrigation from the City's reclaimed water system. Sewage biosolids are disposed of in a sludge disposal unit.

Source: *City of Abilene Records*

B. Wastewater Data for Service Area

1. Percent of water service area served by wastewater system: 96%

2. Monthly volume treated for previous three years (in 1,000 gallons):

City of Abilene Influent Wastewater Flow 2006-2008 (1,000 gal)

	2006	2007	2008
January	357,528	333,309	340,974
February	317,105	296,713	314,391
March	359,312	355,103	386,730
April	350,223	352,816	382,663
May	389,682	417,509	398,488
June	357,534	380,105	345,804
July	361,642	434,611	339,356
August	371,765	463,369	369,288
September	348,458	408,272	357,418
October	340,910	371,525	359,006
November	325,757	341,712	328,475
December	342,699	326,831	330,020
Total Treated	4,222,615	4,481,875	4,252,613

Source: *City of Abilene Records*

Appendix C

Profile & Water Conservation Plan Requirements for Wholesale Public Water Suppliers

Texas Commission on Environmental Quality

PROFILE & WATER CONSERVATION PLAN REQUIREMENTS FOR WHOLESALE PUBLIC WATER SUPPLIERS

This form is provided to assist entities in water conservation plan development for municipal water use by a retail public water supplier. Information from this form should be included within a water conservation plan for municipal use. If you need assistance in completing this form or in developing your plan, please contact the conservation staff of the Resource Protection Team in the Water Supply Division at (512) 239-4691.

Date: April 2010

Name of Entity: City of Abilene

Address & Zip: P.O. Box 60, Abilene, TX 79604-0060

Telephone Number: (325) 676-6000

Form Completed By: Scott F. Hibbs, P.E.

Title: Principal Engineer; Enprotec/Hibbs & Todd, Inc.

STATE OF TEXAS
SCOTT F. HIBBS
63462
REGISTERED PROFESSIONAL ENGINEER

Signature 4/2/10

Form Verified By: Tommy O'Brien, P.E.

Title: Director of Abilene Water Utilities

Signature Tommy O'Brien, P.E.

UTILITY PROFILE

I. POPULATION AND CUSTOMER DATA

A. Population and Service Area Data

1. Attach a copy of your service-area map and, if applicable, a copy of your Certificate of Convenience and Necessity (CCN).
(See Appendix A)

2. Service area size (square miles): Approximately 874 square miles

3. Current population of service area: 36,755 persons within the wholesalers' CCNs outside the City's CCN

4. Current population served:

   a. water 36,755 persons within wholesalers' CCNs

   b. wastewater approximately 2,860 wholesale customers

5. Population served by water utility for the previous five years:

Year	Population
2004	35,938
2005	36,077
2006	36,216
2007	36,356
2008	36,497

6. Projected population for service area in the following decades:

Year	Population
2010	36,755
2020	37,495
2030	37,669
2040	37,569
2050	37,060

7. List source/method for the calculation of current and projected population:

Brazos G Regional Water Planning Group (current)
Initially Prepared 2011 Brazos G Regional Water Plan (projected)

B. Customers Data

List (or attach) the names of all wholesale customers, amount of annual contract, and amount of the annual use for each for the previous year:

Wholesale potable water customers are listed below. Dyess AFB is treated as a City of Abilene user in the City's 'Municipal Use Profile'.

Wholesale Customer	Contracted Amount (ac-ft/yr)	Previous Year Amount of Water Delivered (ac-ft)
City of Baird	77	75
City of Merkel	353	384
City of Tye	184	158
City Clyde	307	33
City of Lawn	77	0
Blair WSC	77	55
Hamby WSC	308	176
Hawley WSC	307	277
S.U.N. WSC	230	227
Eula WSC	61	98
Potosi WSC	307	608
Steamboat Mountain WSC	307	549
View-Caps WSC	199	173

II. WATER USE DATA FOR SERVICE AREA

A. Wholesale Water Delivery for Previous Year: 2,813 ac-ft of treated water (excludes Dyess AFB, which is treated as a City of Abilene user in the City's 'Municipal Use' profile).

B. Water Accounting Data

1. Total amount of water diverted at point of diversion for previous five years (in 1,000 gal) for all water uses:

City of Abilene Total Raw Water Diverted for Treatment 2004-2008 (1,000 gal)

Raw to WTP	2004	2005	2006	2007	2008
January	517,936	502,216	599,401	522,910	573,907
February	460,014	440,540	502,379	490,892	549,687
March	503,529	504,919	583,885	582,014	538,049
April	562,099	611,803	701,335	581,750	612,829
May	633,324	639,107	780,205	552,666	740,611
June	673,055	746,620	845,475	593,671	818,674
July	760,180	808,654	1,016,388	647,983	971,612
August	671,108	701,906	1,010,464	732,829	804,612
September	665,896	749,767	686,065	680,280	681,089
October	550,632	639,036	671,329	716,580	655,275
November	484,921	574,066	613,976	602,358	602,735
December	509,935	576,336	547,164	543,350	572,865
a) Total Raw to WTP	6,992,629	7,494,970	8,558,066	7,247,283	8,121,945
b) Total Treated from WTP	6,822,260	7,223,594	8,093,202	6,963,459	7,673,495
c) Production Loss at WTP (a-b)	170,369	271,376	464,864	283,824	448,450

Source: City of Abilene Records

2. Wholesale population served and total amount of water diverted for previous five years:

Year	Population	Total Water Diverted (ac-ft)	Total Water Diverted for Wholesale Users (ac-ft)	Wholesale Per Capita Use (GPCD)
2004	35,938	21,469	2,888	72
2005	36,077	23,022	2,948	73
2006	36,216	26,288	3,665	90
2007	36,356	22,246	3,616	89
2008	36,497	24,933	3,850	94

Source: Brazos G Regional Water Planning Group and City of Abilene Records

C. Projected Water Demands (If applicable, attach projected water supply demands for the next ten years.)

Year	Retail Demand (ac-ft/yr)	Wholesale Demand (ac-ft/yr)	Total Demand (ac-ft/yr)
2010	22,891	3,427	26,318
2011	22,950	3,427	26,377
2012	23,010	3,427	26,437
2013	23,069	3,427	26,496
2014	23,129	3,427	26,556
2015	23,188	3,427	26,615
2016	23,247	3,427	26,674
2017	23,307	3,427	26,734
2018	23,366	3,427	26,793
2019	23,426	3,427	26,853

Source: Initially Prepared 2011 Brazos G Regional Water Plan

III. WATER SUPPLY SYSTEM DATA

A. Water Supply Sources

List all current water supply sources and the amounts authorized with each: Current raw water supply sources used to produce potable water include:

Source	Amount (ac-ft/yr)
Lake Fort Phantom Hill [1]	9,316
Hubbard Creek Reservoir [2]	20,086
Lake O.H. Ivie [3]	6,720

[1] Amount obtained from Initially Prepared 2011 Brazos G Regional Water Plan.
[2] Delivered under contract from the West Central Texas MWD. Amount obtained from Initially Prepared 2011 Brazos G Regional Water Plan.
[3] Delivered under contract from the Colorado River MWD. Amount limited to current treatment capacity of 6 MGD.

B. Treatment and Distribution System

1. Daily capacity of wholesale purchasers' systems: 17.5 MGD
2. Purchasers' storage capacity: Elevated: 3.3 MG
   Ground: 5.5 MG

Source: Texas Water Utility Database

3. If surface water, do you recycle filter backwash to the head of the plant?
Yes __X__ Approximately 0.4 MGD.

Source: City of Abilene Records

4. Please attach a description of the water system. Include the number of treatment plants, wells, and storage tanks. If possible, include a sketch of the system layout.

A pump station located on the eastern bank of Lake Ft. Phantom pumps raw surface water from Lake Ft. Phantom to the Northeast Treatment Plant and the Grimes Treatment Plant. A raw water delivery system consisting of two parallel pipelines can provide up to 27 million gallons per day (MGD) from Hubbard Creek Reservoir to the Ft. Phantom delivery system. Raw water is pumped approximately 50 miles from Lake O.H. Ivie to the Hargesheimer Water Treatment Plant located on Highway 83/84 near Tuscola. A pump station on the banks of the Clear Fork of the Brazos River, near Lake Ft. Phantom provides diversion pumping for up to 30,000 ac-ft/yr into Lake Ft. Phantom under selected volume and quality conditions.

The City's Water Treatment System consists of three treatment plants having a maximum treatment capacity of 51 MGD and combined treated water storage of 20.76 million gallons (MG). The Northeast Water Treatment Plant on East Lake Road has a capacity of 25 MGD and treats raw water drawn from Lake Ft. Phantom and Hubbard Creek Reservoir. The Grimes Water Treatment Plant on East Highway 80 has a treatment capacity of 20 MGD and treats water drawn from Lake Ft. Phantom and Hubbard Creek Reservoir. The Hargesheimer Water Treatment Plant located on Highway 83/84 near Tuscola has a micro-filtration capacity of 8.95 MGD, and a reverse osmosis/ blended capacity of 6.0 MGD, and treats raw water drawn from Lake O.H. Ivie.

The City of Abilene's water distribution system provides economical and compatible facilities that are capable of furnishing sufficient water at suitable pressures to both Abilene retail and wholesale purchasers. The system consists of nearly 750 miles of underground water mains, twelve pumping stations, seven ground storage tanks, eight elevated storage tanks, over 12,000 valves, over 2,700 fire hydrants, and over 38,400 meters.

After the water is processed at the treatment plants, it is pumped into the distribution system and stored in ground and elevated storage tanks with a combined volume of 19.25 million gallons. The distribution network is laid out in a continuous looped system to circulate water and maintain constant system pressure. Pumping stations are located strategically throughout the system to pump water, maintain uniform pressure and maintain storage tank levels.

Treated water from the Abilene treatment plants enters the wholesalers' systems through metered interconnections. According to TCEQ's records as available through the Texas Water Utility Database (TWUD), production capacity of the wholesale purchasers' systems amount to approximately 17.5 MGD. Based on TWUD records, ground storage capacity within the wholesalers' systems is approximately 5.5 million gallons while total elevated storage volume is approximately 3.3 million gallons.

IV. WASTEWATER SYSTEM DATA

A. Wastewater System Data

1. Design capacity of wastewater treatment plant(s): 22 MGD

   Source: City of Abilene Records

2. Is treated effluent used for irrigation on-site _X_, off-site _X_, plant washdown _X_, or chlorination/dechlorination _X_?
   If yes, approximately __35__ million gallons per month.

3. Briefly describe the wastewater system(s) of the area serviced by the water utility. Describe how treated wastewater is disposed of. Where applicable, identify treatment plant(s) with the TCEQ name and number, the operator, owner, and, if wastewater is discharged, the receiving stream. If possible, attach a sketch or map which locates the plant(s) and discharge points or disposal sites.

   Abilene's wastewater collection system consists of a network of approximately 653 miles of sewer lines, five lift stations, and 5,100 manholes serving the cities of Abilene, Tuscola, Tye and the Hawley ISD. Sewage flows by gravity, aided when necessary by lift stations, through the collection system into the Buck Creek Pump Station, which has a rated pumping capacity of approximately 24 MGD. An emergency storage basin at this facility has a capacity of approximately 23 million gallons. Sewage is metered at Buck Creek and then pumped five miles to the wastewater treatment plant. Collected wastewater is treated at the City of Abilene's Hamby Wastewater Reclamation Plant which is operated under permit number 10334-004. The operator in responsible charge of the Hamby Plant is employed by the City of Abilene

   Raw sewage undergoes full biological treatment that includes grit removal, sedimentation, activated sludge process, filtration, chlorine disinfection, and disinfectant removal. Wastewater quality is protected against industrial pollution through an Industrial Pre-Treatment Program. Industrial users are

required to treat wastewater to specific standards before it is released into the municipal sanitary sewer system. Irrigators in and around the City reuse some of the treated effluent, while the remainder is discharged to Deadman Creek by way of Freewater Creek, discharged to Lake Kirby by way of the City's reclaimed water system, or is used for irrigation from the City's reclaimed water system. Sewage biosolids are disposed of in a sludge disposal unit.

Source: *City of Abilene Records*

B. Wastewater Data for Service Area

1. Percent of total wastewater flow from wholesale users: Approximately 1%

2. Monthly volume treated for previous three years (in 1,000 gallons):

Total Wastewater Influent for Wholesale Wastewater System Users (2006-2008) (1,000 gal)

	2006	**2007**	**2008**
January	1,884	3,887	3,957
February	3,787	3,997	3,212
March	1,905	5,413	3,000
April	2,498	3,561	5,134
May	2,730	4,143	3,582
June	3,553	3,266	3,452
July	2,622	4,286	0
August	2,803	6,654	7,401
September	3,330	4,149	3,571
October	3,220	4,114	4,457
November	3,474	3,861	2,879
December	3,959	3,676	3,054
Total	**35,765**	**51,007**	**43,699**

Source: *City of Abilene Records*

Appendix D

System Inventory and Water Conservation Plan for Agricultural Water Suppliers Providing Water to More Than One User

Texas Commission on Environmental Quality

SYSTEM INVENTORY AND WATER CONSERVATION PLAN FOR AGRICULTURAL WATER SUPPLIERS PROVIDING WATER TO MORE THAN ONE USER

This form is provided to assist entities in conservation plan development for agricultural water suppliers providing water to more than one user individually-operated irrigation systems. If you need assistance in completing this form or in developing your plan, please contact the conservation staff of the Resource Protection Team in the Water Supply Division at (512) 239-4691.

Date: April 2010

Name of Entity: City of Abilene

Address & Zip: P.O. Box 60, Abilene, TX 79604-0060

Telephone Number: (325) 676-6000

Form Completed By: Scott F. Hibbs, P.E.

Title: Principal Engineer, Enprotec/Hibbs & Todd, Inc.

STATE OF TEXAS
SCOTT F. HIBBS
83462
REGISTERED PROFESSIONAL ENGINEER

Signature 4/2/10

Form Verified By: Tommy O'Brien, P.E.

Title: Director of Abilene Water Utilities

Signature Tommy O'Brien, P.E.

I. STRUCTURAL FACILITIES

A. Description of service area:

The service area for water supplied for agricultural/irrigation water use is contained within an area encompassing approximately 108 square miles in and around the City of Abilene.

B. Total miles of main canals and pipelines:

The system does not use canals but does have approximately 42 miles of pipeline to deliver agricultural irrigation water to end users.

C. Total miles of lateral canals and pipelines:

The system does not use canals, and lateral pipelines are typically private ownership.

D. Reservoir capacity, if applicable: NA

E. Description of pumps and pumping stations:

The City of Abilene owns and operates a wastewater reuse system through which treated wastewater and/or raw water is sold for irrigation use. The Hamby Wastewater Reclamation Facility (Hamby) with a permitted capacity of 22 million gallons per day (MGD) operates under Texas Pollutant Discharge Elimination System (TPDES) Permit number 10334-004. A single pipeline directs the reclaimed water from the Hamby plant in a southwesterly direction toward the City of Abilene to the first of two reclaimed water pump stations. The first reclaimed water pump station downstream from the Hamby plant is located at the Grimes Water Treatment Plant near the intersection of US Business 20 and Highway 83. The Grimes reclaimed water pump station delivers the reclaimed water to users located between Grimes and Lake Kirby. The City's TPDES permit authorizes up to 4 MGD to be discharged into Lake Kirby via the Grimes pump station. A second pump station at Lake Kirby pumps reclaimed irrigation water (prior to discharge into Lake Kirby) or raw water from Lake Kirby to irrigation users in west Abilene at a rate of approximately 1.3 MGD. Abilene also provides treated effluent (under the City's TPDES permit) from the Hamby plant's secondary (final) clarifiers for agricultural use on privately-owned and City-owned land near the Hamby treatment plant. Treated effluent for agricultural use near the Hamby treatment plant is supplied primarily by gravity flow through a network of transmission pipelines.

F. Description of meters and/or measuring devices:

Agricultural/irrigation water use by each water user being supplied from the system is individually metered at the service connection to each user.

G. Description of customer gates and measuring devices:

Customer water use is measured via individual service meters on the customer service supply line to each user.

H. Description of canal construction:

1. Miles of unlined canals:

   Unlined canals are not used in this system.

2. Miles of lined canals:

   Lined canals are not used in this system.

3. Miles of enclosed pipelines:

   Approximately 42 miles of enclosed water pipelines are used to convey treated water from the Hamby plant to the individual users.

4. Other:

   NA

I. Description of canal conditions and recent or planned improvements:

NA

J. Description of any other structural facilities not covered above:

NA

II. MANAGEMENT PRACTICES

A. Total water available to City (in acre-feet/year):

Source	Amount (ac-ft/yr)
Lake Kirby	3,880
Lake O.H. Ivie [1]	6,720
Lake Fort Phantom Hill [2]	9,316
Hubbard Creek Reservoir [3]	20,086
Treated Effluent/Reclaimed Water [4]	13,330

[1] Delivered under contract from the Colorado River MWD. Source limited to current treatment capacity of 6 MGD.

[2] Amount obtained from Initially Prepared 2011 Brazos G Regional Water Plan.

[3] Delivered under contract from the West Central Texas MWD. Amount obtained from Initially Prepared 2011 Brazos G Regional Water Plan.

[4] Average amount for the 5-year period from 2004-2008.

B. Maximum water rights allocation to City (in acre-feet/year):

Surface Water Source	Authorization	Amount (ac-ft/yr)
Lake O.H. Ivie [5]	Contract Purchase	6,720
Hubbard Creek Reservoir	Contract Purchase	20,086
Lake Fort Phantom Hill	CA 12-4161 (as amended)	30,690
Lake Abilene	CA 12-4142 (as amended)	1,675
Lake Kirby	CA 12-4150 (as amended)	3,880
Treated Effluent/ Reclaimed Water	Permit No. 4266C and 210 Authorization	13,330

[5] Source limited to current treatment capacity of 6 MGD.

C. Other water contracted to be delivered by the City:

Contracted Customer	Water Supplied	Contracted Amount (ac-ft/yr) [1]
City of Baird	Potable Water	77
City of Merkel	" "	353
City of Tye	" "	184
City of Clyde	" "	307
City of Lawn	" "	77
Blair WSC	" "	77
Hamby WSC	" "	308
Hawley WSC	" "	307
S.U.N. WSC	" "	230
Eula WSC	" "	61
Potosi WSC	" "	307
Steamboat Mountain WSC	" "	307
View-Caps WSC	" "	199
Dyess AFB [6]	" "	491
Authorized Creek Diversions [7]	Treated Effluent	50
210 Customers [8]	Reclaimed Water	3,469
Agricultural Irrigators Near Hamby and Creek Diversion [9]	Treated Effluent	5,434

[6] The Dyess contract does not indicate a specific contract delivery amount but states only that the City will "provide all of the potable demand for all operations and maintenance as required by Dyess." Dyess has historically used just under 500 ac-ft/yr.

[7] The City contracts to deliver treated effluent discharged from the Hamby Reclamation Plant to Freewater Creek to one (1) customer in the amount of 50 ac-ft/yr.

[8] The City contracts with multiple customers for reclaimed water under the City's 210 authorization.

[9] The City has potential obligations to provide treated effluent for agricultural irrigators near the Hamby Reclamation Plant.

D. Average annual water diverted by City: Approximately 24,500 ac-ft/yr

E. Average annual water delivered to customers: Approximately 23,150 ac-ft/yr [11]

F. Delivery efficiency (percentage): Approximately 94%

G. Historical diversions and deliveries:

Year	Annual Rainfall (in./yr.)	Total Annual Water Diverted [10] (acre-feet)	Annual Irrigation Water Delivered [10] (acre-feet)	Annual Municipal Water Delivered (acre-feet)	Other Water Delivered (acre-feet)	Total Annual Water Delivered [14] (acre-feet)	Estimated Delivery Efficiency (percentage)
2006	20.77	26,288 [12]	4,290	21,461	1,167	22,649 [16]	~94%
2007	35.84	22,246 [13]	1,615	17,241	784	18,026 [17]	
2008	24.37	24,933 [14]	2,281	19,772	804	20,580 [18]	
Avg	26.99	24,489	2,729	19,491	918	20,418	

[10] A portion of this figure is comprised of treated effluent and reclaimed treated wastewater.

[11] This figure includes 26, 263 acre-feet of raw water diverted for treatment at the water treatment plants, 21 acre-feet diverted for raw agricultural use, and 4 acre-feet for raw industrial use.

[12] This figure includes 22, 241 acre-feet of raw water diverted for treatment at the water treatment plants, 1 acre-foot diverted for raw agricultural use, and 4 acre-feet for raw industrial use.

[13] This figure includes 24, 925 acre-feet of raw water diverted for treatment at the water treatment plants, 4 acre-feet diverted for raw agricultural use, and 4 acre-feet for raw industrial use.

[14] Reclaimed treated effluent and reclaimed treated wastewater have been subtracted out of this figure to prevent counting delivery of reuse water twice.

[15] This figure includes 21,461 acre-feet of treated water sold for municipal use, 1,167 acre-feet sold for industrial use, and 21 acre-feet for raw agricultural use.

[16] This figure includes 17,241 acre-feet of treated water sold for municipal use, 784 acre-feet sold for industrial use, and 1 acre-foot for raw agricultural use.

[17] This figure includes 19,772 acre-feet of treated water sold for municipal use, 804 acre-feet sold for industrial use, and 4 acre-feet for raw agricultural use.

H. Practices and/or devices used to account for water deliveries:

It is Abilene's policy to individually meter all water sold or provided for irrigation. Abilene's universal metering program has resulted in a water delivery accuracy rate as determined system-wide, well within accepted industry operating standards. It is also Abilene's policy to purchase meters that meet at least the minimum standards developed by the American Water Works Association. All metering devices used to meter water diverted from the source of supply are accurate to within plus or minus 5% to measure and account for raw, treated effluent and reclaimed water diverted for irrigation use. Aged meters are systematically replaced to assure reliability of meter performance. The City has established the following meter maintenance and replacement programs:

Meter Type	Calibration Period and Replacement
Master Meters	Annually and replaced as needed
1-1/2 inch and larger	Annually and replaced as needed
Smaller than 1-1/2	Every 10 years and replaced as needed

I. Water pricing policy:

With the exception of treated effluent provided to users at no cost under terms of legal settlements or easements, the City of Abilene maintains an established water pricing mechanism consistent with the contractual requirements and the City's utility rate structure.

J. Operating rules and policies which encourage water conservation:

The City of Abilene's Water Conservation Program utilizes Supply Management Methods and Demand Management Methods to work towards optimizing use of Abilene's water resources.

1. Supply Management Program Elements consist of:

   a. Coordinated use of water supplies to ensure the City withdraws water from its water supply reservoirs in a manner that ensures maximum dependable yield and efficiency of operation.
   b. Watershed management to ensure diversion structures to Lake Ft. Phantom are clean, relatively straight, and obstruction-free to increase captured water flow while minimizing flooding potential in populated areas.
   c. Metering all service connections to ensure maximum return for delivered water while minimizing unaccounted-for water loss.
   d. Leak detection and repair to minimize unaccounted-for water loss.

e. Treated wastewater reuse and recycling to lessen the demand for raw water used to produce potable water, and for raw water used for irrigation.

2. Demand Management Program Elements consist of:

a. Water pricing as a mechanism for encouraging water customers to conserve.
b. Regulations for conserving water via the Water Conservation Plan and Drought Contingency Plan adopted by the City.
c. Plumbing Code for the City of Abilene requires maximum standard plumbing fixture capacities not be exceeded. Abilene supports consideration of a Low-Income Housing Retrofit Program and City Building Retrofit program to determine the feasibility of retrofitting fixtures in selected structures.
d. Continuing education programs to increase public awareness of supply, treatment and conveyance systems in Abilene, to increase public awareness of the benefits and need for conservation, and to make information about practical cost-effective methods and technologies to achieve conservation readily available.

3. Year Round Water Use Management.

The City of Abilene utilizes year-round water conservation measures to restrict certain potable water use activities by all customers of the City of Abilene Water Utility System. Pursuant to this measure all potable water irrigation by commercial, industrial, and residential customers utilizing individual sprinklers, or sprinkler systems, on lawns, gardens, landscaped areas, trees, shrubs or other plants may water only on designated day(s) and then only during designated hours as outlined in the City's drought contingency plan.

K. Other management practices and services provided by the City:

In order to lessen the demand on the City's raw water sources the City relies on reuse of treated wastewater for supply to irrigators located within the City's service area. It is the City's policy to assist irrigators where feasible and practical to utilize reclaimed wastewater as their irrigation supply water. The City strives to work closely with local irrigation water users to ensure effective use of the City's water resources through improved irrigation systems, promoting healthy vegetation, and improved farming practices.

III. USER PROFILE

A. Total number of acres in service area:

Approximately 69,000 acres.

B. Average number of acres irrigated annually:

Estimated to be 4,473.

C. Projected number of acres to be irrigated in 10 years:

Estimated to be 5,333.

D. Number of active irrigation customers:

Approximately 24 reclaimed water reuse irrigation customers and 10 treated effluent agricultural irrigators around the Hamby Reclamation Plant, including irrigation of the Hamby plant grounds.

E. Total irrigation water delivered annually (in acre-feet):

Approximately 4,820 acre-feet per year.

F. Types of crops grown by customers:

Landscaping foliage, lawns and irrigated grounds are typical crops for users within the Abilene urban area. Cotton, wheat, hay, milo and coastal Bermuda are the typical crops grown around the Hamby Wastewater Reclamation Facility and by agricultural users of reclaimed water.

G. Types of irrigation systems used by customer:

Commercial sprinkler/drip irrigation systems are typical for urban users. Center pivot and flood irrigation techniques are common for agricultural users.

H. Types of drainage systems used by customers:

Abilene use policies require tailwater containment and control to prevent unauthorized discharges.

I. Further description of irrigation customers:

Irrigation customers consist of a mixture of landscaping growers, golf courses, schools, universities, detention facilities and private individuals in addition to agricultural users.

J. List of municipal customers and number of acre-feet allocated annually:

Wholesale Customer	Contracted Amount (ac-ft/yr)
City of Baird	77
City of Merkel	353
City of Tye	184
City of Clyde	307
City of Lawn	77
Blair WSC	77
Hamby WSC	308
Hawley WSC	307
S.U.N. WSC	230
Eula WSC	61
Potosi WSC	307
Steamboat Mountain WSC	307
View-Caps WSC	199
Dyess AFB [6]	491

Refer to page 5 for Dyess AFB [6].

K. List of large industrial and other large customers and number of acre-feet allocated annually. Large industrial customers using municipal potable water include the following:

Customer	Acre-feet/year
Abtex Beverage Corp	234
Apani Southwest	26
Bandag Inc.	39
Cintas	39
Coca Cola	338
Conley Printing	<1
Energy Maintenance	<1
Fehr Foods Inc.	6
Frontier Welded Products	1
Hirschfeld Steel	2
Martin Sprocket	5
Micro Metals	8
Mrs. Bairds	14
Mueller	<1
PWP Industries	4
Rentech	4
Tige Boats	6
US Brass/ Valley Faucett	<1
Tower Tech Systems	No Data Available (new facility)
Zoltek Corp	52

L. Additional information about water users:

NA

IV. Describe **specific and quantified five-year and ten-year targets for water savings** including maximum allowable losses for the storage and distribution system:

The 5-year and 10-year targets for water savings is to maintain the irrigation requirement at or below the area agronomic standard of 24-inches per acre per year. It should be noted that occasionally the City allows the agronomic standard rate to be exceeded in order to flush the crop root zone to improve plant productivity, livelihood, growth enhancement and overall reduction in crop water demand.

The maximum allowable losses from storage (transmission system storage, not open lakes/ponds) and distribution is targeted at 15%, as calculated by metered water sold or provided and the City's master meter diversion records.

V. Describe the practice(s) and/or device(s) which will be utilized to measure and account for the amount of water diverted from the source(s) of supply:

The City of Abilene utilizes individual meters at each point that water is diverted from the City's facilities to a user. All water delivered by the City for agricultural use is metered by the City including unbilled water delivered to irrigators around the Hamby Water Reclamation Facility. Water discharged to Freewater Creek from the Hamby Water Reclamation Facility is metered using an open-channel Parshall flume and associated flow metering and recording device. The metering device associated with the Parshall Flume at the plant undergoes annual calibration.

VI. Describe the monitoring and record management program for water deliveries, sales, and losses:

Abilene utilizes a record management system which records all water diverted from raw water sources and all raw, treated, and treated effluent/reclaimed water deliveries. The City tracks water deliveries by water type as raw water, treated water, reclaimed water and treated effluent irrigation water (provided to irrigators around the Hamby Water Reclamation Plant). The City monitors water diversion and water deliveries to track water transmission, distribution, and delivery to customers. This information is used to evaluate the integrity of the water delivery system from source to end user to control and minimize unaccounted-for uses of water. The record management system utilized by the City of Abilene segregates water sales and users into user classes of raw water, reclaimed water, treated residential, treated commercial, treated public/institutional, treated industrial and treated wholesale.

VII. Describe any methods that will be used for water loss control, leak detection, and repair:

Water loss control is practiced through water loss accounting procedures. The City's record keeping system aids in comparing the water sold figures to the water diverted figures to detect unusual use patterns and possible leaks from the system. It is Abilene's policy to investigate complaints associated with potential water leaks on a timely basis. Once alerted to a potential leak, City crews visually inspect suspected leaks, with quick and timely repairs to those leaks when detected.

VIII. Describe any program for customer assistance in the development of on-farm water conservation and pollution prevention measures:

It is the City's policy to assist any water user with water conservation and pollution prevention measures where feasible. It is also the City's policy to refer irrigation users supplied by the City to the Jones County and Taylor County Extension Offices for expert assistance with development of individual on-farm water conservation and pollution prevention measures.

IX. Describe any other water conservation practice, method, or technique which the supplier shows to be appropriate for achieving conservation (if applicable):

The City of Abilene has developed and implemented a reclaimed water program whereby treated wastewater is supplied to irrigators in the service area thereby lessening the demand for both raw and treated water use for irrigation.

X. Additional requirements:

It is Abilene's policy to include in every wholesale potable water supply contract entered into or renewed after official adoption of the City's Municipal Water Conservation Plan, including any contract extension, that each successive wholesale customer develop and implement a water conservation plan or water conservation measures using applicable elements in 30 TAC 288. If the wholesale customer intends to resell the water, then the contract between Abilene and the wholesale customer must provide that the contract for the resale of the water must have water conservation requirements so that each successive customer in the resale of the water will be required to implement water conservation measures in accordance with 30 TAC 288.

Appendix E

Industrial/Mining Water Conservation Plan

Texas Commission on Environmental Quality

INDUSTRIAL/MINING WATER CONSERVATION PLAN

This form is provided to assist entities in conservation plan development for industrial/mining water use. If you need assistance in completing this form or in developing your plan, please contact the conservation staff of the Resource Protection Team in the Water Supply Division at (512) 239-4691.

Date: April 2010

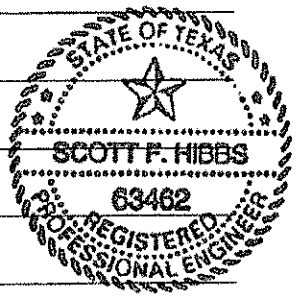
Name of Entity: City of Abilene

Address & Zip: P.O. Box 60, Abilene, TX 79604-0060

Telephone Number: (325) 676-6000

Form Completed By: Scott F. Hibbs, P.E.

Title: Principal Engineer; Enprotec/Hibbs & Todd, Inc.



Signature 4/2/10

Form Verified By: Tommy O'Brien, P.E.

Title: Director of Abilene Water Utilities

Signature , P.E.

I. BACKGROUND DATA

A. Water use

1. Annual diversion appropriated or requested (in acre-feet):

The City of Abilene diverted in 2008 approximately 24,934 acre-feet of which approximately 804 acre-feet of the surface water diversion was used by industrial users. It should be noted that prior to 2005 the industrial user

category included public and institutional users consisting of hospitals and universities. In 2005, the City began tracking public/institutional water sales in a separate category apart from industrial use. Industrial use represented in this plan is exclusive of public/institutional use.

2. Maximum diversion rate (cfs):

The City's potable water treatment works have a combined capacity of 51 million gallons per day (MGD). At 51 MGD the diversion of raw water to the treatment works is 79 cubic feet per second (CFS).

B. Water sources

1. Please indicate the maximum or average annual amounts of water currently used and anticipated to be used (in acre-feet) for industrial/mining purposes:

Projected annual industrial use over the next decade is summarized as follows:

Year	Industrial Diversion (ac-ft/yr)
2010	900
2011	905
2012	910
2013	916
2014	921
2015	927
2016	932
2017	938
2018	943
2019	949

Source: Initially Prepared 2011 Brazos G Regional Water Plan (Jones & Taylor County Manufacturing) & City of Abilene Records

2. How was the surface water data provided above (B1) obtained?
Master meter ____; Customer meter _X_;

3. Was purchased water raw __X_ or treated __X_?
If both, % raw _0.5%_, % treated _99.5%_.
Supplier(s): NA

4. How was the groundwater data provided above (B1) obtained? NA
Master meter____; Customer meter____; Estimated ____; Other ____
If other, identify source: _____

5. What is the rate and cost of purchased water?
Rate : per 1,000 gallons Cost: $2.16
There is an additional charge of $0.60 per thousand gallons for costs associated with developing the City's Lake Ivie Supply. Rates and charges are current as of September 10, 2009.

C. Industrial/Mining Information

1. Major product or service produced by applicant:

Industrial water users receiving water from the City of Abilene utilize water to operate and produce a variety of products and services including:

Industry	SIC	NAICS	# of Employees
Linen and uniform rental supply	7213	812331	50-99
Other specialty food stores	5451	445299	10-19
All other food mfg.	2015	311999	100-249
Bread and bakery product mfg.	2051	311812	100-249
Soft drink mfg.	2086	312111	300-747
Plate work/fabricated structural product	3443	332312	10-19
Turbine and power transmission equipment	3568	333613	50-99
Other electronic component mfg.	3679	334419	100-249
Plumbing goods merchant wholesalers	3432	423720	100-249
Ship and boat building	3732	336612	100-249
Bottled/bulk water companies	2086	312112	10-19
All other plastic product mfg.	3089	326199	20-49
All other chemical preparation mfg.	2899	325998	100-249
Other rubber products mfg.	3069	326299	100-249
Printing	2752	323110	10-19
All other misc mfg.	2499	339999	2

Source: Texas Workforce Commission-Labor Market Information

II. WATER USE AND CONSERVATION PRACTICES

A. Water Use in Industrial or Mining Process:

Production Use	% Groundwater	% Raw Surface Water	% Saline Water	% Treated Water	Water Use (In Acre-Feet)
Cooling, condensing, & refrigeration	0	0	0	0	0
Processing, washing,	0	3%	0	97%	68
Boiler feed	0	0	0	0	0
Incorporated into product	0	0	0	100%	494
Other	0	0	0	0	0

Facility Use	% Groundwater	% Raw Surface Water	% Saline Water	% Treated Water	Water Use (In Acre-Feet)
Cooling tower(s)	0	0	0	0	0
Pond(s)	0	0	0	0	0
Once through	0	0	0	0	0
Sanitary & drinking water	0	0	0	100%	240
Irrigation & dust control	0	100%	0	0	2

1. Was fresh water recirculated at these facilities?
   _____ Yes __X__ No

2. Was electric power generated at these facilities (for in-plant use or for sale)?
   _____ Yes __X__ No

3. Description of the above use(s) of water (e.g., if water is being used for cooling, indicate the cooling system: tower, pond, etc.):

The City of Abilene supplies water to approximately 21 industrial users. Approximately 61% of Abilene's current industrial use is water that is incorporated into the product and is not returned to sewer. An additional 8% of Abilene's current industrial use is process water used in production and is not returned to sewer. Approximately 30% of the current industrial use is water for domestic drinking, bathing and wash water use at these facilities or is used in the process in some form yet returned to sewer. The remaining 1% of industrial water use is raw water use for truck washing, irrigation use or dust control.

4. Describe or illustrate how surface water is diverted and delivered to the point(s) of use, the location of the diversion(s) and points of use, and how diversions are measured:

Raw surface water is supplied to Abilene's treatment works from several sources. Abilene utilizes master meters at each source of supply to account for the amount of water diverted from each source of supply. A pump station located on the eastern bank of Lake Fort Phantom pumps raw water from Lake Fort Phantom to the Northeast Treatment Plant and the Grimes Treatment Plant. A raw water delivery system consisting of two parallel pipelines can provide up to 27 million gallons per day (MGD) from Hubbard Creek Reservoir to the Fort Phantom delivery system. Raw water is also pumped approximately 50 miles from Lake O.H. Ivie to the Hargesheimer Water Treatment Plant located on Highway 83/84 near Tuscola. Water flows through a 21-mile long gravity pipeline from Lake Abilene to the small Abilene Treatment Plant (currently not in use) located near Buffalo Gap Road and FM 707. A pump station on the banks of the Clear Fork of the Brazos River, near Lake Fort Phantom provides diversion pumping for up to 30,000 ac-ft/yr into Lake Fort Phantom under selected volume and quality conditions.

The City's Water Treatment System consists of three treatment plants having the maximum treatment capacity of 51 MGD and combined treated water storage of 20.76 million gallons (MG). The Northeast Water Treatment Plant on East Lake Road has a capacity of 25 MGD and treats raw water drawn from Lake Fort Phantom and Hubbard Creek Reservoir. The Grimes Water Treatment Plant on East Highway 80 has a treatment capacity of 20 MGD and treats water drawn from Lake Fort Phantom and Hubbard Creek Reservoir. The Hargesheimer Water Treatment Plant located on Highway 83/84 near Tuscola has a micro-filtration capacity of 8.95 MGD, and a reverse osmosis/ blended capacity of 6.0 MGD, and treats raw water drawn from Lake O.H. Ivie. In addition to the 20.76 MG of treated water storage at the three treatment plants, Abilene has 19.25 MG of ground/elevated storage located throughout the City's potable water distribution system.

Two of the industrial water users supplied by the City utilize raw water diversion totaling approximately 3-4 acre-feet per year or approximately 0.5% of the total industrial water use. Raw water diverted for industrial use is delivered from the raw water delivery system that supplies water to the Grimes water treatment plant. Each of the two industrial raw water service lines is equipped with a meter that measures water diversion to each industrial raw water user.

5. Monthly water demand for previous year (in acre-feet):

2008	Industrial Diversion (ac-ft)	% of Industrial Diversion Returned to WWTP	Net Monthly Industrial Demand (ac-ft)
January	57	30%	40
February	62	30%	43
March	62	30%	43
April	61	30%	43
May	65	30%	46
June	77	30%	54
July	6	30%	4
August	141	30%	99
September	101	30%	71
October	59	30%	41
November	60	30%	42
December	53	30%	37
Total	**804**		**563**

6. Projected monthly water demand for next year (in acre-feet):

2010	Industrial Diversion (ac-ft)	% of Industrial Diversion Returned to WWTP	Net Monthly Industrial Demand (ac-ft)
January	64	30%	45
February	71	30%	50
March	66	30%	46
April	81	30%	57
May	85	30%	60
June	92	30%	64
July	50	30%	35
August	99	30%	69
September	94	30%	66
October	65	30%	46
November	75	30%	52
December	58	30%	40
Total	**900**		**630**

B. Specific and Quantified Conservation Goal

Water conservation goals for the industrial and mining sector are generally established either for (1) the amount of water recycled, (2) the amount of water reused, or (3) the amount of water not lost or consumed, and therefore is available for return flow.

1. Water conservation goal (water use efficiency measure):

Type of goal to be used:

___ Percent of water reused
___ Percent of water not consumed, and therefore returned as flow
_X_ Other (see Item 2. below)

2. Provide the specific and quantified five-year and ten-year targets for water savings and the basis for development of such goals for this water use/facility:

The primary industrial water use by industrial users currently served by the City of Abilene is water incorporated into industrial products. Approximately 61% of industrial water use by users currently served by the City is water

incorporated into the industrial products produced by these users and is not subject to conservation measures. In 2008 this industrial water use amounted to 494 ac-ft. The remaining areas of industrial water facility use subject to water conservation measures currently include water for wash-down, dust control and sanitary/domestic uses and represents 39% of industrial diversions or approximately 310 ac-ft in 2008. Conservation measures appropriate for reduction of industrial water used for wash-down, dust control, and sanitary/domestic uses include: reuse of treated wastewater effluent for wash-down and dust control; implementation of water-efficient practices and technologies; and sanitary/domestic industrial water use conservation strategies.

Based on these industrial water conservation measures the 5- and 10-year target for industrial water savings is to maintain source water diversion for wash-down, dust control and sanitary/domestic uses by current industrial users at not more than 350 acre-feet per year through the end of 2015 and 2020. The 5 and 10-year goals represent an annual water savings of approximately 12-20 acre-feet per year[(1)] over present industrial water use rates, and were developed considering Abilene's current industrial user base and projected industrial water use for the coming decade. The City will evaluate and revise industrial water use conservation goals, if warranted, as industrial users are added or subtracted from the current user base. The City encourages new industrial users to include and implement water conservation as a strategic part of their operating program.

Note 1: Projected industrial use in 2015 and 2020 are 927 and 954 ac-ft/yr respectively.
(927 ac-ft x 39%) - 350 ac-ft = 12 ac-ft
(954 ac-ft x 39%) - 350 ac-ft = 22 ac-ft

3. Describe the methods and/or device within an accuracy of plus or minus 5% used to measure and account for the amount of water diverted from the source of supply:

It is Abilene's policy to purchase meters that meet at least the minimum standards developed by the American Water Works Association. Metering devices used to meter water diverted from the source of supply are typically accurate to within plus or minus 5% to measure and account for water diverted from the source of supply.

4. Leak-detection, repair, and water-loss accounting measures used:

It is Abilene's policy to investigate complaints associated with potential water leaks on a timely basis. Once alerted to a potential leak, City crews visually

inspect suspected leaks, with quick and timely repairs to those leaks when detected. Water loss control is practiced through water loss accounting procedures and water loss audits. The City's record keeping system aids in comparing the water sold figures to the water diverted figures to detect unusual use patterns and possible leaks from the system.

5. Equipment and/or process modifications used to improve water use efficiency:

The Water Utilities Department strives to work with area industries to find best methods to conserve water use. Industrial facility inspections and individual responses to public inquiries about water and conservation measures help to focus conservation efforts towards the industrial sector needs.

6. Other conservation techniques used:

The City of Abilene's Water Conservation Program utilizes Supply Management Methods and Demand Management Methods to work towards optimizing use of Abilene's water resources.

a. Supply Management Program Elements consist of:
   (1) Coordinated use of water supplies to ensure the City withdraws water from its water supply reservoirs in a manner that ensures maximum dependable yield and efficiency of operation.
   (2) Watershed management to ensure diversion channels to Lake Fort Phantom Hill are clean, relatively straight, and obstruction-free to increase captured water flow while minimizing flooding potential in populated areas and reducing siltation entering Lake Fort Phantom Hill.
   (3) Metering all service connections to ensure maximum return for delivered water while minimizing unaccounted-for water loss.
   (4) Leak detection and repair to minimize unaccounted-for water loss.
   (5) Treated wastewater reuse and recycling to lessen the demand for raw water used to produce potable water, and for raw water pumping for irrigation uses.

b. Demand Management Program Elements consist of:
   (1) Water pricing as a mechanism for encouraging water customers to conserve.
   (2) Regulations for conserving water via the various Water Conservation Plans and the Drought Contingency Plan adopted by the City.

(3) Plumbing Code for the City of Abilene requires maximum standard plumbing fixture capacities not be exceeded. Abilene supports a Low-Income Housing Retrofit Program and City Building Retrofit program to determine the feasibility of retrofitting fixtures in selected structures.

(4) Continuing education programs to increase public awareness of supply, treatment and conveyance systems in Abilene, to increase public awareness of the benefits and need for conservation, and to make information about practical cost-effective methods and technologies to achieve conservation readily available.

III. WASTEWATER USE CHARACTERISTICS

A. Check the type(s) of wastewater disposal system(s) used at this facility:

____ On-site wastewater plant
____ Septic tank(s)
____ Injection well(s)
__X__ City or regional wastewater system
_____ Other (Please identify)

B. What quantity of fresh water was consumed, and therefore not returned to a wastewater treatment system (public or private), or to a water course (including loss to product, evaporation, injection, etc.)?

During the period of 2006-2008 the system-wide average of wastewater treated at the City's Hamby wastewater treatment plant as a percentage of the total raw water diverted for treatment at the City's potable water treatment facilities averaged 55%. Therefore, 45% of diverted raw water was not returned to the Hamby Plant during the period of 2006-2008. Industrial users return even less with approximately 30% of diverted industrial water being returned to the Hamby plant for treatment, based on industrial facility inspections conducted by the City staff and available City records.

IV. ADDITIONAL COMMENTS/INFORMATION

Please provide any additional information that may indicate the present and future water needs at this facility, and any water problems. NA

Appendix F

City of Abilene Reservoir Operation Plan

City of Abilene
Reservoir Operation Plan

In accordance with 30 Texas Administrative Code §288.5(1)(H), the City of Abilene operates Lake Ft. Phantom Hill and Hubbard Creek Reservoir as generally outlined in the 1980 Study of Coordinated Operation of Existing Raw Water Supply Sources (Study) and the 1989 Report on Economy of System Operation (Report) and the 1998 Memorandum Report Water Supply Pumpage Guideline (Memorandum). A copy of the 1989 Report and 1998 Memorandum are available for review during normal business hours. A copy of the 1980 Study can be obtained from the engineering consultant who prepared the Study, upon request.

The City is updating the previous operation plans to incorporate current hydrology data and operating practices. Additionally, Lake O.H. Ivie will be added to the City's Reservoir Operation Plan. Once complete, the updated Reservoir Operation Plan will be available for review during normal business hours.

Appendix G

Resolution Adopting the Water Conservation Plan

RESOLUTION NO. 12-2010

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF ABILENE, TEXAS, APPROVING A RESOLUTION SEPARATING THE WATER CONSERVATION PLAN ("WCP") FROM THE WATER MANAGEMENT PLAN AND APPROVING NON-SUBSTANTIVE UPDATES TO THE WCP.

WHEREAS, Texas Administrative Code (TAC) Chapter 288, "Water Conservation Plans, Drought Contingency Plans, Guidelines and Requirements", requires water systems holding surface water rights in excess of 1,000 acre-feet per year must maintain and submit to the Texas Commission on Environmental Quality (TCEQ) a current Water Conservation Plan (WCP); and

WHEREAS, on March 24, 2005 through Resolution 8-2005 the City of Abilene adopted a WCP as part of the City's Water Management Plan; and

WHEREAS, on September 27, 2007 Resolution 32-2007 supplemented the Water Management Plan to include an Industrial/Mining Conservation Plan and an Agricultural Water Conservation Plan; and

WHEREAS, the Water Management Plan has not been updated and as a result has become obsolete except to those sections related to the WCP; and

WHEREAS, the City maintains a Drought Contingency Plan under Chapter 32, Article VI of the City of Abilene Municipal code (Water Conservation Plan ordinance), which was amended through Ordinance 9-2005 passed on April 14, 2005 and is referenced in the Water Management Plan; and

WHEREAS, the TCEQ requires each WCP to be updated at least every five years; and

WHEREAS, in order to make the updating process more efficient, staff desires to accommodate the two different dates for updating by updating both the municipal water use and wholesale water supplier plans and the agricultural and industrial water use plans together at this time;

NOW THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF ABILENE, TEXAS:

Part 1: That the City of Abilene Water Conservation Plan and the Drought Contingency Plan (Water Conservation Plan ordinance) shall be removed from the Water Management Plan and be considered for all purposes separate documents.

Part 2: That the updates to the Water Conservation Plan include the following system inventory information: (1) Utility Profile & Water Conservation Plan Requirements for Municipal Water Use by Public Water Suppliers; (2) Profile & Water Conservation Plan Requirements for Wholesale Public

Water Suppliers; (3) Industrial/Mining Water Conservation Plan; and (4) System Inventory and Water Conservation Plan for Agricultural Water Supplies Providing Water To More than One User as summarized in Exhibit "A" are accepted and approved.

ADOPTED this 8th day of April, 2010.

APPROVED:

Norm Archibald, Mayor

ATTEST:

City Secretary

APPROVED AS TO FORM:

City Attorney

Exhibit A

City of Abilene
Water Conservation Plan Summary

Section I. Declaration of Policy, Purpose and Intent

The purpose of the Water Conservation Plan (Plan) is to: promote the wise and responsible use of water by implementing structural programs that result in quantifiable water conservation results; develop, maintain, and enforce water conservation policies and ordinances; and support public education programs that educate customers about water and wastewater facilities operations, water quantity and quality, water conservation and non-point source protection.

Section II. Utility Profile Summary

Population

Abilene's population in the year 2010 as determined by information supplied by the Brazos Region G Water Planning Group is estimated to be 124,607 and is projected to reach 130,220 by 2020. Abilene supplies treated water to wholesale purchasers who in turn resell that water to their system users. Total population of wholesale users in the year 2010 is estimated to be 36,755, and is projected to reach 37,495 persons by the year 2020.

Customer Data and Water Use Data

Abilene's water customers consist of a mixture of residential, commercial, industrial, wholesale, institutional and irrigation users. City of Abilene residential customers are supplied through approximately 34,200 connections with approximately 200 residential connections added each year. Abilene serves approximately 3,830 commercial connections with a net average gain of approximately 15 new commercial connections each year. Abilene serves approximately 21 industrial users with an average of three new industrial connections added each year. Abilene also contracts to sell water to 13 wholesale customers and Dyess AFB.

Approximately 24 reclaimed water customers citywide and an additional 10 agricultural irrigators around the Hamby Water Reclamation Plant utilize treated wastewater for agricultural and irrigation use.

Abilene customers including residential, commercial, industrial, and institutional users use approximately 86% of the total water delivered from the City's potable water treatment works while wholesale customers use approximately14% of the total water delivered from the City's treatment works.

Water Supply System

Water Sources

Raw surface water is supplied to Abilene's treatment works from several sources. The City of Abilene owns and holds surface water rights to 30,690 acre feet per year (ac-ft/yr) from Lake Fort Phantom Hill, of which 25,690 ac-ft/yr are for municipal purposes, 4,000 ac-ft/yr are for industrial purposes, and 1,000 ac-ft/yr are for irrigation. The Clear Fork Diversion, owned and operated by Abilene, allows a maximum of 30,000 ac-ft/yr to be diverted from the Clear Fork of the Brazos to Lake Fort Phantom Hill.

The City owns and is allocated use of 1,675 ac-ft/yr of water for municipal purposes from Lake Abilene. Lake Abilene, however, is not considered a dependable supply by the City and is currently not used. The City also holds surface water rights to 3,880 ac-ft/yr from Lake Kirby, also owned by Abilene, for multiple use purposes and for storage/diversion of reclaimed water used for irrigation purposes. Hubbard Creek Reservoir, owned and operated by the West Central Texas Municipal Water District provides by contract up to 25,500 ac-ft/yr (125% of Abilene's portion of the allocated safe yield of Hubbard Creek Reservoir, depending on the lake level) of raw surface water for use by the City. Abilene may utilize by contract up to 16.54% of the safe yield of Lake O.H. Ivie.

Water Treatment

A pump station located on the eastern bank of Lake Ft. Phantom Hill pumps raw surface water from Lake Ft. Phantom Hill to the Northeast Treatment Plant and the Grimes Treatment Plant. A raw water delivery system consisting of two parallel pipelines can provide up to 27 million gallons per day (MGD) from Hubbard Creek Reservoir to the Ft. Phantom Hill delivery system. Raw water is pumped approximately 50 miles from Lake O.H. Ivie to the Hargesheimer Water Treatment Plant located on Highway 83/84 near Tuscola. A pump station on the banks of the Clear Fork of the Brazos River, near Lake Ft. Phantom Hill provides diversion pumping of up to 30,000 ac-ft/yr into Lake Ft. Phantom Hill under selected volume and quality conditions.

The City's Water Treatment System consists of three treatment plants having a maximum treatment capacity of 51 MGD and combined treated water storage of 20.76 million gallons (MG). The Northeast Water Treatment Plant on East Lake Road has a capacity of 25 MGD and treats raw water drawn from Lake Ft. Phantom Hill and Hubbard Creek Reservoir. The Grimes Water Treatment Plant on East Highway 80 has a treatment capacity of 20 MGD and treats water drawn from Lake Ft. Phantom Hill and Hubbard Creek Reservoir. The Hargesheimer Water Treatment Plant located on Highway 83/84 near Tuscola has a micro-filtration capacity of 8.95 MGD, and a reverse osmosis/ blended capacity of 6.0 MGD, and treats raw water drawn from Lake O.H. Ivie.

Water Distribution

The City of Abilene's water distribution system provides economical and compatible facilities that are capable of furnishing sufficient water at suitable pressures to both Abilene retail and wholesale purchasers. The system consists of nearly 750 miles of underground water mains, twelve pumping stations, seven ground storage tanks, eight elevated storage tanks, over 12,000 valves, over 2,700 fire hydrants, and over 38,400 meters.

After the water is processed at the treatment plants, it is pumped into the distribution system and stored in ground and elevated storage tanks with a combined volume of 19.25 million gallons. The distribution network is laid out in a continuous looped system to circulate water and maintain constant system pressure. Pumping stations are located strategically throughout the system to pump water, maintain uniform pressure and maintain storage tank levels.

Treated water from the Abilene treatment plants enters the wholesalers' systems through metered interconnections. According to TCEQ's records as available through the Texas Water Utility Database (TWUD), production capacity of the wholesale purchasers' systems amount to approximately 17.5 MGD. Based on TWUD records, ground storage capacity within the wholesalers' systems is approximately 5.5 million gallons while total elevated storage volume is approximately 3.3 million gallons.

Wastewater System

Wastewater Collection

Abilene's wastewater collection system consists of a network of approximately 653 miles of sewers, five lift stations, and approximately 5,100 manholes serving the cities of Abilene, Tuscola, Tye and the Hawley ISD. Sewage flows by gravity, aided when necessary by lift stations, through the collection system into the Buck Creek Pump Station, which has a rated pumping capacity of approximately 24 MGD. An emergency storage basin at this facility has a capacity of approximately 23 million gallons. Sewage is metered at Buck Creek and then pumped five miles to the wastewater treatment plant. Collected wastewater is treated at the City of Abilene's Hamby Wastewater Reclamation Plant which is operated under permit number 10334-004. The operator in responsible charge of the Hamby Plant is employed by the City of Abilene.

Wastewater Treatment

When wastewater reaches the Hamby treatment facilities northeast of town, it undergoes full biological treatment that includes grit removal, sedimentation, activated sludge process, filtration, chlorine disinfection, and disinfectant removal. Wastewater quality is protected against industrial pollution through an Industrial Pre-Treatment Program. Industrial users are required to treat wastewater to specific standards before it is released into the municipal sanitary sewer system. Irrigators in and around the City reuse some of the treated effluent. The remainder is discharged to Deadman Creek by way of Freewater Creek or is discharged to Lake Kirby by

way of the City's reclaimed water system. Sewage biosolids are disposed of in a sludge disposal unit.

Section III. Water Conservation Goals

Municipal Use Goals

Water users (all City of Abilene water users such as residential, commercial, and industrial) located within the City of Abilene's Certificate of Convenience and Necessity (CCN) coverage area historically use (when not under water use restrictions) approximately 149 gallons of water per capita per day (gpcd). The 5-year goal for water use reduction by City of Abilene users is to maintain per capita water use at or below 162 gpcd by the end of 2015. The 10-year goal is to maintain per capita use at or below 161 gpcd by the end of 2020. These goals are set in accordance with Region G Planning Group projections.

Wholesale Use Goals

Wholesale water users served by the City of Abilene, located outside the City of Abilene's CCN coverage area, historically use (when not under water use restrictions) approximately 83 gpcd of water supplied by Abilene. The 5 and 10-year goals for wholesale users supplied by the City of Abilene is to reduce per capita use by 1 gallon per day per user to 82 gpcd by the end of 2015 and 2020. These goals are set in accordance with Region G Planning Group projections.

Industrial Use Goals

The 5- and 10-year target for industrial water savings is to maintain source water diversion for wash-down, dust control and sanitary/domestic uses by current industrial users at not more than 350 acre-feet per year through the end of 2015 and 2020. The 5 and 10-year goals represent an annual water savings of approximately 12-20 acre-feet per year over present industrial water use rates, and were developed considering Abilene's current industrial user base and projected industrial water use for the coming decade.

Agricultural Use Goals

The 5-year and 10-year target for water savings is to maintain the irrigation requirement at or below the area agronomic standard of 24-inches per acre per year. It should be noted that occasionally the City may allow the agronomic standard rate to be exceeded in order to flush the crop root zone to improve plant productivity, livelihood, growth enhancement and overall reduction in crop water demand.

Section IV. Metering Devices

It is Abilene's policy to purchase meters that meet at least the minimum standards developed by the American Water Works Association. All metering devices used to meter water diverted from the source of supply are accurate to within plus or minus 5% to measure and account for water diverted from the source of supply. All service connections in the distribution system are

metered. Aged meters are systematically replaced to assure reliability of meter performance. The City has established the following meter maintenance and replacement programs:

Meter Type	Calibration Period and Replacement
Master Meters	Annually and replaced as needed
1-1/2 inch and larger	Annually and replaced as needed
1-1/2 inch and smaller	Every 10 years and replaced as needed

The wholesale water purchasers are responsible for metering device installation, maintenance and calibration for meters located within their service areas.

Section V. Universal Metering

It is Abilene's policy to individually meter all water usage, except for fire protection and fire hydrant flushing to maintain a safe potable water system, including all new construction within the City's CCN coverage area. Combined with an aggressive leak detection and repair program, electronic data collection devices, and a computerized billing system, Abilene's universal metering program has resulted in a water delivery accuracy rate well within industry operating standards.

Section VI. Measures to Determine and Control Unaccounted-For Uses of Water

The record management system utilized by the City of Abilene segregates water sales and users into user classes of residential, commercial, public/institutional, and industrial. It is Abilene's policy to investigate customer complaints of low pressure and possible leaks. Abilene visually inspects suspected leaks and makes quick and timely repairs to those leaks when detected. Abilene utilizes a record management system which records water pumped, water delivered, water sales and water losses to track water transmission, distribution, and delivery to customers. This information is used to evaluate the integrity of the water delivery system from source to end user to control and minimize unaccounted-for uses of water.

Section VII. Water Conservation Program

The City of Abilene's Water Conservation Program utilizes Supply Management Methods and Demand Management Methods to work towards optimizing use of Abilene's water resources.

Supply Management Program Elements consist of:

1. Coordinated use of water supplies to ensure the City withdraws water from its water supply reservoirs in a manner that ensures maximum dependable yield and efficiency of operation.
2. Watershed management to ensure diversion channels to Lake Ft. Phantom Hill are clean, relatively straight, and obstruction-free to increase captured water flow while minimizing flooding potential in populated areas, and reducing siltation entering Lake Ft. Phantom Hill.

3. Metering all service connections to ensure maximum return for delivered water while minimizing unaccounted-for water loss.
4. Leak detection and repair to minimize unaccounted-for water loss.
5. Treated wastewater reuse and recycling to lessen the demand for raw water used to produce potable water, and for raw water pumping for irrigation uses.

Demand Management Program Elements consist of:

1. Water pricing as a mechanism for encouraging water customers to conserve.
2. Regulations for conserving water via the Water Conservation Plan and Drought Contingency Plan adopted by the City.
3. Plumbing Code for the City of Abilene requires maximum standard plumbing fixture capacities not be exceeded. Abilene supports a Low-Income Housing Retrofit Program and City Building Retrofit program to determine the feasibility of retrofitting fixtures in selected structures.
4. Continuing education programs to increase public awareness of supply, treatment and conveyance systems in Abilene, to increase public awareness of the benefits and need for conservation, and to make information about practical cost-effective methods and technologies to achieve conservation readily available.

Section VIII. Public Involvement

Public involvement in the formation of Abilene's Water Conservation Plan formally began in February 1985 with the appointment of a Water Conservation Advisory Committee to assist the Water Utilities staff in the preparation of the Water Conservation Plan. Since that time public involvement has been an ongoing and integral part of Abilene's water conservation programs. A public information and education program developed and implemented by the City is an important component in the City's water conservation strategy. Water Utilities education programs have three principal objectives including:

- Increase public awareness of supply, treatment, and conveyance systems in Abilene.
- Increase public awareness of the needs for and benefits of conservation.
- Make available information about practical cost effective methods and technologies to achieve conservation.

A variety of communication and marketing techniques are being utilized including: printed marketing materials; electronic information and marketing materials via Abilene's internet website; billboard advertising; newspaper supplements; presentations at neighborhood, civic, social, and professional organizations; public service announcements; special promotions sponsored by local media; and public school programs.

Section IX. Water Rate Structure

In 1984, the City of Abilene adopted a non-promotional, inverted rate structure. Under this rate structure the billing rate increases as individual water consumption increases. This rate structure promotes conservation and shifts the cost of supplying water to those consumers using it most.

Section X. Means of Implementation and Enforcement

This Water Conservation Plan has been adopted by the City by means of resolution.

1. Enforcement Within Abilene's CCN Area

The Plan is enforced within the Abilene CCN coverage area by providing service taps only to customers complying with adopted ordinances, maintaining a non-declining rate structure, discontinuing service to those customers who do not pay their water bills until payment is made, and certifying new construction only after verifying it conforms to adopted ordinances and plumbing codes.

2. Enforcement for Abilene's Wholesale Purchasers

Wholesale customers will receive written notification of Plan adoption and any subsequent Amendments. Adoption of this Plan by the City of Abilene per 30 Texas Administrative Code (TAC) Rule §288.5 obligates wholesale customers as defined in 30 TAC Rule §288.1 to implement water conservation measures.

Section XI. Additional Wholesale Water Contract Requirements

It is Abilene's policy to include in every wholesale water supply contract entered into or renewed after official adoption of the Plan, including any contract extension, that each successive wholesale customer develop and implement a water conservation plan or water conservation measures using applicable elements in 30 TAC 288. If the wholesale customer intends to resell the water, then the contract between Abilene and the wholesale customer must provide that the contract for the resale of the water must have water conservation requirements so that each successive customer in the resale of the water will be required to implement water conservation measures in accordance with 30 TAC 288.

Section XII. Coordination with Brazos Region G Planning Group

All of the customers served by the City of Abilene are located within the Brazos G Regional Planning Area. Abilene has provided a copy of this Plan to the Brazos Region G Planning Group.

Section XIII. Revisions to the Water Conservation Plan

The City of Abilene will review and update this water conservation plan, as appropriate, based on new or updated information, such as the adoption or revision of the regional water plan. As a minimum the Plan will be updated every five (5) years.

Section XIV. Severability

It is hereby to be the intention of Abilene that the sections, paragraphs, sentences, clauses, and phrases of this Plan are severable and if, any phrase, clause, sentence, paragraph or section shall be declared unconstitutional by the valid judgment or decree of any court of competent jurisdiction, such unconstitutionality shall not affect any of the remaining phrases, clauses, sentences, paragraphs or sections of this Plan, since the same would not have been enacted by Abilene without the incorporation into this Plan of any such unconstitutional phrase, clause, sentence, paragraph or section.

Appendix H

Notification to Wholesale Purchasers

Enprotec / Hibbs & Todd

April 9, 2010

Mayor Jeff Barton
City of Baird
328 Market St.
Baird, TX 79504-6410

Re: Update of City of Abilene Water Conservation Plan

Dear Mayor Barton:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568

P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. Donnie Edwards
City of Merkel
100 Kent St.
Merkel, TX 79536-3612

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Edwards:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568

P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mayor Roger Schuman
City of Tye
P.O. Box 369
Tye, TX 79563-0369

Re: Update of City of Abilene Water Conservation Plan

Dear Mayor Schuman:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568 P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mayor Dustin Hawk
City of Clyde
P.O. Box 1155
Tye, TX 79510-1155

Re: Update of City of Abilene Water Conservation Plan

Dear Mayor Hawk:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568

P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Environmental, Civil & Geotechnical Engineers

Abilene Office
402 Cedar
Abilene, Texas 79601
P.O. Box 3097
Abilene, Texas 79604
325.698.5560 | 325.691.0058 fax

Lubbock Office
6310 Genoa Avenue, Suite E
Lubbock, Texas 79424
806.794.1100 | 806.794.0778 fax

Granbury Office
1301 Crawford Ave.
Granbury, Texas 76048
817.579.6791 | 817.579.8491 fax

Plano Office
One Preston Park
2301 Ohio Drive, Suite 105
Plano, Texas 75093
972.599.3480 | 972.599.3513 fax

www.e-ht.com

Firm Registration No. 1151

Enprotec / Hibbs & Todd

April 9, 2010

Mayor Veronica Burleson
City of Lawn
P.O. Box 246
Lawn, TX 79530-0246

Re: Update of City of Abilene Water Conservation Plan

Dear Mayor Burleson:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568

P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. Farris Neill
Blair WSC
P.O. Box 386
Merkel, TX 79536-0386

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Neill:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568

P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. Wade Anthony
Hamby WSC
4043 State Highway 351
Abilene, TX 79601-7425

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Anthony:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568

P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. Clois Versyp
Hawley WSC
P.O. Box 296
Hawley, TX 79525-0296

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Versyp:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568

P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. Mike Walla
SUN WSC
P.O. Box 217
Merkel, TX 79536-0217

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Walla:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568

P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. Lloyd Barr
Eula WSC
5744 FM 603
Clyde, TX 79510-6320

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Barr:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568 P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. Dwain Vinson
Potosi WSC
734 FM 1750
Abilene, TX 79602-7712

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Vinson:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568 P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. Bruce Harris
Steamboat Mountain WSC
P.O. Box 367
Tuscola, TX 79562-0367

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Harris:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568 P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. Dennis Reiling
View-Caps WSC
7017 US Highway
Abilene, TX 79606-4705

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Reiling:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568

P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. Brian Danko
7 CES/CEVC (Water Program Manager)
710 Third Street
Abilene, TX 79607-1670

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Danko:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568

P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Enprotec / Hibbs & Todd

April 9, 2010

Mr. David E. Laurence
7 CES/CEVC (Environmental Flight Chief)
710 Third Street
Abilene, TX 79607-1670

Re: Update of City of Abilene Water Conservation Plan

Dear Mr. Laurence:

As you are aware, in accordance with requirements found in 30 Texas Administrative Code (TAC) Chapter 288, the City of Abilene (City) is required by the State of Texas to develop, implement, and maintain a Water Conservation Plan ("Plan"). The City's existing Plan, in place since the mid 1980's, was recently updated. While essential and required elements of the Plan remain unchanged, we take this opportunity to remind you (on behalf of the City of Abilene) of the requirements for your water system. A summary of the City of Abilene, Texas Water Conservation Plan is provided for your review. The full version of the plan is available upon your request.

As a wholesale water customer of the City of Abilene, your system is obligated to develop a Water Conservation Plan of your own. The requirement for your system to develop a Water Conservation Plan is found in 30 TAC §288.5 (G). We request that at the time you submit your system's plan to the State, you furnish a copy to the City of Abilene as well. Providing a copy to the City of Abilene ensures a higher degree of accuracy as Abilene updates their Plan on a regular and prescribed basis. Please call me at 325.698.5560 if I may be of assistance to you on this matter.

Sincerely,

Enprotec / Hibbs & Todd, Inc.

Scott F. Hibbs, P.E.
Principal Engineer

c: Tommy O'Brien, P.E. City of Abilene
Project File 4568 P:\Projects\Abilene, City of\Water Conservation - Drought Contingency Plans\April 2010\Working Documents\Wholesaler Notification 04 02 10 a.doc

Appendix I

City of Abilene Water Rate Structure

EXHIBIT A

CITY OF ABILENE
WATER UTILITY DEPARTMENT
SCHEDULE OF RATES AND CHARGES
ADOPTED 9-10-09
BY RESOLUTION NO 30-2009

	WATER	SEWER
Residential *Service to all domestic housing of three units or less.*	Customer Service Charge. . . . . Based on Meter Size* First 6,000 gallons. . . . . $1.84 per thousand gallons 7,000 – 15,000 gallons. . . . .$2.60 per thousand gallons Over 15,000 gallons. . . . . .$3.60 per thousand gallons *+ O.H. Ivie Charge. . . . . $0.60 per thousand gallons*	Customer Service Charge. . . . . $9.00 Minimum First 10,000 gallons. . . . $1.23 per thousand gallons Over 10,000 gallons. . . . . No Charge
Commercial *Business operations including residential housing with four units or more.*	Customer Service Charge. . . . . .Applicable Minimum* First 6,000 gallons. . . . . $1.87 per thousand gallons Over 6,000 gallons. . . . . .$2.49 per thousand gallons *+ O.H. Ivie Charge . . . . . .$0.60 per thousand gallons*	Customer Service Charge . . . . . $9.00 Minimum All use . . . . . $1.23 per thousand gallons
Industrial	Customer Service Charge . . . . Applicable Minimum* All consumption . . . . . $2.16 per thousand gallons *+ O.H. Ivie Charge. . . . . $0.60 per thousand gallons*	Customer Service Charge . . . . . $9.00 Minimum All use . . . . . $1.23 per thousand gallons Surcharge Rate: B.O.D. ($0.091/lb) T.S.S. ($0.067/lb) F.O.G ($0.051/lb)
Yard Meter	Yard Meters all use . . . . . .$3.60 per thousand gallons *+ O.H. Ivie Charge. . . . . $0.60 per thousand gallons*	
Construction Water	Set-up fee . . . . . $60.00 All Use . . . . . $3.60 per thousand gallons *+ O.H. Ivie Charge. . . . . $0.60 per thousand gallons*	
Outside of City limits, double above rates for water consumption.		

***Charge Applies to Meter Size Indicated:**

5/8 or ¾	$10.40 Min. per month
1 inch	15.00
1-1/2 inch	27.00
2 inch	45.80
3 inch	86.00
4 inch	122.00
6 inch	214.00
8 inch	351.00
10 inch	451.00

MONTHLY ACCOUNT FEES

Environmental Rate:
All accounts . . . . . $2.50 per account
This fee supports the Stormwater Services and the Solid Waste Environmental Program.

Multiple Housing Units:
When more than two living or business units are supplied through one meter, each additional living or business unit will be charged two dollars and fifty cents ($2.50). No credit shall be allowed for vacant or unoccupied units if the utility account remains active.

Fire Line Sprinkler Systems:
$2.00 per inch in diameter of service connection

SERVICE FEES AND CONSTRUCTION FEES ON REVERSE SIDE

City of Abilene Water Utilities
Schedule of Rates and Charges – continued

SERVICE CHARGES:

New Service	$25.00
Transfer Service	$17.50
Temporary Service	$10.00
Delinquent On	$17.50
Illegal Consumption	$30.00
Re-read meter	$10.00
Return Check Charge	$30.00 per account
Meter Test	$25.00

DEPOSITS:

Deposits may be required based on payment history and/or credit worthiness.

TAP FEES:

Note: A plumbing permit must be issued by Building Inspection prior to payment of the tap fee.

New Taps:

¾ inch	$350.00
1 inch	375.00
1 ½ inch	525.00
2 inch and larger	Actual cost of installation

Replacement Tap Credit:

¾ inch	$20.00
1 inch	40.00
1 ½ inch	100.00

PRO RATA CHARGE FOR WATER AND SEWER LINE CONNECTION:

Sewer:

Installed prior to June 30, 1981	$2.25 per frontage foot
Installed after June 30, 1981	$4.00 per frontage foot

Water:

Installed prior to June 30, 1981	$3.25 per frontage foot
Installed after June 30, 1981	$5.00 per frontage foot

The basis for determining footage amounts is described in Chapter 32 of the Municipal Code.

RESOLUTION NO. 30-2009

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF ABILENE, TEXAS, REVISING THE SCHEDULE OF RATES AND CHARGES FOR WATER AND SEWER UTILITY SERVICE.

WHEREAS, Section 32-37 and Section 32-39 of the Abilene Municipal Code provide for the establishment of a Schedule of Rates and Charges for Water and Sewer Utility Service; and,

WHEREAS, the Schedule of Rates and Charges for Water and Sewer Utility Service has from time to time been revised by the Council;

WHEREAS, on September 11, 2008 the City Council of the City of Abilene adopted, by Resolution No. 31-2008, a Schedule of Rates and Charges for Water and Sewer Utility Service; and,

WHEREAS, at this time there is a need to revise the Schedule of Rates and Charges for Water and Sewer Utility Service adopted on September 11, 2008, NOW THEREFORE;

BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF ABILENE, TEXAS:

PART 1: That the Schedule of Rates and Charges for Water and Sewer Utility Service adopted on September 11, 2008 is hereby replaced by the Schedule of Rates and Charges for Water and Sewer Utility Service attached hereto as Exhibit "A".

PART 2: That this Schedule of Rates and Charges for Water and Sewer Utility Service shall be kept on file in the City Secretary's office and in the Water Utility office.

PART 3: That the effective date of the action for all non-contract customers shall be such that the first billing statement prepared in November 2009, which generally reflects water used in October 2009, and all subsequent billing statements, shall be based upon and reflect the rates presented in Exhibit A.

PART 4: That the effective date of the action for all contract customers shall be such that the first billing statement prepared in January 2010, which generally reflects water used in December 2009, and all subsequent billing statements, shall be based upon and reflect the rates presented in Exhibit A.

PART 5: The City Council will annually review and adjust the Schedule of Rates and Charges for Water and Sewer Utility Service to ensure that projected revenues can cover all projected expenses and financial obligations of the Department.

ADOPTED the 10th day of September, A.D., 2009.

ATTEST:

CITY SECRETARY

MAYOR

APPROVED:

CITY ATTORNEY

DROUGHT CONTINGENCY PLAN
(Water Conservation Plan Ordinance)

City of Abilene, Texas
Drought Contingency Plan Summary

Requirements for drought contingency planning are found in Texas Administrative Code (TAC) Chapter 288 and mandate that public water systems implement drought contingency planning. Drought planning serves to conserve the available water supply and protect the integrity of water supply facilities, with particular regard for domestic water use, sanitation, and fire prevention. Drought planning is also intended to protect and preserve public health, welfare, and safety and minimize the adverse impacts of water supply shortage or other water supply emergency conditions.

The Drought Contingency Plan (DCP) serves to minimize or eliminate water uses that are considered to be non-essential during times of water shortage or other emergency water supply conditions. Defined activities that constitute a waste of water subjects the offender(s) to penalties established in the DCP. The DCP applies to persons, customers, and property utilizing the Abilene Water Utility System wherever situated, including wholesale customers such as water supply corporations and others that receive water from the City of Abilene on a contract basis. The DCP provides that if a shortage of water in the City's water supply occurs, the water to be distributed will be divided among all users pro rata, according to the amount each may be entitled to, so that preference is given to no one user or user group. The DCP does not apply to the use of alternate water sources, including non-potable water and well water.

The DCP incorporates a Year Round Water Use Management component to maintain public awareness of the need to conserve water. The DCP describes four water conservation stages in order of severity including Stage 1 Water Alert, Stage 2 Water Warning, Stage 3 Water Emergency, and Stage 4 Water Crisis. The DCP describes drought contingency plan enforcement procedures including assessment of fines, procedures for contesting fines, hearing officers, administration of hearings, and appeals to hearing findings. The DCP also describes procedures for making payment of assessed fines, penalties for subsequent violations, and procedures for granting variances to the conditions of the DCP.

In its current form the City's DCP meets all State requirements for drought contingency plans. The current DCP also remains a useful management tool for controlling water use by system users during extreme drought conditions or major line breaks or leaks requiring reduced consumption by system users. The City of Abilene's Drought Contingency Plan is provided in Chapter 32, Article VI of the City of Abilene Municipal Code. The Drought Contingency Plan is often referred to as the "Water Conservation Plan Ordinance".

ARTICLE VI. WATER CONSERVATION PLAN*

*__Editor's note:__ Ord. No. 21-2003, Pt. 1(Exh. A), adopted May 22, 2003, amended art. VI in its entirety to read as herein set out. Formerly, art. VI pertained to similar subject matter as enacted by Ord. No. 23-1999, Pt. 1(Exh. A), adopted May 27, 1999; as amended. See the Code Comparative Table.

DIVISION 1. GENERALLY

Sec. 32-140. Declaration of policy.

In order to conserve the available water supply and protect the integrity of water supply facilities, with particular regard for domestic water use, sanitation, and fire prevention and to protect and preserve public health, welfare, and safety and minimize the adverse impacts of water supply shortage or other water supply emergency conditions, the City of Abilene hereby adopts the following regulations and restrictions on the delivery and consumption of water.

Water uses regulated or prohibited under this water conservation plan (the plan) are considered to be non-essential and continuation of such uses during times of water shortage or other emergency water supply conditions are deemed to constitute a waste of water which subjects the offender(s) to penalties as defined in sections 32-147 through 32-155 of this plan.

No person shall make, cause, use or permit the use of water from the City of Abilene Water Utility System for residential, commercial, industrial, agricultural, governmental or any other purpose in a manner contrary to provisions of this plan or in an amount in excess of that use permitted by the plan in effect pursuant to action taken by the mayor or his/her designee in accordance with the provisions of this plan.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-141. Authorization.

The mayor, mayor pro tempore, or the city manager, if so designated, is hereby authorized, consistent with the Charter of the City of Abilene, Sections 21 and 22 to exercise those powers considered to be reasonable or necessary for the protection of persons or property in assessing the current state of our water supply and directing the city manager to implement or terminate any stage, phase, or portion of the water conservation plan. Implementation and termination of any stage may occur, but is not mandated to occur, when conditions warrant.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-142. Application.

The provisions of this plan shall apply to persons, customers, and property utilizing the Abilene Water Utility System wherever situated, including customers such as water supply corporations, and

any others that receive water from the City of Abilene on a contract basis. If a shortage of water in the city's water supply occurs, the water to be distributed shall be divided among all users pro rata, according to the amount each may be entitled to, so that preference is given to no one and everyone suffers alike.

These water use restrictions do not apply to the use of alternate water sources, including non-potable water and well water. Customers using water from private wells on days other than those designated in this plan, or those watering from private wells during the hours of 10:00 am and 6:00 pm., must post a sign stating "WELL WATER". The sign must be properly sized and posted so it is visible from the street. The City of Abilene strongly encourages the use of alternative water sources for landscape purposes.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-143. Regional water planning groups and public involvement and education.

Sec. 32-143.1. Coordination with regional planning groups.

The service area of the City of Abilene is currently located within the Region G water planning area. The City of Abilene will cooperate and provide information regarding the plan as needed to all regional planning area groups.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-143.2. Public involvement.

The adoption of this plan and any amendments will provide for public input at a public hearing held in conjunction with one of the readings of said ordinance enacting the plan or amendments thereto.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-143.3. Public education.

The initial implementation of the plan and any subsequent stage shall be made public via announcement at a media conference. Year round water use management and any subsequent water conservation stages shall be publicized and shall become effective immediately upon such announcement. All implementation and termination of water conservation stages shall likewise occur via media conference.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

DIVISION 2. WATER CONSERVATION PLAN PROCEDURES

Sec. 32-144. Year round water use management.

To conserve water supplies available to the City of Abilene, year round water use management shall be implemented to restrict certain potable water use activities by all customers of the City of Abilene Water Utility System.

When conditions warrant, pursuant to section 32-141, the water conservation plan will be implemented in accordance with the applicable provisions of this plan.

(1) Year round water use management. The following year round provisions shall apply to all potable water customers of the City of Abilene Water Utility System:

a. Watering days: Customers are encouraged to conserve water by watering their lawn areas only once every seven (7) days on one of their designated watering days.

A customer's watering day is determined by the last digit of the house number or property address. Multi-unit properties will use the lowest address number, customers on rural routes will use the last number of their post office box number or their route number if they do not have a post office box number. Customers at Ft. Phantom Lake will use the last number of their lake lot. Customers in trailer parks will use the last number of their lot number.

When Ft. Phantom Reservoir is above 1630.9 feet elevation (less than five (5) feet below the spillway) the following three (3) day a week watering schedule applies:

TABLE INSET:

Designated Watering Days:	
Wednesday, Friday, Sunday	Odd numbered addresses
Tuesday, Thursday, Saturday	Even numbered addresses
Monday, Wednesday, Friday	Industrial, commercial, government customers, public and private schools and universities

When Ft. Phantom Reservoir is between 1630.9 feet and 1625.9 feet elevation (between five (5) and ten (10) feet below the spillway), the following two (2) day a week watering schedule applies:

TABLE INSET:

Designated Watering Days:	
Thursday, Sunday	Odd numbered addresses
Tuesday, Saturday	Even numbered addresses
Monday, Friday	Industrial, commercial, government customers, public and private schools and universities

b. Watering times: Watering by all commercial, industrial, and residential customers utilizing individual sprinklers, or sprinkler systems, on lawns, gardens, landscaped areas, trees, shrubs or other plants is prohibited except on designated day(s) and then only during the hours of 12:00 midnight to 10:00 am and from 6:00 pm until 12:00 midnight.

c. Watering of gardens, flowerbeds, trees and shrubs is permitted at any time of any day if:

i. A garden hose is used and is held in the hand during the duration of the irrigation event, or

ii. A faucet-filled container of five gallons or less is used, or

iii. A drip irrigation system such as a soaker hose, deep root water system, or bubbler is used. For the purpose of this section a drip irrigation system is defined as an irrigation device or system designed to emit water at low volumes and low pressures directly onto soil surface or below soil surface without airborne streams or droplets.

d. Irrigation of lawns is permitted at any time on any day if:

i. A garden hose is used and is held in the hand during the duration of the irrigation event, or

ii. A faucet-filled container of five (5) gallons or less is used.

A drip irrigation system shall not be used to irrigate lawns except on designated days and at designated times.

e. New lawns that have been seeded (not to include re-seeding or overseeding existing turf), sodded or mulched may be watered daily for eight minutes once during each of the following periods: 11:00 a.m. to 1:00 p.m.; 2:00 p.m. to 4:00 p.m.; 5:00 p.m. to 7:00 p.m.; and at regular intervals between 9:00 p.m. and 10:00 a.m. for a maximum of three (3) weeks. To qualify under this section, new lawns are those installed in conjunction with the construction of a new residence and for a period six (6) months thereafter or the re-tilling of an area equaling at least fifty (50) per cent of an existing yard.

f. Water wasting. The following uses of water are defined as "waste of water" and are absolutely prohibited:

i. Allowing water to run off a property through the street, gutter, ditch, alley, or drain for more than seventy-five (75) feet from the downgrade of the property line;

ii. Failure to repair a controllable leak, including a broken sprinkler head, a leaking valve, leaking or broken pipes, or a leaking faucet.

iii. Operating a permanently installed irrigation system with a broken sprinkler head; a sprinkler head that is spraying over a street or parking lot because it is out of adjustment; or a sprinkler head that is misting due to high pressure.

g. Use of water from fire hydrants shall be limited to firefighting activities or other activities necessary to maintain public health, safety, and welfare. The director of water utilities will review written requests on a case by case basis for the purchase and withdrawal of fire hydrants for land development and building construction processes.

h. Ornamental fountains are allowed if the fountain is equipped with a device for recycling water and water may be added to sustain appropriate maintenance levels only on the customer's regularly designated watering days.

i. Water may be added to swimming pools to sustain appropriate maintenance levels only on the customer's regularly designated watering days.

j. The operation of charity car washes must:

i. Not allow water to run-off more than seventy-five (75) feet, and

ii. Use hoses with on/off nozzles and buckets.

k. Large-scale recreational development, such as, but not limited to, water

parks, shall submit a plan to the director of water utilities that detail expected water consumption and maintenance requirements. Any deviation from the requirements of this article will be resolved on a case by case method.

(2) Administrative enforcement, presumption of ownership and control; hearing officers; administration of hearings, hearings, appeals, payment, subsequent violations, fees, and requests for variances as pertaining to year round water use management are addressed in sections 32-147 through 32-156.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-145. Water conservation stages.

(a) *Watering days.*

(1) During water conservation stages, a customer's watering day is determined by the last digit of the house number or property address. Multi-unit properties will use the lowest address number. Customers on rural routes will use the last number of their post office box number or their route number if they do not have a post office box number. Customers at Ft. Phantom Lake will use the last number of their lake lot. Customers in trailer parks will use the last number of their lot number.

TABLE INSET:

If a residential customer's last number is:	Customer's watering day is:
7 or 8	Sunday
9	Monday
0	Tuesday
1	Wednesday
2	Thursday
3 or 4	Friday
5 or 6	Saturday

For example: If an address is 555 Walnut Street, the last number is five (5) and the watering day is Saturday.

For purposes of this section only, residential usage includes single family residences, multi-family residences and apartment complexes. Non-residential customers shall follow the above schedule with the exception of the following changes:

TABLE INSET:

7 or 8	Wednesday
5 or 6	Tuesday

(2) Bi-weekly watering as prescribed in Stage 2 will occur according to location in east or west sides of the city, bounded on the north side of the city by Grape St. and then Pine St. to the north city limits (north of Grape St.) and on the south side of the city by Sayles Blvd. to Buffalo Gap Road and then Buffalo Gap Road to the south city limits.

(3) Entities with large, open spaces (e.g., schools, universities, city parks, golf courses) using potable water may submit alternate watering schedules to the director of water utilities except as otherwise prohibited in this article. Upon his/her written approval acknowledged by the entity in question, these entities may follow the approved schedule rather than the calendar system, and will be held responsible for all the provisions of this

article, based on the approved schedule.

(b) *Stage 1 water alert--Implementation criteria:* Combined treatment plant pumpage in excess of 49.5 (mgd) for two (2) consecutive days; or, continually falling water storage facility levels which do not refill above fifty (50) per cent overnight; or, depletion of the Ft. Phantom Reservoir to the elevation 1625.9 (10 ft. below spillway) if Hubbard Creek Reservoir is at sixty (60) per cent capacity or less or 1624.9 (eleven (11) ft. below spillway) if Hubbard Creek Reservoir is at greater than sixty (60) per cent of capacity, or any unforeseen conditions that may occur that cause the city manager to recommend implementation to the mayor.

Upon announcement and implementation by the city, the following restrictions shall apply to all persons:

(1) Landscape irrigation.

a. Irrigation by all commercial, industrial, (including agricultural irrigation), and residential customers utilizing individual sprinklers, or sprinkler systems, of lawns, gardens, landscaped areas, trees, shrubs or other plants is prohibited except on a designated day which shall be once every seven (7) days and then only during the hours of 12:00 midnight to 10:00 a.m. and from 6:00 p.m. until 12:00 midnight.

Provided, however, irrigation of gardens, flowerbeds, trees and shrubs is permitted at any time of day if:

i. A garden hose is used and is held in the hand during the duration of the irrigation event, or

ii. A faucet-filled container of five (5) gallons or less is used, or

iii. A drip irrigation system such as soaker hose, deep root water system, or bubbler is used. For the purpose of this section a drip irrigation system is defined as an irrigation device or system designed to emit water at low volumes and low pressures directly onto soil surface or below soil surface without airborne streams or droplets.

Irrigation of lawns is permitted at any time on any day if:

i. A garden hose is used and is held in the hand during the duration of the irrigation event, or

ii. A faucet-filled container of five (5) gallons or less is used.

A drip irrigation system shall not be used to irrigate lawns except on designated days and at designated times.

b. New lawns that have been seeded (not to include re-seeding or overseeding existing turf), sodded or mulched may be watered daily for eight (8) minutes once during each of the following periods: 11:00 a.m. to 1:00 p.m.; 2:00 p.m. to 4:00 p.m.; 5:00 p.m. to 7:00 p.m.; and at regular intervals between 9:00 p.m. and 10:00 a.m. for a maximum of three (3) weeks. To qualify under this section, new lawns are those installed in conjunction with the construction of a new residence and for a period six (6) months thereafter or the re-tilling of an area equaling at least fifty (50) per cent of a new yard.

(2) Vehicle washing.

a. It is permissible to wash automobiles, trucks, trailers, boats, and other types of mobile equipment at any time on the immediate premises of a commercial car wash or commercial service station or at any location including a residence by using a five (5) gallon container and/or a hand held hose equipped with a quick shut-off nozzle for quick rinses.

b. If the health, safety and welfare of the public depends upon frequent vehicle cleaning, as determined by the director of water utilities or his/her designee, then washing of vehicles such as emergency vehicles, aircraft, garbage trucks, and vehicles used to transport food and perishables will be allowed.

c. Charity car washes are prohibited.

(3) Water may be added to swimming pools to sustain appropriate maintenance levels only on designated irrigation day.

(4) Ornamental fountains are allowed if the fountain is equipped with a device for recycling water and water may be added to sustain appropriate maintenance levels only on the customer's regularly designated watering day.

(5) Use of water from fire hydrants shall be limited to firefighting activities or other activities necessary to maintain public health, safety and welfare. By written approval from the director of water utilities, businesses may purchase and draw water from fire hydrants for land development and building construction processes.

(6) The following uses of water are defined as "waste of water" and are absolutely prohibited:

a. Allowing water to run off a property through the street, gutter, ditch, alley, or drain for more than seventy-five (75) feet from the downgrade of the property line;

b. Failure to repair a controllable leak; including a broken sprinkler head, a leaking valve, leaking or broken pipes, or a leaking faucet.

c. Operating a permanently installed irrigation system with:

i. A broken sprinkler head;

ii. A sprinkler head that is spraying over a street or parking lot because it is out of adjustment; or

iii. A sprinkler head that is misting due to high pressure

d. Washing sidewalks, driveways, parking areas, tennis courts, patios or other paved areas, except to alleviate immediate fire, health and safety hazards, or to prepare an area for pavement repair or application.

(7) Commercial and industrial users.

a. Commercial and industrial users of water shall, in addition to complying with other applicable articles in this article, reduce their monthly consumption of water by a minimum of fifteen (15) per cent compared to use during the same month of the previous year.

b. Industrial users may, in order to justify water use, present a conservation plan for approval by the director of water utilities.

c. Golf courses will submit a conservation plan for approval by the director of water utilities if potable irrigation water is to be used.

(c) *Stage 2 water warning--Implementation criteria:* Combined treatment plant pumpage in excess of 49.5 mgd for two (2) days; or, continually falling water storage facility levels which do not refill above fifty (50) per cent overnight or, depletion of the Ft. Phantom Reservoir to the elevation 1618.9 (seventeen (17) ft. below spillway); or, major line breaks, or pump system failure which causes unprecedented loss of capability to provide service, or any unforeseen conditions that may occur that cause the city manager to recommend implementation to the mayor.

Upon announcement and implementation by the city, the following restrictions shall apply to all persons:

(1) Landscape irrigation.

a. Irrigation by all commercial, industrial and residential customers utilizing individual sprinklers, or sprinkler systems, of lawns, gardens, landscaped areas, trees, shrubs or other plants is prohibited except on a designated day which shall be once every two (2) weeks and then only during the hours of 12:00 midnight to 10:00 a.m. and from 6:00 p.m. until 12:00 midnight.

Provided, however, irrigation of gardens, flowerbeds, trees and shrubs is permitted at any time of day if:

i. A garden hose is used and is held in the hand during the duration of the

ii. Irrigation event, or

iii. A faucet-filled container of five (5) gallons or less is used, or

iii. A drip irrigation system such as soaker hose, deep root water system, or bubbler is used. For the purpose of this section a drip irrigation system is defined as an irrigation device or system designed to emit water at low volumes and low pressures directly onto soil surface or below soil surface without airborne streams or droplets.

Irrigation of lawns is permitted at any time on any day if:

i. A garden hose is used and is held in the hand during the duration of the irrigation event, or

ii. A faucet-filled container of five (5) gallons or less is used.

A drip irrigation system shall not be used to irrigate lawns except on designated days and at designated times.

b. New lawns may be watered daily for eight (8) minutes once during each of the following periods: 11:00 a.m. to 1:00 p.m.; 2:00 p.m. to 4:00 p.m.; 5:00 p.m. to 7:00 p.m.; and at regular intervals between 9:00 p.m. and 10:00 a.m. for a maximum of three (3) weeks. To qualify under this section, new lawns are those installed in conjunction with the construction of a new residence and for a period six (6) months thereafter. Re-tilling or any replanting or reseeding of existing lawns shall not qualify for new lawn status in this section.

(2) Vehicle washing.

a. It is permissible to wash automobiles, trucks, trailers, boats, and other types of mobile equipment at any time on the immediate premises of a commercial car wash or commercial service station or at any location including a residence by using a five (5) gallon container and/or a hand held hose equipped with a quick shut-off nozzle for quick rinses.

b. If the health, safety and welfare of the public depends upon frequent vehicle cleaning, as determined by the director of water utilities or his/her designee, then washing of vehicles such as emergency vehicles, aircraft, garbage trucks, and vehicles used to transport food and perishables will be allowed.

c. Charity car washes are prohibited.

(3) Water may be added to swimming pools to sustain appropriate maintenance levels weekly, on the customer's regularly designated irrigation day.

(4) Ornamental fountains are allowed if the fountain is equipped with a device for recycling water and water may be added to sustain appropriate maintenance levels only on the customer's regularly designated watering day.

(5) Use of water from fire hydrants shall be limited to firefighting activities or other activities necessary to maintain public health, safety and welfare. By written approval from the director of water utilities, businesses may purchase and draw water from fire hydrants for land development and building construction processes.

(6) The following uses of water are defined as "waste of water" and are absolutely prohibited:

a. Allowing water to run off a property through the street, gutter, ditch, alley, or drain for more than seventy-five (75) feet from the downgrade of the property line;

b. Failure to repair a controllable leak; including a broken sprinkler head, a leaking valve, leaking or broken pipes, or a leaking faucet;

c. Operating a permanently installed irrigation system with:

i. A broken sprinkler head;

ii. A sprinkler head that is spraying over a street or parking lot because it is out of adjustment; or

iii. A sprinkler head that is misting due to high pressure.

d. Washing sidewalks, driveways, parking areas, tennis courts, patios or other paved areas, except to alleviate immediate fire, health or safety hazards, or to prepare an area for pavement repair or application.

(7) Commercial and industrial users.

a. Commercial and industrial users of water shall continue to maintain at least a fifteen (15) per cent monthly reduction of water use compared to use during the same month of the previous year.

Individual allotments may be adjusted by the director based on historical water usage conservation practices of customer. The other restrictions of Stage 2 still apply to commercial and industrial users.

b. Industrial users may present a conservation plan for approval by the director of water utilities.

c. Golf courses using potable water will reduce consumption by thirty (30) per cent of contracted amount.

(d) *Stage 3 water emergency--Implementation criteria:* Combined treatment plant pumpage in excess of thirty (30) mgd for three (3) days and depletion of the Ft. Phantom Reservoir to the elevation 1614.9 (twenty-one (21) ft. below spillway); or major line breaks, or pump system failure which causes unprecedented loss of capability to provide service, or any unforeseen conditions that may occur that cause the city manager to recommend implementation to the mayor.

Upon announcement and implementation by the city, the following restrictions shall apply to all persons:

(1) Landscape irrigation. Irrigation of gardens, flowerbeds, trees and shrubs (not lawns) by all commercial, industrial, and residential customers is permitted at any time on any day only if:

a. A garden hose is used and is held in the hand during the duration of the irrigation event, or

b. A faucet-filled container of five (5) gallons or less is used, or

c. A drip irrigation system such as soaker hose, deep root water system, or bubbler is used. For the purpose of this section a drip irrigation system is defined as an irrigation device or system designed to emit water at low volumes and low pressures directly onto soil surface or below soil surface without airborne streams or droplets.

Watering of lawns is prohibited at any time. No new lawns may be installed.

(2) Vehicle washing.

a. It is permissible to wash automobiles, trucks, trailers, boats, and other types of mobile equipment at any time on the immediate premises of a commercial car wash or commercial service station.

b. If the health, safety and welfare of the public depends upon frequent vehicle cleaning, as determined by the director of water utilities or his/her designee, then washing of vehicles such as emergency vehicles, aircraft, garbage trucks, and vehicles used to transport food and perishables will be allowed.

c. Charity car washes are prohibited.

(3) Water may be added to swimming pools to sustain appropriate maintenance levels weekly, on the customer's regularly designated irrigation day. New construction of swimming pools is prohibited.

(4) Ornamental fountains are allowed if the fountain is equipped with a device for recycling water and water may be added to sustain appropriate maintenance level only on the customer's regularly designated watering day. New construction of ornamental fountains is prohibited.

(5) Use of water from fire hydrants shall be limited to fire-fighting activities or other activities necessary to maintain public health, safety and welfare. By written approval from the director of water utilities, businesses may purchase and draw water from fire hydrants for land development and building construction processes.

(6) The following uses of water are defined as "waste of water" and are absolutely prohibited:

a. Allowing water to run off a property through the street, gutter, ditch, alley, or drain for more than seventy-five (75) feet from the downgrade of the property line;

b. Failure to repair a controllable leak; including a broken sprinkler head, a leaking valve, leaking or broken pipes, or a leaking faucet;

c. Operating a permanently installed irrigation system with:

i. A broken sprinkler head;

ii. A sprinkler head that is spraying over a street or a parking lot because it is out of adjustment; or

iii. A sprinkler head that is misting due to high pressure

d. Washing sidewalks, driveways, parking areas, tennis courts, patios or other paved areas, except to alleviate immediate fire, health or safety hazards, or to prepare an area for pavement repair or application.

(7) Commercial and industrial users.

a. Commercial and industrial users of water shall continue to maintain at least a fifteen (15) per cent monthly reduction of water use compared to use during the same month of the previous year.

Commercial and industrial users of water shall continue to maintain at least a fifteen (15) per cent monthly reduction of water use compared to use during the same month of the previous year.

A surcharge rate will be assessed for any water consumption that does not comply with the required reductions. The surcharge in addition to regular charges is as follows:

TABLE INSET:

	First Occurrence	Subsequent Occurrence(s)
First 5,000 gallons over allowed amount per 1,000 gallons	$5.00	$10.00
Next 5,000 gallons, per 1,000 gallons	10.00	20.00
For higher usage, per 1,000 gallons	20.00	30.00

Additionally, if a customer uses more than the allowed amount more than once at any time during Stage 3, the customer's water may be turned off and there will be a two hundred fifty dollar ($250.00) re-connect fee, in addition to the listed fees.

Individual allotments may be adjusted by the director of water utilities based on historical water usage conservation practices of customer. The other restrictions of Stage 3 still apply to commercial and industrial users.

b. Industrial users may present a conservation plan for approval by the director of water utilities.

c. Each golf course using potable water will reduce consumption by fifty (50) per cent of contracted amount.

(e) *Stage 4 water crisis--Implementation criteria:* Loss of capability to provide water service or contamination of supply source, or any unforeseen/unexpected conditions that may occur that cause the city manager to recommend implementation to the mayor.

Upon announcement and implementation by the city, the following restrictions shall apply to all persons:

(1) All outdoor irrigation of vegetation including lawns, using potable water is prohibited.

(2) Only washing of mobile equipment in the critical interest of the public health or safety shall be allowed.

(3) The filling, refilling or adding of water to swimming and/or wading pools is prohibited. The construction of new swimming pools is prohibited.

(4) The operation of any ornamental fountain or similar structure is prohibited. The construction of new ornamental fountains is prohibited.

(5) Use of water from fire hydrants shall be limited to fire fighting and related activities or other activities necessary to maintain public health, safety and welfare. Water for domestic use only may be purchased from the bulk loading station.

(6) The following uses of water are defined as "waste of water" and are absolutely prohibited:

a. Allowing water to run off a property through the street, gutter, ditch, alley, or drain for more than seventy-five (75) feet from the downgrade of the property line;

b. Failure to repair a controllable leak; including a broken sprinkler head, a leaking valve, leaking or broken pipes, or a leaking faucet;

c. Operating a permanently installed irrigation system with:

i. A broken sprinkler head;

ii. A sprinkler head that is spraying over a street or parking lot because it is out of adjustment; or

iii. A sprinkler head that is misting due to high pressure

d. Washing sidewalks, driveways, parking areas, tennis courts, patios or other paved areas, except to alleviate immediate fire, health or safety hazards.

(7) Commercial and industrial users.

a. Commercial and industrial users of water (for other than drinking water and rest rooms) shall continue to maintain at least a fifteen (15) per cent reduction of water use compared to use during the same month of the previous year.

A surcharge rate will be assessed for any water consumption that does not comply with the required reductions. The surcharge in addition to regular charges is as follows:

TABLE INSET:

	First Occurrence	Subsequent Occurrence(s)
First 5,000 gallons over allowed amount per 1,000 gallons	$10.00	$20.00
Next 5,000 gallons, per 1,000 gallons	20.00	40.00
For higher usage, per 1,000 gallons	30.00	60.00

Additionally, if a customer uses more than the allowed amount more than once at any time during Stage 4, then after each such overuse these surcharges will be added and the customer's water may be turned off and there will be a five hundred dollar ($500.00) re-connect fee, in addition to the listed fees.

Individual allotments may be adjusted by the director of water utilities based on historical water usage and conservation practices of the customer. The other restrictions of Stage 4 still apply to commercial and industrial users.

b. Water used for industrial purposes not in the immediate interest of the public health, safety and welfare will be curtailed to the extent necessary to effectuate the needs and purposes of this plan.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-146. Target water use goals.

The following target goals for water usage are established for use during water conservation stages as contained in section 32-145:

(1) *Stage 1. Water alert--Target water use goal:* Combined treatment plant production less than 49.5 million gallons per day (MGD) for all Abilene water treatment facilities.

(2) *Stage 2. Water warning--Target water use goal:* Combined treatment plant production less than 49.5 MGD for all Abilene water treatment facilities.

(3) *Stage 3. Water emergency--Target water use goal:* Combined treatment plant production less than 30 MGD for all Abilene water treatment facilities.

(4) *Stage 4. Water crisis--Target water use goal:* Combined treatment plant production less than 30 MGD for all Abilene water treatment facilities.

(Ord. No. 9-2005, Pt. 1(Exh. A), 4-14-05)

DIVISION 3. WATER CONSERVATION PLAN ENFORCEMENT

Sec. 32-147. Administrative enforcement.

Violations of this plan are declared to be civil penalties with remedies being fines paid directly to municipal court. Non-payment of fines will result in surcharges assessed to the customer's water utility bill. Each violation of a particular component of this plan shall constitute a separate violation, and each day a violation continues shall be considered a new violation for purposes of enforcement and enhancement.

The surcharge will be in addition to the regular water utility bill amount. The water utility office may discontinue water service to the premises if the surcharge is not paid as required under the plan. Any person whose service is discontinued for failure to pay the surcharge shall not be restored until payment of a reconnection charge and any other costs incurred by the city in discontinuing service.

The city's authority to seek injunctive or other civil relief available under the law is not limited by this section.

The following procedures shall apply to anyone contesting the penalties for violating the plan. The hearing process shall be a two-phase hearing process with the final phase being heard before the municipal clerk/administrator or deputy in charge of hearing appeals.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-148. Presumption of ownership and control.

Presumption of ownership/control. Any person, including a person classified as a water customer of city, in apparent control of the property where a violation occurs or originates shall be presumed to be the violator, and proof that the violation occurred on the person's property shall constitute a rebuttable presumption that the person in apparent control of the property committed the violation, but any such person shall have the right to show that he/she did not commit the violation.

All notices shall be issued to the person or entity whose name appears on the water bill.

In any case of a violation of any terms or provisions of this plan by any corporation, business, partnership, or entity, the officers and/or agents actively in charge of the business or entity shall be subject to the penalty provided herein.

If a customer is irrigating during a time period or on a day when irrigation is not permitted for the

street address of that customer and a city worker cannot find any person at that street address to turn off the irrigation system, the city worker may enter the property and turn off the irrigation system and/or the water source.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-149. Hearing officers.

(a) There shall be designated a hearing officer(s) who shall be appointed by the municipal court clerk/administrator.

(b) Hearing officer(s) shall have the authority to administer oaths and to issue orders compelling the attendance of witnesses and the production of documents.

(c) An order compelling the attendance of witnesses or the production of documents may be enforced by the municipal court.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-150. Administration of hearings.

(a) The administrative adjudication process for plan violations shall be initiated by the issuance of a notice which may be issued by a peace officer or other authorized enforcement agent. Authorized enforcement agents shall include any police officer, water utilities worker, city marshal, or other employee of the city designated by the city manager to enforce the provisions of this Code in regard to the plan.

(b) The notice may be issued by affixing it to the front door of the property in question, in a conspicuous place.

(c) The notice shall provide that the person charged with violation of the plan shall have the right of hearing to determine the validity for the charged offense. Such right to a hearing shall be exercised by mail or by appearing in person before a hearing officer within ten (10) days from the date of the notice.

(d) The original or any copy of the notice or summons is a record kept in the ordinary course of business in the city and is rebuttable proof of the facts it contains.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-151. Hearings.

(a) At the hearing before the hearing officer, the violator may admit, admit with explanation, or deny the alleged infraction. It is not a defense to the offense that the violator did not intend the alleged infraction, there being no culpable mental state required for the infraction.

(b) The issuing officer shall not be required to attend the hearing.

(c) It is not required that the city's attorney attend the hearing. Provided, however, that if the defendant is represented by legal counsel at the hearing, the hearing officer shall notify the city attorney who shall have a right to appear on behalf of the city at said hearing.

(d) No formal or sworn complaint shall be necessary. The hearing officer shall examine the contents of the notice and the evidence related to ownership of the property in question and shall hear and review the testimony and evidence presented by the violator. If the hearing officer determines by the preponderance of the evidence that the infraction was committed by the

violator, he shall find the violator responsible and assess a fine.

(e) At the conclusion of the hearing, the hearing officer shall issue an order stating whether or not the person charged is responsible for the violation of the plan and the amount of the fine assessed against him. The order shall be filed with the clerk of the municipal court. All such orders shall be kept in a separate index or file by the municipal court clerk using appropriate data processing techniques.

(f) Failure of a person charged with the offense to appear at a hearing within the aforesaid ten-day period shall be considered an admission of liability for the charged offense.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-152. Appeals.

A person determined by the hearing officer to be in violation of any provision of the Plan may appeal this determination to the municipal court clerk or a deputy so designated to hear plan appeals.

The appeal must be instituted by filing a written petition, not later than the tenth day after the filing of the hearing officer's order, with the clerk of the municipal court along with payment of a nonrefundable administrative appeal filing fee in the amount of ten dollars ($10.00).

After filing a petition for appeal, the municipal clerk shall schedule a hearing and notify all parties of the date, time, and place of the hearing.

The appeal hearing shall be a de novo review. The municipal court clerk shall examine the evidence presented at the appellate hearing and if the court clerk determines by the preponderance of the evidence that the infraction was committed by the violator, the court clerk shall find the violator responsible therefore.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-153. Payment.

(a) Any person alleged to have violated the plan who merely desires to make payment shall provide same to the municipal court clerk in charge of water violations within ten (10) days after receiving notice of said violation.

(b) Any person alleged to have violated the plan and who fails to appear within the ten (10) days as reflected in 32-149.3(c) above shall be assessed a surcharge on their next water bill in the amount of the minimum fine.

(c) Any person found to have violated the plan by the hearing officer shall pay the fine within ten (10) days of said hearing or the fee shall be assessed in a surcharge on the violator's next water bill.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-154. Subsequent violations; increased fees; discontinuation of service; injunctive relief.

Subsequent violations of the plan shall result in increased fine or upon the occurrence of three (3) violations, after notice, the discontinuation of services. Services discontinued under this provision shall be restored only upon payment of a reconnection fee and any other costs incurred by the city in discontinuing service.

Compliance with the plan may also be sought through injunctive relief in district court.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-155. Fines--Minimum and maximum.

(a) Any person, firm, or corporation found to have violated any provision of the plan, shall be assessed a fine in an amount not to exceed one thousand dollars ($1,000.00) for each offense, the amount to be determined by the hearing officer in his reasonable discretion, subject to review on appeal to the municipal court clerk.

(b) Unless higher amounts are required by state law or a lesser amount is determined by the hearing officer or municipal court clerk or so designated deputy, the minimum fines for violating the plan shall be as follows:

(1) Violation of year round water use management, first offense . . . $50.00

(2) Violation of year round water use management, second offense . . . 75.00

(3) Violation of year round water use management, subsequent offenses . . . 250.00

(4) Violation of Stage 1, first offense . . . 50.00

(5) Violation of Stage 1, second offense . . . 75.00

(6) Violation Stage 1, subsequent offenses . . . 250.00

(7) Violation of Stage 2, first offense . . . 100.00

(8) Violation of Stage 2, second offense . . . 150.00

(9) Violation of Stage 2, subsequent offenses . . . 500.00

(10) Violation of Stage 3 or 4, first offense . . . 250.00

(11) Violation of Stage 3 or 4, second offense . . . 500.00

(12) Violation of Stage 3 or 4, subsequent offenses . . . 1,000.00

(13) Reconnect fees for failure to pay the surcharge . . . 250.00

(14) Reconnect fees for repeated violations of the plan . . . 500.00

(c) It is an affirmative defense to any violation of this article if the customer proves that the misused wasted water is from an operable water well serving said property.

(d) Fraudulent misrepresentation of well water use will result in a five hundred dollar ($500.00) fine.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-156. Requests for variance.

Requests for variance should be made in writing to the director of water utilities. Requests must include name of customer, location, type of variance requested, reason for variance request and duration of deviation from this plan. Upon the director's written approval acknowledged by the entity in question, these entities may follow the requested variance and will be responsible for all other provisions of this article.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Sec. 32-157. Severability.

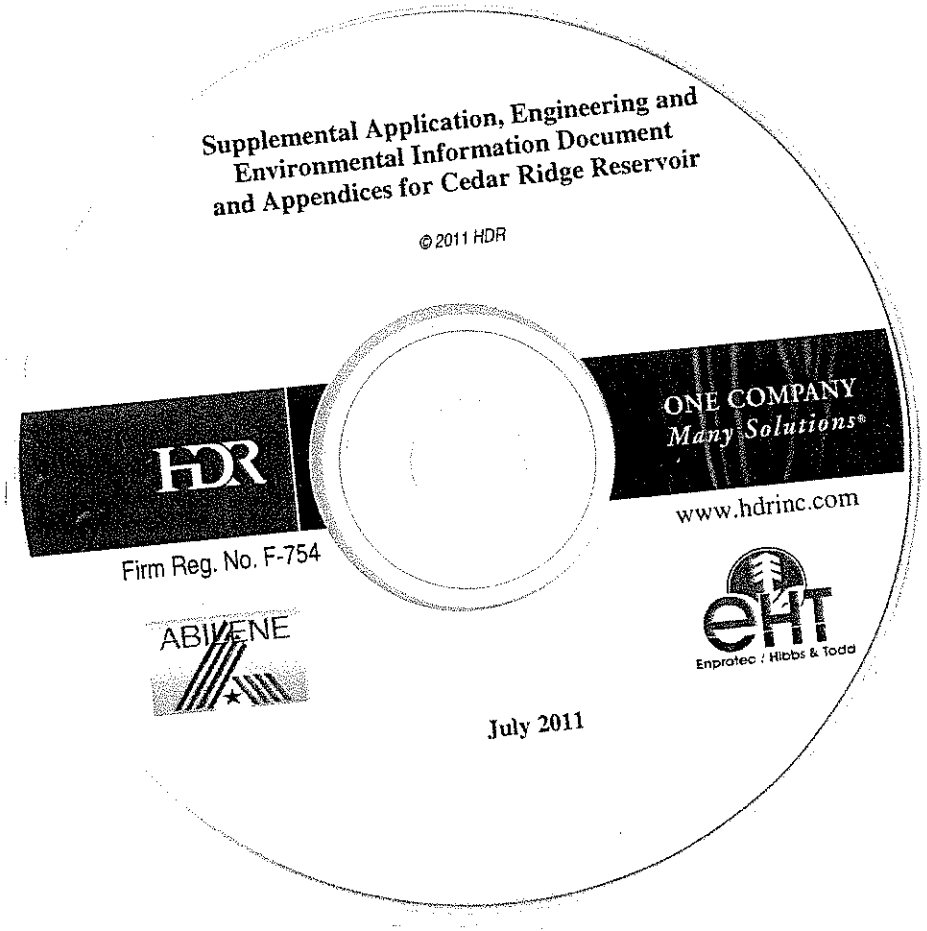
If any provision or any section of this plan shall be held to be void or unconstitutional, such holding shall in no way affect the validity of the remaining provisions or sections of the plan, which shall remain in full force and effect.

(Ord. No. 21-2003, Pt. 1(Exh. A), 5-22-03)

Secs. 32-158, 32-159. Reserved

ATTACHMENT D

SUPPLEMENTAL APPLICATION, ENGINEERING AND ENVIRONMENTAL INFORMATION DOCUMENT FOR CEDAR RIDGE RESERVOIR


Supplemental Application, Engineering and
Environmental Information Document
and Appendices for Cedar Ridge Reservoir
© 2011 HDR
HDR
ONE COMPANY
Many Solutions®
www.hdrinc.com
Firm Reg. No. F-754
ABILENE
eHT
Enpratec / Hibbs & Todd
July 2011

Supplemental Application, Engineering and Environmental Information Document for Cedar Ridge Reservoir

Prepared for:

City of Abilene, Texas

Prepared by:

HDR | ONE COMPANY *Many Solutions*℠

Texas Registered Engineering Firm F-754

and:

eHT Enprotec / Hibbs & Todd

Texas Registered Engineering Firm F-1151

July 2011

Supplemental Application, Engineering and Environmental Information Document for Cedar Ridge Reservoir

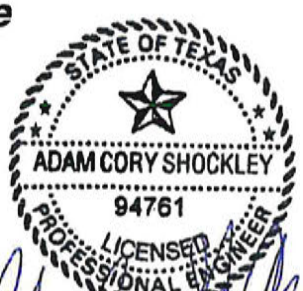
July 2011

Signature Page



7/12/11

Kenneth L. Choffel, P.E.



7/12/11

Adam Cory Shockley, P.E.



7/12/11

David D. Dunn, P.E.



7/12/11

Scott F. Hibbs, P.E.



7/12/11

Sunit R. Deo, P.E.



7/12/11

Peter L. Newell, P.E.

Table of Contents

Section		Page
1	Background and Requested Authorizations	1-1
2	New Drought of Record, Project History and Alternative Water Management Strategies	2-1
2.1	New Drought of Record	2-1
2.2	Project History	2-2
2.3	Alternative Water Management Strategies and Selection of Recommended Strategy	2-4
2.4	Consistency with Regional and State Water Plans	2-7
2.5	Cedar Ridge Reservoir Designated as Unique Reservoir Site	2-7
3	Population Projections, Beneficial Use, and Conservation	3-1
3.1	Population Projections Prepared by Texas Water Development Board	3-1
3.2	Beneficial Use with Water Demand Projections Prepared by Brazos G	3-3
3.3	Supplies and Needs Summary for the City of Abilene	3-4
3.4	Water Conservation Plan and Drought Contingency Plan	3-6
4	Dam, Spillway, and Flood Analyses	4-1
4.1	Dam, Spillway, and Outlet Works Configuration	4-1
4.2	Flood Hydrology	4-6
4.2.1	Introduction	4-6
4.2.2	Watershed Description	4-6
4.2.3	Historical Flood Events	4-8
4.2.4	Development of Rainfall/Runoff Model	4-10
4.2.5	Rainfall/Runoff Model Results	4-10
5	Water Availability Analyses	5-1
5.1	Abbreviations and Definitions	5-1
5.2	Elevation, Surface Area, and Capacity Data for Cedar Ridge Reservoir	5-3
5.3	Water Availability Modeling Approach	5-5
5.3.1	Development of Baseline Run without Cedar Ridge Reservoir (Run 1)	5-5
5.3.2	Development of Run 2 – Cedar Ridge Reservoir with no IF Requirement	5-6
5.3.3	Development of Run 3 — Cedar Ridge Reservoir with IF Requirement	5-6

Table of Contents (Continued)

Section			Page
		5.3.4 Development of Environmental Instream Flow Requirement for Cedar Ridge Reservoir	5-8
	5.4	Comparisons of Runs	5-13
		5.4.1 Reservoir Storage Comparisons	5-13
		5.4.2 Regulated Flow Comparisons	5-16
	5.5	No Impacts to Other Water Rights	5-25
6		Affected Environment, Potential Effects, and Measures to Minimize Impacts	6-1
	6.1	Introduction	6-1
	6.2	Project Description	6-1
	6.3	Geological Elements	6-3
	6.4	Hydrological Elements	6-4
	6.5	Climatic Elements	6-5
	6.6	Floodplains, Wetlands, and Stream Stability	6-6
		6.6.1 Floodplains	6-6
		6.6.2 Waters of the U.S., including Wetlands	6-6
		6.6.3 Stream Stability	6-8
	6.7	Biological Elements	6-13
		6.7.1 Vegetation	6-13
		6.7.2 Wildlife	6-20
		6.7.3 Rare, Threatened, and Endangered Species	6-23
		6.7.4 Aquatic Resources	6-40
		6.7.5 Water Quality	6-62
	6.8	Cultural Resources	6-72
		6.8.1 Affected Environment	6-72
		6.8.2 Potential Effects	6-76
	6.9	Economic Conditions	6-78
	6.10	Land Use	6-79
		6.10.1 Existing Conditions	6-79
		6.10.2 Potential Effects	6-80
	6.11	Hazardous Materials	6-80

Table of Contents (Concluded)

Section **Page**

6.12 Permitting and Regulatory Requirements 6-80
6.13 Summary of Proposed Mitigation Actions 6-81
6.14 Schedule of Environmental Studies and Resource Agency Coordination 6-82
7 No Harmful Impacts to Groundwater Resources 7-1

Appendices

A Interlocal Agreement with the Brazos River Authority
B Rainfall/Runoff Model
C Brazos Water Availability Model Data (Provided on Compact Disc)
D Photographs of the Project Area Channel and Bank ConditionsThroughout the Study Reach
E Vegetation Species Observed within the Proposed Cedar Ridge Reservoir Site along the Clear Fork of the Brazos River, 23-26 March 2009
F Wildlife Habitat Appraisal Procedure (WHAP)
G Brazos Water Snake
H Aquatic Life Monitoring Data Report (Includes Attachments H1, H2, and H3)
Attachment H1 - Stream Physical Characteristics Worksheets, Physical Characteristics of Water Body Worksheets, and Habitat Quality Index (HQI) Worksheets, 2009 and 2010. (Provided on Compact Disc)
Attachment H2 - Photographs, Aquatic Life Monitoring Locations, 2009 and 2010 (Provided on Compact Disc)
Attachment H3 - 24-Hour Monitoring at Three Locations May and July 2010
I Freshwater Mussels of the Clear Fork Brazos River; Cedar Ridge Reservoir Project (2009 Report)
J Cedar Ridge Reservoir Project, Freshwater Mussel Surveys (2010 Report)

List of Figures

Figure		Page
1-1	Location of Cedar Ridge Reservoir	1-2
2-1	Comparison of Cumulative Streamflow During Two 14-Year Droughts for Clear Fork Brazos River at Nugent, Texas	2-1
2-2	Location of Breckenridge Reservoir, and Original and Selected Cedar Ridge Reservoir Dam Locations	2-3
2-3	General Location Map of Water Management Strategies	2-6
3-1	City of Abilene and Surrounding Counties	3-2
4-1	Cedar Ridge Reservoir and Associated Facilities	4-2
4-2	Conceptual Plan for Dam, Spillways and Outlet Works	4-3
4-3	Centerline Profile of Dam and Spillways	4-4
4-4	Conceptual Dam Cross-Section	4-5
4-5	Cedar Ridge Reservoir Watershed Sub-basins	4-7
4-6	Maximum Annual Peak Flow for USGS Gage on Clear Fork at Nugent	4-8
4-7	Maximum Annual Peak Flow for USGS Gage on Clear Fork at Ft. Griffin	4-9
4-8	Computed Reservoir Stage, Storage, and Inflow and Outflow Hydrographs for PMF	4-12
5-1	Elevation-Area and Elevation-Capacity Curves for Cedar Ridge Reservoir	5-3
5-2	Location of Cedar Ridge Reservoir, Nugent Gage and Key BWAM Primary Control Points	5-7
5-3	Storage Frequency Curves for Cedar Ridge Reservoir Used to Identify the Hydrologic Condition Triggers for Three Annual Reservoir Demands	5-13
5-4	Comparison of Time Series of Cedar Ridge Reservoir Storage	5-14
5-5	Comparison of Storage Frequency of Cedar Ridge Reservoir Storage	5-15

List of Figures (Continued)

Figure		Page
5-6	Comparison of Time Series of Possum Kingdom Lake Storage	5-15
5-7	Comparison of Storage Frequency of Possum Kingdom Lake	5-16
5-8	Comparison of Regulated Flow Frequency at Cedar Ridge Reservoir (High Flows)	5-19
5-9	Comparison of Regulated Flow Frequency at Cedar Ridge Reservoir (Flows below 5,000 acft/mo)	5-19
5-10	Comparison of Regulated Flow Frequency at Cedar Ridge Reservoir (Flows below 1,000 acft/mo)	5-20
5-11	Comparison of Regulated Flow Frequency at Clear Fork near Fort Griffin (High Flows)	5-20
5-12	Comparison of Regulated Flow Frequency at Clear Fork near Fort Griffin (Flows below 5,000 acft/mo)	5-21
5-13	Comparison of Regulated Flow Frequency at Clear Fork near Fort Griffin (Flows below 1,000 acft/mo)	5-21
5-14	Comparison of Regulated Flow Frequency at Brazos River near South Bend (High Flows)	5-22
5-15	Comparison of Regulated Flow Frequency at Brazos River near South Bend (Flows below 5,000 acft/mo)	5-22
5-16	Comparison of Regulated Flow Frequency at Brazos River near South Bend (Flows below 1,000 acft/mo)	5-23
5-17	Comparison of Regulated Flow Frequency at Brazos River near Palo Pinto (High Flows)	5-23
5-18	Comparison of Regulated Flow Frequency at Brazos River near Palo Pinto (Flows below 5,000 acft/mo)	5-24
5-19	Comparison of Regulated Flow Frequency at Brazos River near Palo Pinto (Flows below 1,000 acft/mo)	5-24
6-1	Location of Cedar Ridge Reservoir	6-2
6-2	Comparison of Historical Thalweg Positions for the Clear Fork	6-9

List of Figures (Concluded)

Figure		Page
6-3	Comparison of Historical Thalweg Positions for the Clear Fork	6-10
6-4	Comparison of Historical Thalweg Positions for the Clear Fork	6-11
6-5	Vegetation Cover Types within Cedar Ridge Reservoir Conservation Pool	6-18
6-6	Area Surveyed and Locations of Brazos Water Snakes, March 2009–October 2010, Including Locations Reported by McBride	6-37
6-7	Aquatic Sample Locations, 2009 and 2010	6-43
6-8	Freshwater Mussel Survey August 2009	6-55
6-9	Freshwater Mussel Survey Locations, July and October 2010	6-57
6-10	TCEQ Monitoring Stations Located in the Clear Fork Watershed	6-68
6-11	Comparison of Chloride Concentration at Nugent Gage and Cedar Ridge Reservoir	6-70
6-12	Schedule for Environmental Studies and Resource Agency Site Visit	6-82

List of Tables

Table		Page
1-1	HEFR-Based Environmental Flow Pass-Through Regime for Cedar Ridge Reservoir	1-5
1-2	Cedar Ridge Reservoir Storage Triggers for Determining Hydrologic Conditions for HEFR-Based Environmental Instream Flow Pass-Throughs for Three Annual Reservoir Demands	1-5
2-1	Summary of Water Management Strategies for Abilene Evaluated in State and Regional Water Plans Since 1997	2-7
2-2	Summary of Water Management Strategies	2-8
2-3	Comments for Water Management Strategies Described in Table 2-2	2-9
3-1	TWDB Population Projections for City of Abilene Service Area	3-3
3-2	Brazos G Water Demand Projection for the City of Abilene (acft/yr)	3-4
3-3	Water Supply Summary for the City of Abilene	3-5
3-4	Water Demand and Supply Summary for the City of Abilene 2011 Brazos G Regional Water Plan Demand Projections	3-6
4-1	TCEQ Hydrologic Criteria for Dams	4-7
4-2	Elevation-Storage-Discharge Data for Cedar Ridge Reservoir	4-11
4-3	Comparison of Peak Inflows, Outflows and Stages for Cedar Ridge Reservoir for Historical and HEC-HMS Model Storm Events	4-12
5-1	Elevation-Area-Capacity Data for Cedar Ridge Reservoir	5-4
5-2	HEFR-Based Environmental Flow Pass-Through Regime for Cedar Ridge Reservoir	5-10
5-3	Cedar Ridge Reservoir Storage Triggers for Determining Hydrologic Conditions for HEFR-Based Environmental Instream Flow Pass Throughs for Three Annual Reservoir Demands	5-10
5-4	Comparison of Regulated Streamflow Statistics	5-18
6-1	Estimated Acres of Vegetation Cover Types Found within the Project Area	6-20

List of Tables (Concluded)

Table		Page
6-2	Common Wildlife Species of the Kansan Biotic Province	6-21
6-3	Federal and State-Listed Threatened, Endangered, and Rare Species of Potential Occurrence in Haskell, Jones, Shackelford, and Throckmorton Counties	6-26
6-4	Checklist of Benthic Macroinvertebrates Collected by Kicknet 2009 and 2010	6-46
6-5	Metrics and Scoring Criteria for Benthic Macroinvertebrate, Kick Net Samples 2009 and 2010 Index and Critical Periods	6-48
6-6	A Checklist of Fish Species Collected by Seine at Five Stations 2009-2010	6-51
6-7	Metrics and Scoring Criteria for Fish Samples Based On Ecoregions 27, 29, and 32 Criteria 2009-2010 Index and Critical Periods	6-52
6-8	Comparison of Present Survey Fish Collection Results with Historical River Collections and Area Reservoir Assemblages	6-60
6-9	Texas Surface Water Quality Standards	6-63
6-10	A Checklist of Representative Algal Species at Three River locations July 2010	6-66
6-11	TCEQ Designated Monitoring Stations in the Clear Fork Watershed	6-67
6-12	Water Quality Parameters by Sampling Station 2009-2010	6-67
6-13	Percentage of County Land Use in 1982 and 1997	6-79

Section 1
Background and Requested Authorizations

This application is made by the City of Abilene, Texas (City, Abilene or Applicant) under Sections 11.121, 11.042, and 11.085 of the Texas Water Code. The City serves as a major water supplier for its citizens and for surrounding communities in and near Taylor and Jones Counties, Texas. The City projects that its water supply demands and that of surrounding communities will continue to grow and are projected to exceed available supplies in the near future. By this application, the City seeks authorization to construct the Cedar Ridge Reservoir and to impound state water therein to meet existing and future water supply demands.

The Applicant requests the following authorizations:

- To construct a dam and reservoir (Cedar Ridge Reservoir or reservoir) on the Clear Fork Brazos River (Clear Fork); a tributary of the Brazos River. (Note: The dam is located in the southwest corner of Throckmorton County 22.3 miles southwest of the town of Throckmorton, Texas, which is the county seat of Throckmorton County, Texas, and is 14.7 miles in a northeast direction from the town of Lueders, Texas (Figure 1-1); is located in the B&B Survey, Abstract No. 176, Section 17 and the B&B Survey, Abstract No. 1158, Section 18, Throckmorton County, Texas; and station 0+00 on the centerline of the dam is located south 80 degrees west (bearing) 3,727 feet from the northeast corner of the B&B Survey, Abstract No. 176, Section 17, in Throckmorton County, Texas).
- To impound in the conservation pool of the reservoir approximately 227,127 acre feet (acft) of water with a surface area of approximately 6,635 acres. (Note: The watershed at the dam is 2,728 square miles).
- To divert up to 34,400 acft of water per year (acft/yr) from the reservoir for multi-purpose uses including: municipal, domestic, industrial, agricultural, livestock, steam-electric, mining, and recreation uses in the City's existing and future wholesale and retail service areas. (Note: This quantity does not include the diversion of historical and future City return flows at Diversion Point No. 2 pursuant to Certificate of Adjudication 12-4161C).
- To divert water from the perimeter of the reservoir at a rate not to exceed 95 cubic feet per second (cfs) or 42,636 gallons per minute (gpm). (Note: This quantity does not include the diversion of historical and future City return flows at Diversion Point No. 2 pursuant to Certificate of Adjudication 12-4161C). Such water together with the historical and future City return flows diverted at the reservoir pursuant to Certificate of Adjudication 12-4161C, will be transported via pipeline to either Lake Fort Phantom Hill (LFPH) or to the City's raw water system for subsequent treatment and use.

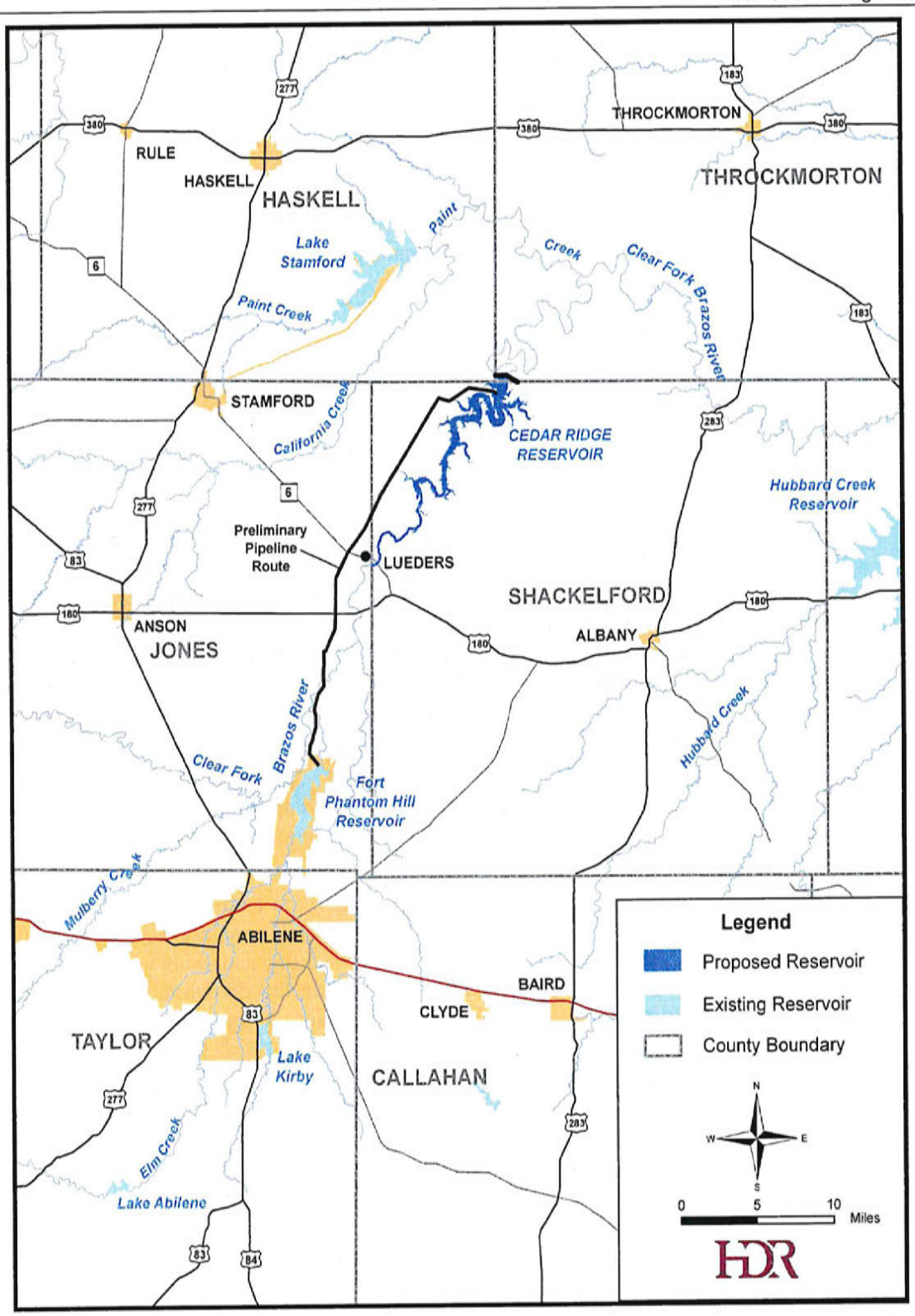


Figure 1-1. Location of Cedar Ridge Reservoir

- To discharge water diverted from the reservoir at outfall(s) into LFPH outfall(s), authorized by Certificate of Adjudication 12-4161 as amended, for subsequent diversion and use. Such discharges shall include up to 34,400 acre-feet of water proposed to be diverted from the reservoir pursuant to this Application, as well as the historical and future City return flows diverted from the reservoir pursuant to Certificate of Adjudication 12-4161C, including the return flows resulting from the use of the water supplies made available by the Cedar Ridge Reservoir project.
- To use the bed and banks of LFPH to convey up to 34,400 acre-feet of water proposed to be diverted from the reservoir pursuant to this Application, as well as the historical and future City return flows diverted from the reservoir pursuant to Certificate of Adjudication 12-4161C and delivered to LFPH, to diversion point((s) located on the perimeter of LFPH and to divert such water at a rate not to exceed 95 cfs or 42,636 gpm. This diversion will be from new/and or existing diversion facilities and in addition to the rate authorized under Certificate of Adjudication 12-4161, as amended, for LFPH.
- To transfer water diverted from the reservoir from the Brazos River Basin to those portions of Callahan, Nolan, Mitchell, Scurry, Eastland, Brown, Comanche, and Taylor Counties located in the Colorado River Basin, pursuant to an exempt Interbasin Transfer.

With the approval of the above requests, the Applicant will support the inclusion of these special conditions in the permit:

- Applicant will maintain a subordination agreement with the owner of both Certificate of Adjudication 12-5155 (CA 12-5155 or Possum Kingdom Lake) and the water right to be issued pursuant to the pending Application No. 5851, under which senior calls for water from Cedar Ridge Reservoir will not be made by the owner of CA 12-5155 or the water right to be issued pursuant to Application No. 5851. (Appendix A includes Interlocal Agreement between City and the Brazos River Authority relating to this subordination.)
- Applicant will maintain a stream gage on the Clear Fork at a location near Lueders, Texas (Lueders gage or USGS gage # 080804200), and will use the Lueders gage to estimate average daily inflows to the reservoir in cfs.
- Applicant will use data from the Lueders gage to determine pass-through quantities for downstream senior water rights, when required, as well as pass-through quantities for purposes of maintaining downstream environmental flows in accordance with the flows in Table 1-1.
- Hydrologic conditions (wet, average, and dry) will be defined on the basis of the volume of water in storage at Cedar Ridge Reservoir and the annual demand on the reservoir in accordance with values listed in Table 1-2. Hydrologic condition will be defined on day 1 of a season and will remain at that condition regardless of the storage in the reservoir until the first day of the next season when the hydrologic condition will be reset based on the storage in the reservoir.
- Pass-throughs of reservoir inflows (as either baseflow or high flow pulse (HFP) as shown in Table 1-1) will be made on a daily basis based on average daily reservoir

inflows as measured at the Lueders gage. Flows as measured on the previous day will be compared to the Hydrology-Based Environmental Flow Regime (HEFR) flows listed in Table 1-1 for the applicable hydrologic condition (wet, average, dry) to determine the rate (in cfs) at which water will be passed. If the previous day's average flow equals or exceeds the listed peak flow (Qp or Qpeak) value and the HFP target has not previously been met for that season, then a pass-through will be made at the specified Qp rate. HFP pass-throughs will continue at the maximum rate of either the Qp target or the previous day's measured inflow (whichever is less) until either the volume or duration targets are met, whichever occurs first. Once an HFP pass has been made for a one-per season event, the HFP requirement will be satisfied until the next season. For a two-per season event, two HFP pass-through events will need to occur before the HFP requirement is satisfied for that season.

- When the previous day's flow does not trigger an HFP, then a baseflow amount for the applicable hydrologic condition, as shown in Table 1-1, will apply. When reservoir inflow exceeds the listed baseflow rate (but not the HFP rate) for the applicable hydrologic condition, then the listed baseflow rate will be passed. When reservoir inflow is less than the listed baseflow rate for wet and average hydrologic conditions, then the previous day's measured inflow will be passed. When reservoir inflow is less than the listed baseflow rate for dry hydrologic condition then the minimum of the subsistence flow of 1.5 cfs or the previous day's measured inflow will be passed. When there are no reservoir inflows as measured at the Lueders gage, then there will be no pass-throughs.

Table 1-1.
HEFR-Based Environmental Flow Pass-Through Regime for Cedar Ridge Reservoir

		Winter				Spring			Summer			Fall	
		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Overbank Flows		To be met from spill events from the reservoir, not controlled passes.											
High Flow Pulses	Wet[1]	Qpeak: 50 cfs Freq.: 1 per season Volume: 314 acft Duration: 5 days				Qpeak: 384 cfs Freq.: 1 per season Volume: 2,224 acft Duration: 9 days			Qpeak: 421 cfs[2] Freq.: 1 per season Volume: 2,157 acft Duration: 7 days			Qpeak: 184 cfs Freq.: 1 per season Volume: 843 acft Duration: 5 days	
	Avg[1]	Not Recommended				Qpeak: 65 cfs Freq.: 2 per season Volume: 311 acft Duration: 4 days			Qpeak: 119 cfs Freq.: 2 per season Volume: 501 acft Duration: 4 days			Qpeak: 22 cfs Freq.: 2 per season Volume: 77 acft Duration: 2 days	
	Dry[1]	Not Recommended				Qpeak: 65 cfs Freq.: 1 per season Volume: 311 acft Duration: 4 days			Qpeak: 119 cfs Freq.: 1 per season Volume: 501 acft Duration: 4 days			Qpeak: 22 cfs Freq.: 1 per season Volume: 77 acft Duration: 2 days	
Baseflows (cfs)	Wet[1]	16				14			11			12	
	Avg[1]	9.0				8.0			6.0			6.0	
	Dry[1]	5.0				4.0			2.0			2.0	
Subsistence Flows (7Q2)[3] (cfs)		1.5				1.5			1.5			1.5	

Note: All values shown in cfs (cubic feet per second) and are based on average daily flows and not instantaneous flows. Period of Record used: 1/1/1939 to 12/31/2009.

[1]Wet, average and dry hydrologic conditions are determined based on annual demand and reservoir storage on day 1 of each season. Reservoir storage transition points are summarized in Table 1-2.

[2]High Flow Pulses in August are limited to a peak flow of 184 cfs, a volume of 843 acft, and duration of 5 days for juvenile snake considerations (same as the Fall season).

[3]Subsistence flow is equal to the published 7Q2 value for the Clear Fork at Nugent Gage.

Table 1-2.
Cedar Ridge Reservoir Storage Triggers for Determining Hydrologic Conditions for HEFR-Based Environmental Flow Pass-Throughs for Three Annual Reservoir Demands

Annual Reservoir Demand (acft/yr)	*25th Percentile Reservoir Storage (for transition from wet to average hydrologic conditions)*	*75th Percentile Reservoir Storage (for transition from average to dry hydrologic conditions)*
0 to17,200	98%	85%
17,201 to 25,800	96%	74%
25,801 to 34,400	91%	60%

This page is intentionally left blank.

Section 2
New Drought of Record, Project History and Alternative Water Management Strategies

2.1 New Drought of Record

From 1993 through 2006, the region of Texas near Abilene experienced a severe drought. As shown on Figure 2-1, cumulative flow in the Clear Fork during this 14-year period was 82 percent of the cumulative flow that occurred during the previous drought of record which occurred during the 14-year period from 1943 through 1956. This recent drought is the new drought of record. As a result of the severity of the recent drought, in 2009 Abilene, the Brazos G Regional Water Planning Group (BGRWPG) and the Texas Water Development Board (TWDB) adopted the use of a 2-year safe yield[1] for water supply planning purposes for the Abilene region. Previously, the City used a 1-year safe yield to determine its reliable water supply.

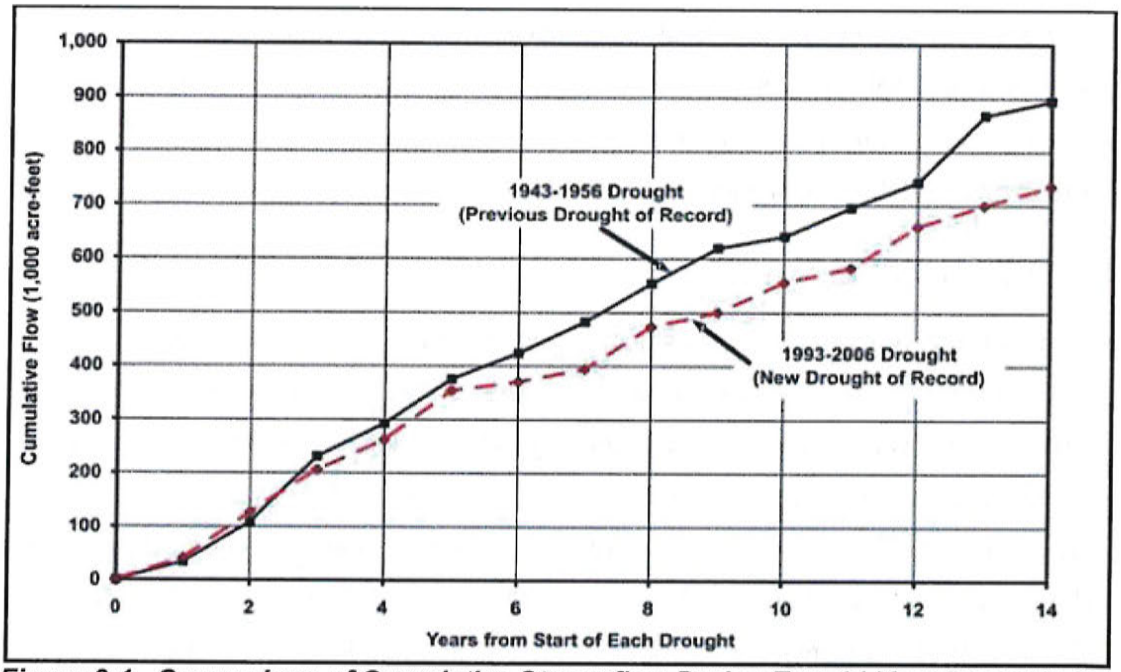


Figure 2-1. Comparison of Cumulative Streamflow During Two 14-Year Droughts for Clear Fork Brazos River at Nugent, Texas

[1] The safe yield of a reservoir is defined as the amount of water that could be diverted from the reservoir every year of the drought of record with the minimum volume of water remaining in storage during the worst month equal to the annual diversion amount. For example, if the 2-year safe yield of a reservoir is 10,000 acft/yr, then the amount of water remaining in storage in the worst month of the drought of record would be 20,000 acft.

In planning for a reliable water supply, the use of the 2-year safe yield helps to reduce the risk of water shortages in the event a drought worse than the historical drought of record occurs. This is particularly important in semi-arid environments like West Texas when considering the potential future effects of climate change and the potential for reduced precipitation and streamflow and increased evaporation and evapotranspiration rates.

The importance of using an adequate safe yield reserve has been demonstrated to the Abilene region during the last several decades in its supply of water available from O.H. Ivie Reservoir. The City has a long-term contract for 16.54 percent of the 1-year safe yield of O.H. Ivie, which is operated by the Colorado River Municipal Water District (CRMWD). Originally, in 1976, the 1-year safe yield of O.H. Ivie was estimated to be 90,700 acft/yr. However, over the past several decades, inflows to O.H. Ivie have been substantially affected by drought conditions and the safe yield has been revised several times. The most recent study[2] indicates the 1-year safe yield of O.H. Ivie is 65,940 acft/yr or 72.7 percent of the original 1976 estimate. This suggests that CRMWD would not have adequate water supplies from O.H. Ivie to meet demands based on a 1-year safe yield. As a result of climatic uncertainties and to reduce the risk of the City's water supply being depleted, Abilene approved the use of a 2-year safe yield for supplies from Lake Fort Phantom Hill. This was approved by the BGRWPG on August 19, 2009 and accepted by the TWDB on September 30, 2009.

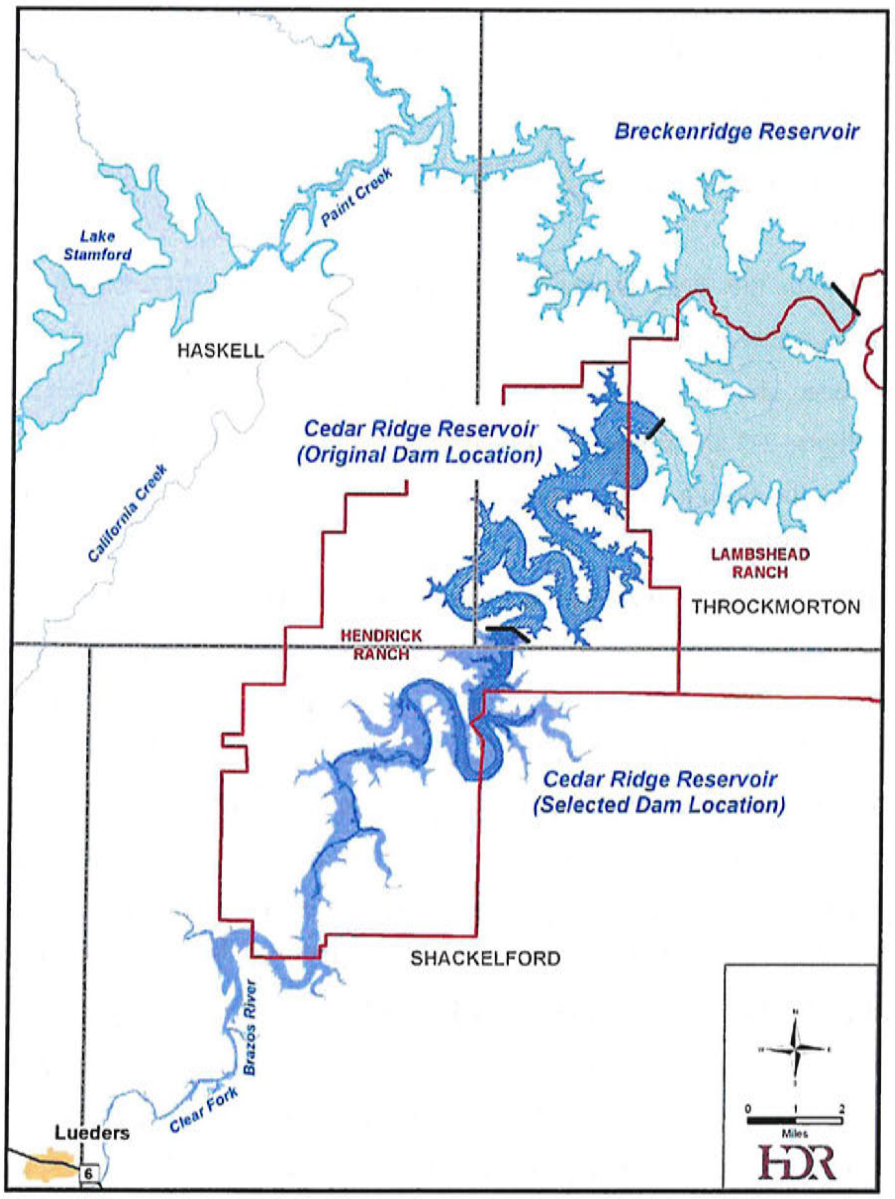
2.2 Project History

The proposed reservoir has been studied and recommended as a strategy to meet regional water needs beginning with the 1968 State Water Plan. The selected dam location has changed twice since the initial location was proposed. Initially referred to as the Breckenridge Reservoir (Reynolds Bend location), the dam was located in Throckmorton County on the Clear Fork just downstream of the confluence with Paint Creek and about 50 miles north of Abilene (Figure 2-2). The 2001 Brazos G Regional Water Plan (BGRWP) noted that an unreferenced study completed in 1971 estimated the Reynolds Bend location would have a conservation storage capacity of approximately 600,000 acft and a surface area of approximately 14,300 acres. Because the dam was located downstream of Paint Creek, there was concern that total dissolved solids (TDS) and chloride concentrations would require advanced treatment (e.g. reverse osmosis (RO)) to meet drinking water standards. In the early 2000s a new dam location was selected on

[2] Freese and Nichols, Inc. 2006 Report

the Clear Fork at a location upstream of the Paint Creek confluence (original Cedar Ridge dam location) resulting in water quality that would not require advanced treatment.

Figure 2-2. Location of Breckenridge Reservoir, and Original and Selected Cedar Ridge Reservoir Dam Locations



This location is shown on Figure 2-2 and has a conservation storage capacity of approximately 310,700 acft with a surface area of approximately 6,190 acres. However in 2008/2009, a geotechnical investigation identified gypsum at this location, effectively preventing the construction of the reservoir at the original Cedar Ridge dam location. In 2009, a new

location was identified about 19 river miles upstream of the original Cedar Ridge dam location as shown on Figure 2-2. A 2009 geotechnical investigation of this new location indicated that this location was suitable for the construction of a dam. The selected location has a conservation storage capacity of approximately 227,127 acft and a surface area of approximately 6,635 acres and is the location for which the Applicant is pursuing permits. Water from this location will be transported via pipeline to either Lake Fort Phantom Hill or to the City's raw water system for subsequent treatment and use.

2.3 Alternative Water Management Strategies and Selection of Recommended Strategy

According to the 2011 Brazos G Regional Water Plan (2011 BGRWP) the City is projected to have a raw water deficit of 23,694 acft/yr in 2060. Numerous water management strategies have been identified in State and/or Regional Plans since 1997 to meet this deficit and are shown on Figure 2-3 and summarized in Tables 2-1 and 2-2. The Breckenridge/Cedar Ridge Reservoir strategy has been a recommended water management strategy to meet Abilene's needs since the 2001 BGRWP.

Recommended water management strategies included in the 2011 BGRWP for the Abilene region include municipal conservation, Cedar Ridge Reservoir and indirect reuse at Cedar Ridge Reservoir. These three strategies provide a combined 2060 supply of 29,295 acft/yr which is adequate to meet the projected 2060 shortage of 23,694 acft/yr for the Abilene region.

The Possum Kingdom Lake Pipeline is listed as an alternative water management strategy in the 2011 BGRWP and is the only non-reservoir strategy with adequate yield to substantially contribute to meeting the projected 2060 shortage. If this strategy were combined with two other strategies including municipal conservation and direct discharge to Lake Fort Phantom Hill (7 MGD), their combined supply would total 23,576 acft/yr which is only 118 acft/yr less than the required 2060 shortage. However, the average unit cost of combining these strategies would be $1,262 per acft or 70 percent more than the $743 per acft unit cost of Cedar Ridge Reservoir. Additionally energy use for these three combined strategies would average 7,762 kWh per MG or 231 percent more than the 2,345 kWh/MG energy use to deliver water from Cedar Ridge Reservoir. This additional energy requirement is due to a combination of additional pumping head (due to the additional distance and feet of lift) and the need for advanced treatment. When compared to other feasible strategies, Cedar Ridge Reservoir is the

most economical strategy for the Abilene region to meet its water supply needs by a significant margin.

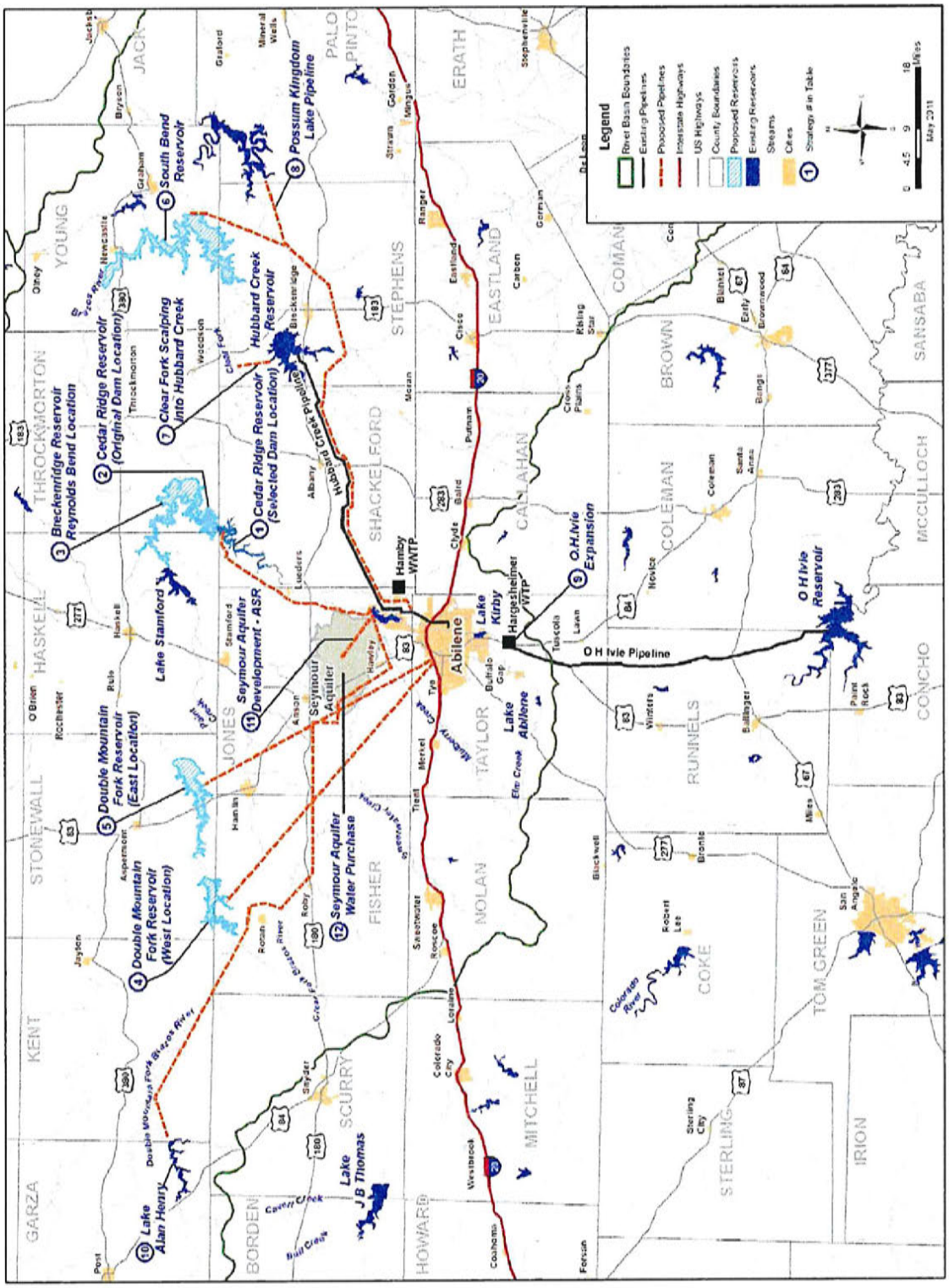


Figure 2-3. General Location Map of Water Management Strategies

Table 2-1.
Summary of Water Management Strategies for Abilene Evaluated in State and Regional Water Plans Since 1997

Strategy Name	Evaluated in Plan			
	1997 SWP	2001 RWP	2006 RWP	2011 RWP
Reservoirs				
Breckenridge Reservoir - Reynolds Bend Location	Alt	Rec		
Cedar Reservoir - Original Dam Location			Rec	
Cedar Ridge - Selected Dam Location				Rec
Double Mountain Fork - West Location			Alt	Eval
Double Mountain Fork - East Location			Alt	Eval
South Bend		Eval	Eval	Eval
Pipelines				
Clear Fork Scalping into Hubbard Creek			Rec	
Possum Kingdom Lake Pipeline		Alt	Alt	Alt
O.H. Ivie Reservoir Conveyance System	Rec	Rec		
Lake Alan Henry - Direct to Abilene			Alt	
Lake Alan Henry - Delivery via trades				
Groundwater				
Seymour Aquifer Development - ASR		Rec		
Seymour Aquifer Water Purchase		Eval		
Other				
Municipal Conservation			Rec	Rec
Abilene Indirect Reuse		Rec	Rec	Rec

Notes:
Rec - Strategy is recommended in the corresponding plan.
Alt - Strategy is listed as an alternative in the corresponding plan.
Eval - Strategy was evaluated but either not recommended or listed as an alternative in the corresponding plan.

2.4 Consistency with Regional and State Water Plans

Cedar Ridge Reservoir has been included as a recommended water management strategy in the regional and state water plans since 2006 and 2007, respectively. The 2011 BGRWP adopted by the BGRPG on July 21, 2010 includes Cedar Ridge Reservoir (selected dam location) as a recommended water management strategy for the Abilene region. The TWDB approved the 2011 BGRWP on November 18, 2010.

2.5 Cedar Ridge Reservoir Designated as Unique Reservoir Site

The 2007 State Water Plan and the 2011 BGRWP both designate Cedar Ridge Reservoir as a unique reservoir site. During the 2007 Texas legislative session, the Legislature designated 19 reservoir sites in Texas (that were included in the 2007 State Water Plan), including Cedar Ridge Reservoir, as unique reservoir sites.

Table 2-2.
Summary of Water Management Strategies

Strategy No.	Strategy Name	Yield[1] [acft/yr]	Delivery to Abilene [acft/yr]	Not Practicable	2011 Brazos G RWP	Feasible					
						Economics [$/acft]	Environmental Impacts: Pipeline Length (mi.)	Environmental Impacts: Reservoir Footprint (ac)	Environmental Impacts: Main Stem (mi.)	Environmental Impacts: Secondary Streams (mi.)	Energy Intensity [kWh/MG]
Reservoirs											
1	Cedar Ridge Reservoir - Selected Dam Location	24,775	23,694		Recommended	$743	29.5	6,635	28.6	16.6	2,345
2	Cedar Ridge Reservoir - Original Dam Location	28,011	23,694	X							
3	Breckenridge Reservoir - Reynolds Bend Location	72,265	23,694	?		$908	38.3	14,300	54.7	32.2	3,048
4	Double Mountain Fork Reservoir - West Location	29,634	22,064			$1,259	48.3	6,600	18.4	10.3	3,428
5	Double Mountain Fork Reservoir - East Location	29,876	22,064			$1,346	39.8	10,800	24.4	23.7	3,575
6	South Bend Reservoir	103,513	23,694			$1,641	78.5	29,877	52.4	41	9,974
Pipelines											
7	Clear Fork Scalping to Hubbard Creek Reservoir	6,194	6,194			$2,145	5.0				6,871
8	Possum Kingdom Lake Pipeline	14,800	14,800		Alternative	$1,572	77.0				8,456
9	O.H. Ivie Expansion[2]	2,763	2,763	?		$1,497	22.0				3,098
10	Lake Alan Henry	16,500	16,500	X							
Groundwater											
11	Seymour Aquifer Development - ASR	2,855	2,855	?		$1,345	12.0				1,325
12	Seymour Aquifer Water Purchase	500	500	X							
Others											
13	Municipal Conservation	1,136			Recommended	$475					
14	Abilene Reuse - Yield increase of Fort Phantom Hill				Alternative						
14-A	Increase Discharge thru Lake Kirby (4 MGD)	3,700	3,700			$533	5.0				271
14-B	Increase Discharge thru Lake Kirby (6 MGD)	5,600	5,600			$568	5.0				269
14-C	Direct Discharge to Fort Phantom (4 MGD)	4,380	4,380			$277	4.0				737
14-D	Direct Discharge to Fort Phantom (7 MGD)	7,640	7,640			$780	15.0				7,551
15	Abilene Reuse - Yield increase of Cedar Ridge Res.	4,465	4,465		Recommended	$119					(406)

Notes:

1 Reservoir yields represent 2-yr safe yields. Yields for Possum Kingdom Lake Pipeline and O.H. Ivie Expansion based on contract amounts. Yield for Clear Fork scalping to Hunbbard Creek Reservoir (HCR) based on increase in 2-yr safe yield of HCR. Yield for ASR based on increase in LFPH 2-yr safe yield. New reservoir yields reduced by 3.0% to account for sedimentation between 2030 and 2060. All Abilene reuse strategies yields are based on increase in associated reservoir's firm yield.

2 - Based on 1-year safe yield of raw supply less existing capacity less 13% brine reject. Supply is from the Colorado River Basin which has experienced recent severe drought. Continuation of current drought conditions could further reduce supply.

? - Indicates that the practicability of an option is uncertain based on available information.

X - indicates not practicable.

Table 2-3.
Comments for Water Management Strategies Described in Table 2-2

Strategy No.	*Comments*
1	Includes annual payment to BRA for Possum Kingdom Lake subordination.
2	Geotechnical investigation revealed gypsum at the location.
3	Poor water quality from Paint Creek requires advanced treatment and uncertain feasibility due to potential for gypsum.
4	Poor water quality requires advanced treatment.
5	Poor water quality requires advanced treatment.
6	Poor water quality requires advanced treatment. 2-year Safe Yield assumes Possum Kingdom Lake subordination with Possum Kingdom Lake yield reduction fully offset by releases from South Bend.
7	Includes annual payment to BRA for Possum Kingdom Lake subordination and delivery of water from Hubbard Creek Reservoir to LFPH.
8	Poor water quality requires advanced treatment.
9	Poor water quality requires advanced treatment. Pipeline has been constructed. Costs assume stream discharge for expanded plant concentrate disposal. Feasibility is uncertain based on on-going drought and potential for additional reduction in yield of O.H. Ivie Reservoir.
10	Supply is no longer available as City of Lubbock is developing this source.
11	Aquifer storage volume is limited due to maximum aquifer thickness of 15 feet. No Groundwater Conservation District (GCD) in place to protect stored water from pumping by others.
12	Recent water level data and analysis indicate that this strategy will have a limited long term yield and would not be a feasible strategy.
13	Yield and cost developed from the 2011 BGRWP. Projected water savings are above amounts anticipated from existing plumbing fixture regulations.
14	Reuse system used to supplement yield of LFPH.
14-A	Maximizes discharge under current reuse authorization. Includes cost for additional infrastructure.
14-B	Requires additional infrastructure and nutrient removal facilities. Potential need for advanced treatment requires additional study.
14-C	Requires additional infrastructure and nutrient removal facilities. Potential need for advanced treatment requires additional study.
14-D	Requires additional infrastructure, advanced treatment and a concentrate reject line.
15	Costs include upsizing transmission pipeline, upgrade of pump station and reduced energy costs. The 42-inch pipeline uses less energy than the 36-inch pipeline from Cedar Ridge Reservoir under Strategy No. 1.

This page is intentionally left blank.

Section 3
Population Projections, Beneficial Use, and Conservation

3.1 Population Projections Prepared by Texas Water Development Board

As part of the Senate Bill 1 water planning process, the TWDB has compiled historical and future population estimates for the Abilene region through the year 2060. These projections were utilized by the Brazos G Regional Water Planning Group (BGRWPG) to develop the 2011 Brazos G Regional Water Plan (2011 BGRWP), which was approved in July of 2010 by Brazos G for inclusion in the 2012 State Water Plan. The locations of the City and surrounding counties are shown in Figure 3-1.

Population estimates for the City's existing service area as included in the 2011 BGRWP are shown in Table 3-1. This table shows that the population of the City's service area identified in the 2011 BGRWP will increase from 141,637 in 2000 to 161,873 by 2040 and decrease to 153,752 by 2060. This represents a net increase between 2000 and 2060 of about 8.6 percent.

The TWDB estimates of growth for the Abilene region are conservative and do not consider factors that could significantly affect the region's future growth. Although many of the smaller West Texas communities are experiencing population declines, the larger communities that serve as regional business hubs, like Abilene, may not experience this trend as corporations consider relocating operations outside of the larger metropolitan areas to avoid higher property taxes, air quality concerns, and congestion. Cities such as Abilene that are situated along major transportation corridors (e.g.,IH-20) are likely candidates to attract new industry.

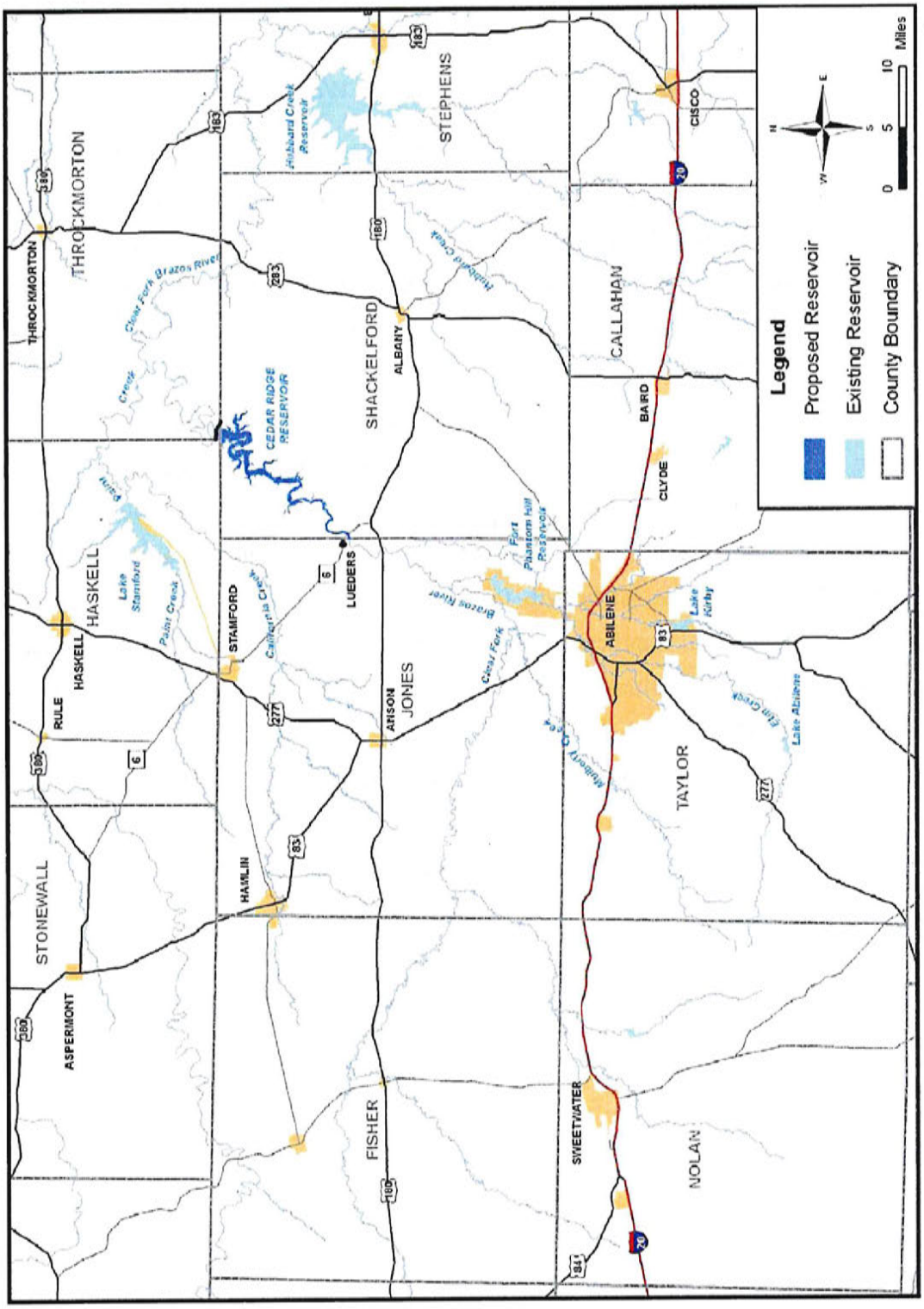


Figure 3-1. City of Abilene and Surrounding Counties

Table 3-1.
TWDB Population Projections for City of Abilene Service Area

Entity[1]	Year						
	2000	2010[4]	2020	2030	2040	2050	2060
Abilene[2]	115,926	124,607	130,220	132,820	133,514	130,943	126,835
Baird[2]	1,623	1,623	1,623	1,623	1,623	1,623	1,623
Clyde[2]	3,344	3,733	3,787	3,706	3,615	3,514	3,430
Merkel[2]	2,637	2,842	2,972	3,035	3,053	2,996	2,903
Tye[2]	1,158	1,248	1,305	1,333	1,341	1,316	1,275
Hawley WSC[2]	6,390	6,562	6,738	6,745	6,657	6,464	6,212
Potosi WSC[2]	3,500	3,765	3,938	4,015	4,034	3,955	3,830
Steamboat Mountain WSC[2]	3,342	3,601	3,767	3,846	3,870	3,797	3,679
County-Other (Callahan)[3]	545	506	512	503	494	483	474
County-Other (Taylor)[3]	3,172	3,418	3,577	3,649	3,672	3,601	3,491
Total Population	***141,637***	***151,905***	***158,439***	***161,275***	***161,873***	***158,692***	***153,752***

Notes:

[1]Additional counties are included in the Water Rights permit application in the event the future Abilene service area is extended.

[2]Population served estimate is entire population for that entity.

[3]Population served estimate is a portion of entire population for that entity. Calculated based upon supply provided from City of Abilene versus other sources.

[4]At the time of submittal of this report, 2010 Census data is available for the cities and counties; however, an analysis has not been completed with regard to the population projections of the WSCs or the portions of the counties that are served by Abilene.

3.2 Beneficial Use with Water Demand Projections Prepared by Brazos G

Water demand projections for the City as approved by the BGRWPG for the 2011 Regional Water Plan are summarized in Table 3-2 for the 2010 through 2060 timeframe. These projections include contracts that the City has with numerous Water Supply Corporations (WSC), other entities, and smaller cities, and include water management strategies recommended by the BGRWPG to be met with water supplied by Abilene. These projections show demands increasing from 40,076 acft/yr in 2010 to 58,441 acft/yr in 2060.

Table 3-2.
Brazos G Water Demand Projection for the City of Abilene (acft/yr)

Entity	Year					
	2010	2020	2030	2040	2050	2060
Abilene[1]	22,891	23,485	23,507	23,181	22,588	21,879
Baird[2]	77	77	77	77	77	77
Clyde[2]	307	307	307	307	307	307
Merkel[2]	353	353	353	353	353	353
Tye[2]	184	184	184	184	184	184
Hawley WSC[2]	307	307	307	307	307	307
Potosi WSC[2]	307	307	307	307	307	307
Steamboat Mountain WSC[2]	307	307	307	307	307	307
County-Other (Callahan)[2]	61	61	61	61	61	61
County-Other (Taylor)[2]	891	891	891	891	891	891
Eagle Construction & Environmental Services, L.P.[2]	11,837	11,837	11,837	11,837	11,837	11,837
Manufacturing (Taylor)[3]	972	1,081	1,177	1,270	1,349	1,462
Baird (Recommended Strategy)[4]	260	240	240	240	240	240
Merkel (Recommended Strategy)[4]	128	139	139	132	120	105
Potosi WSC (Recommended Strategy)[4]	136	142	141	129	116	104
Steamboat Mountain WSC (Recommended Strategy)[4]	55	54	51	43	30	20
Tye (Recommended Strategy)[4]	3	6	6	2	0	0
Steam-Electric (Nolan County Recommended Strategy)[4]	1,000	11,500	20,000	20,000	20,000	20,000
Total Water Demand	***40,076***	***51,278***	***59,892***	***59,628***	***59,074***	***58,441***

Notes:
[1]Water demand includes portions of the City located in Jones and Taylor Counties.
[2]Water demand is the contract amount for these entities.
[3]Water demand is from the 2011 Brazos G Regional Water Plan.
[4]Additional demand identified in the 2011 Brazos G Regional Water Plan to be met by the City of Abilene. With regard to the Nolan County Steam Electric Demand, the initial demand for this portion of the State was identified as 94,298 acft/year by the TWDB based on a BEG 2008 report *"Water Demand Projections for Power Generation in Texas"*; however, it was reduced to 20,000 acft/year by the TWDB at the request of the Brazos G Regional Water Planning Group (BGWPG, 2009, Appendix Q).

3.3 Supplies and Needs Summary for the City of Abilene

A summary of water supply available to Abilene from each of the City's existing water supply sources is included in Table 3-3. These estimates are from the 2011 Brazos G Regional Water Plan and are based on the 2-year safe yield of Lake Fort Phantom Hill under future sediment conditions and the existing potable water production capacity of the Hargesheimer water treatment plant. This table shows that year 2010 supplies from existing sources total 36,122 acft/yr and that by 2060 supplies will be reduced to 34,747 acft/yr due to sedimentation of existing reservoir sources.

Table 3-3.
Water Supply Summary for the City of Abilene

Source	Year					
	2010	2020	2030	2040	2050	2060
Existing Supply (Brazos G Plan):						
Lake Abilene[1]	0	0	0	0	0	0
Lake Kirby[2]	0	0	0	0	0	0
O.H. Ivie Reservoir (Colorado River MWD)[3]	6,720	6,720	6,720	6,720	6,720	6,720
Lake Fort Phantom Hill[4]	9,316	9,082	8,848	8,614	8,380	8,145
West Central Texas MWD (Hubbard Creek Reservoir)[5]	20,086	20,046	20,004	19,963	19,923	19,882
Total Water Supply	***36,122***	***35,848***	***35,572***	***35,297***	***35,023***	***34,747***

Notes:
[1]Lake Abilene is not considered a dependable supply by the City and is not currently used.
[2]Lake Kirby is used primarily to store reuse water for the City's reuse customers. Reuse demands are not included in the water demand projections for the City.
[3]Current treatment capacity (desalination) is approximately 6 MGD (6,720 acft/yr).
[4]The yield from Lake Fort Phantom Hill available to Abilene has been adjusted by 2,500 acft/yr to account for the portion of the water right not owned by the City.
[5]The Hubbard Creek Reservoir amounts available to Abilene are based on the City's existing contract with the WCTMWD.

The City's O.H. Ivie Reservoir supply of 6,720 acft/yr is based on the current capacity of the City's Hargesheimer water treatment plant. The City's contract for such supplies is for 16.54 percent of the 1-year safe yield of the O.H. Ivie Reservoir. Originally, in 1976, the 1-year safe yield of Ivie was estimated to be 90,700 acft/yr. However, over the past two decades, inflows to the O.H. Ivie Reservoir have been seriously affected by drought conditions and the 1-year safe yield has been revised several times. A 2006 study by Freese and Nichols, Inc.[1] indicates that the 1-year safe yield of the project is now 65,940 acft/yr, or 72.7 percent of the original estimate. This means that during the recent drought, if the O.H. Ivie Reservoir had been utilized at its original safe yield amount of 90,700 aft/yr, the reservoir would have gone dry.

Because the water quality of O.H. Ivie Reservoir does not meet secondary drinking water standards, it is treated using reverse osmosis at the City's Hargesheimer water treatment plant. In this treatment process, about 13 percent of the raw water from the O.H. Ivie Reservoir ends up in a waste stream (brine), which is currently disposed of in evaporation ponds or discharged to the City's wastewater system. Because the continuing drought could further reduce the safe yield of the reservoir, future use of O.H. Ivie is assumed to be limited to the current treatment plant capacity of 6,720 acft/yr of potable supply.

[1] Freese and Nichols, 2006. Yields of Lake J.B. Thomas, E.V. Spence Reservoir and O.H. Ivie Reservoir for Colorado River Municipal Water District.

Table 3-4 shows that using the BGRWP demand projections result in a 2040 shortage of 24,331 acft/yr which decreases slightly by 2060 to 23,694 acft/yr.

Table 3-4.
Water Demand and Supply Summary for the City of Abilene
2011 Brazos G Regional Water Plan Demand Projections

	Year					
	2010	***2020***	***2030***	***2040***	***2050***	***2060***
Total Water Demand	40,076	51,278	59,892	59,628	59,074	58,441
Total Supply	36,122	35,848	35,572	35,297	35,023	34,747
Balance/(Shortage)	***(3,954)***	***(15,430)***	***(24,320)***	***(24,331)***	***(24,051)***	***(23,694)***

3.4 Water Conservation Plan and Drought Contingency Plan

Copies of the City's Water Conservation Plan and Drought Contingency Plan (Plans), which were last updated in April 2010, are on file with TCEQ.

Section 4
Dam, Spillways, and Flood Analyses

4.1 Dam, Spillway, and Outlet Works Configuration

The dam location for Cedar Ridge Reservoir is located on the Clear Fork in the southwest corner of Throckmorton County about 29 river miles downstream of State Highway 6 (SH 6) near Lueders, Texas as shown in Figure 4-1. The conceptual design of the reservoir is based on a preliminary geotechnical investigation performed in 2009 and TCEQ requirements in Chapter 299 Rules for dams and reservoirs and includes an earthen dam, two spillways, and an outlet works as shown in Figure 4-2.

The dam will be about 5,200 feet (ft) in length with a crest elevation of about 1,520 ft-msl (feet- above mean sea level) and have a maximum height of about 160 feet. A centerline profile of the dam and spillways is shown in Figure 4-3. The dam embankment will be constructed using predominantly local materials from within the reservoir area. Rock riprap for slope protection and clean sand for internal filter zones will need to be obtained from nearby quarries or other sources. Preliminary geotechnical investigations and engineering analyses performed by Fugro Consultants, Inc. indicate that embankment side slopes of 3H:1V will result in adequate safety factors for stability.[1] A conceptual cross-section of the zoned embankment for the dam is included in Figure 4-4.

The principal spillway is located just west of the dam in a natural topographic saddle. It will be a concrete structure with a 500 feet wide, ogee-shaped crest, tapered chute, and stilling basin with chute and impact blocks to dissipate energy. The crest of the principal spillway will be set at elevation 1,489 ft-msl and will establish the conservative pool level of the reservoir. This structure will not be gated and will spill flood waters when the reservoir level exceeds 1,489 ft-msl. A bridge is planned across this spillway to provide access to the dam and outlet works.

The emergency spillway is located just beyond the east end of the dam. It will be a broad-crested earth and rock cut channel with a crest elevation of 1,500 ft-msl. It will have a crest width of 1,400 feet to pass the required design floods. Hydrologic analyses performed to establish the design floods comply with the requirements of TCEQ's *Hydrologic and Hydraulic Guidelines for Dams in Texas* and are discussed in Section 4.2 and Appendix B.

[1]Fugro Consultants, Inc., "Draft Preliminary Geotechnical Investigation, Cedar Ridge Reservoir Alternative Dam Site, Throckmorton County, Texas," dated October 13, 2009.

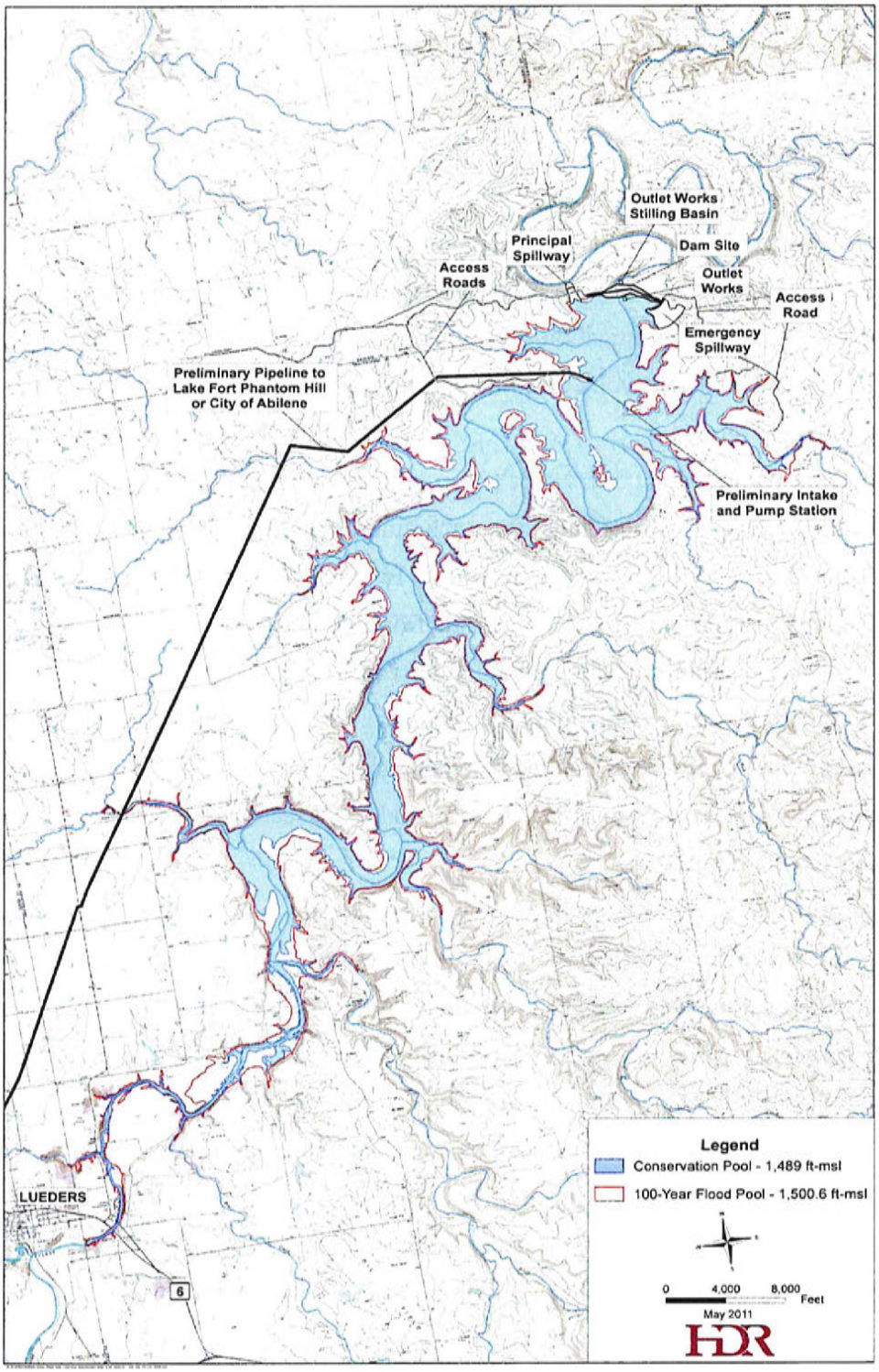
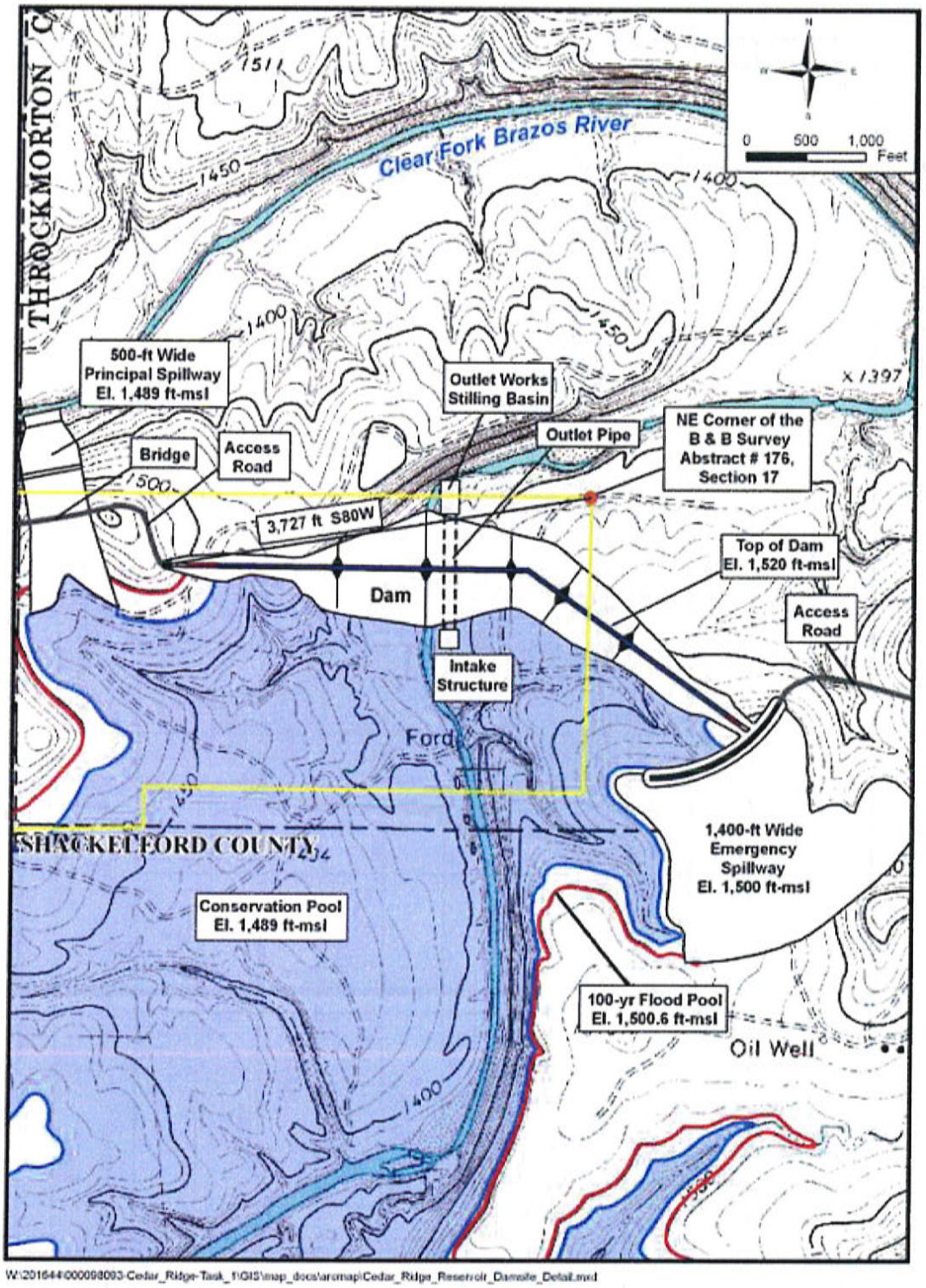


Figure 4-1. Cedar Ridge Reservoir and Associated Facilities



W:\201644\000098093-Cedar_Ridge-Task_1\GIS\map_docs\arcmap\Cedar_Ridge_Reservoir_Damsite_Detail.mxd

Figure 4-2. Conceptual Plan for Dam, Spillways and Outlet Works

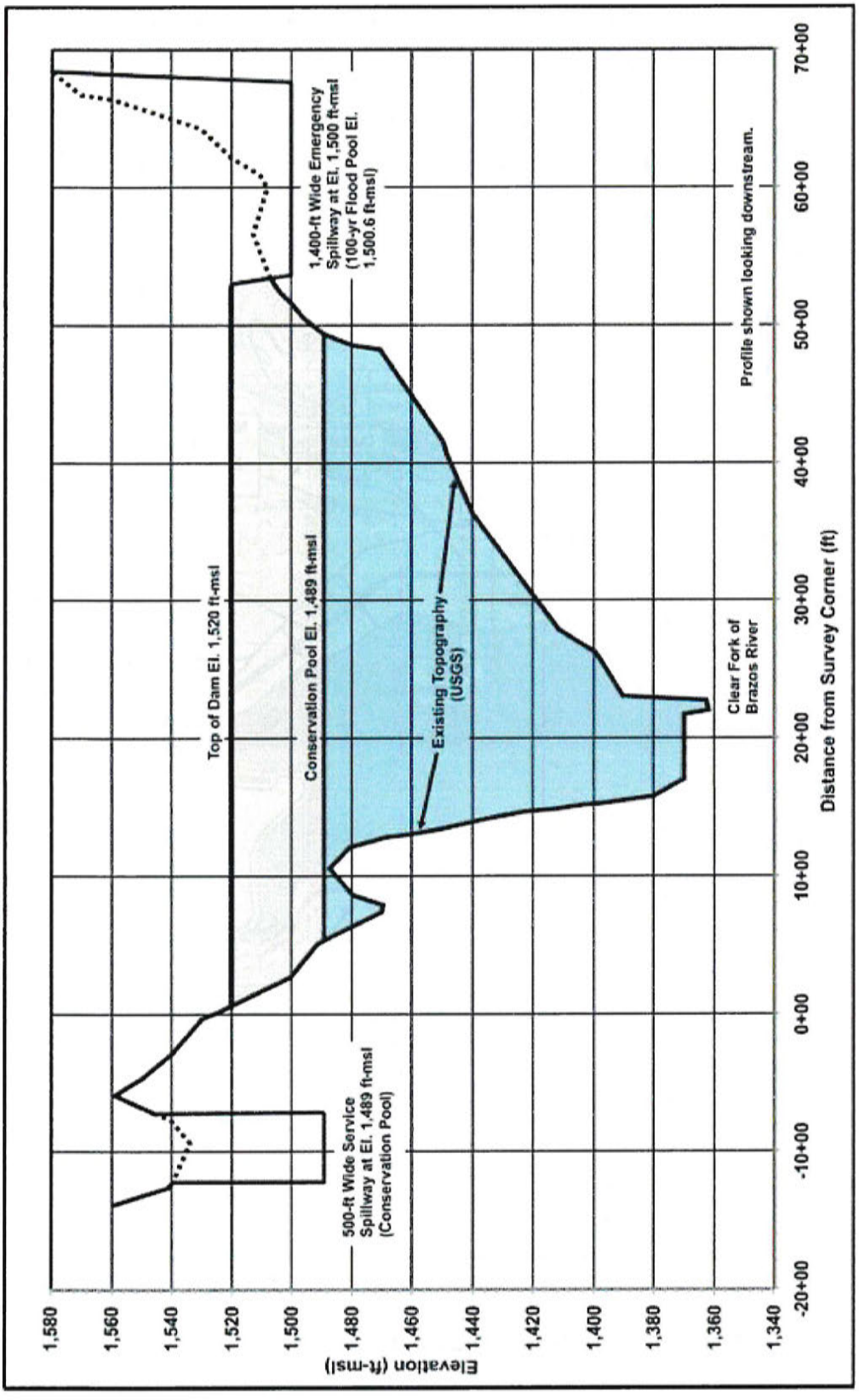


Figure 4-3. Centerline Profile of Dam and Spillways

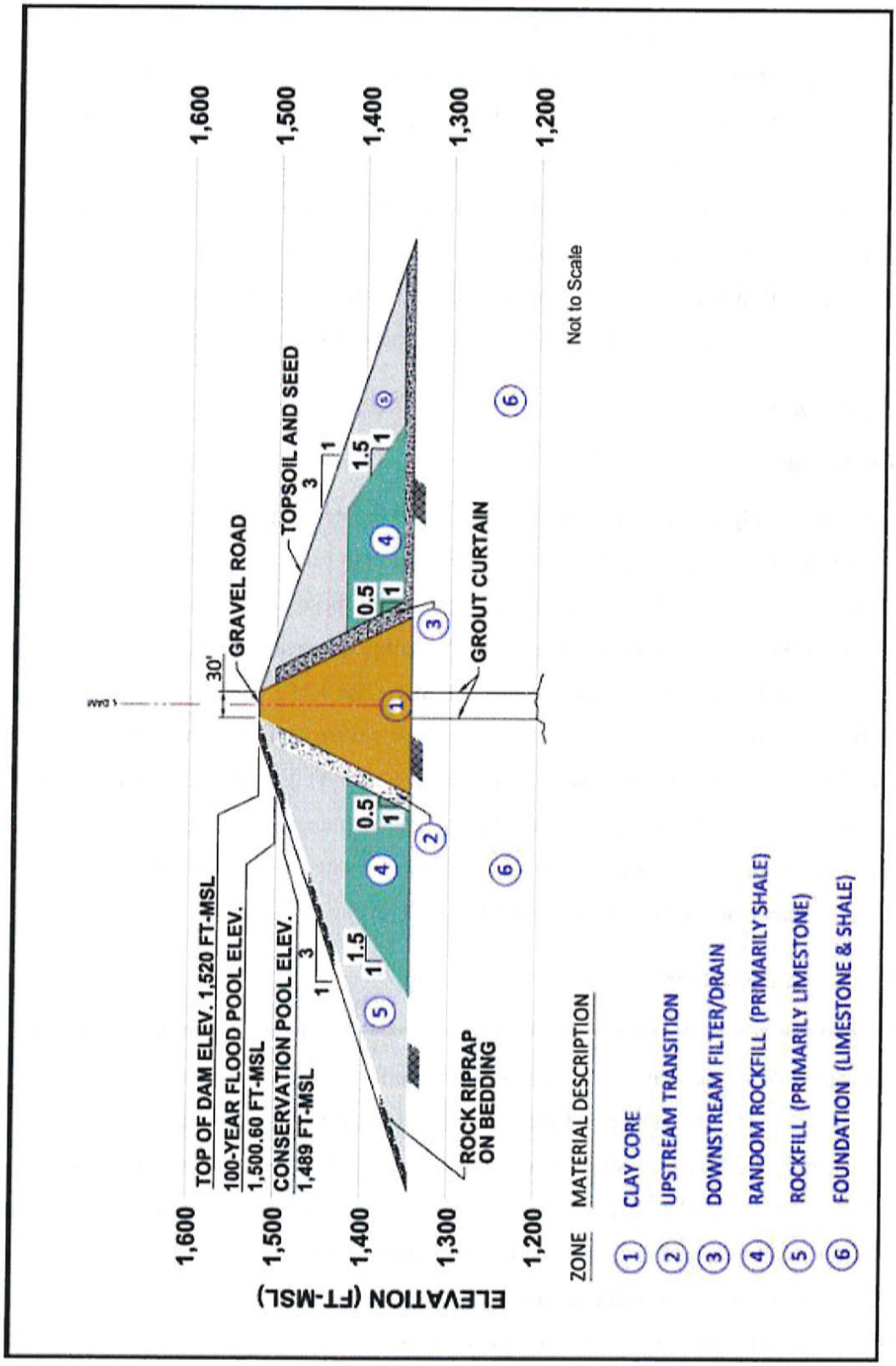


Figure 4-4. Conceptual Dam Cross-Section

The outlet works will include a multi-level intake tower in the reservoir, an outlet pipe beneath the dam, and an outlet structure with impact blocks to dissipate energy and provide aeration benefits. The preliminary location of the outlet works is shown in Figure 4-2 and could change as additional geotechnical data becomes available. The outlet pipe and control gates on the intake structure will be sized to accommodate the range of environmental flow pass-throughs. To help ensure that water with acceptable dissolved oxygen concentration is available for environmental pass-throughs, the intake tower will have multiple control gates spaced so that water can be passed from the upper portion of the reservoir's conservation pool.

4.2 Flood Hydrology

4.2.1 Introduction

Hydrologic analyses were performed to determine the magnitude of design floods used to determine spillway dimensions and the top of dam elevation to safely pass the appropriate design floods. TCEQ has defined flood design criteria for dams and these are summarized in Table 4-1. This table shows the applicable percentage of the probable maximum flood (PMF) a structure must pass based on the hazard and size classifications. The PMF is an extreme flood event, defined as the flood that can be expected from the most severe combination of meteorological and hydrologic conditions that are possible in a region. Under TCEQ criteria, the dam would be classified as a large size dam as the proposed dam height is in excess of 100 ft and the proposed reservoir storage at the top of the dam is greater than 50,000 acft. According to the TCEQ criteria, all large dams must be designed for the full PMF event.

4.2.2 Watershed Description

The watershed area for the proposed reservoir is approximately 2,728 square miles and is shown in Figure 4-5. A majority of the watershed is undeveloped, consisting of mostly pasture and grasslands. There are four intermediate to large size reservoirs in the watershed. The largest is Fort Phantom Hill Reservoir which was constructed in 1938 and has a conservation pool capacity of 74,310 acft. The other three reservoirs in the study area include lakes Abilene, Kirby, and Sweetwater which have combined conservation storage pools of less than 30,000 acft. These three reservoirs were constructed prior to 1930.

The watershed area was subdivided into 11 sub-basins as shown in Figure 4-5. Drainage areas were calculated using United States Geological Survey's (USGS) 30-meter Digital Elevation Model (DEM) obtained through the National Hydrography Dataset (NHDPlus) portal.

Table 4-1.
TCEQ Hydrologic Criteria for Dams

Hazard Classification	Size Classification	Design Flood Event
Low Hazard	Small Intermediate Large	¼ PMF[1] ¼ PMF to ½ PMF PMF
Significant Hazard	Small Intermediate Large	¼ PMF to ½ PMF ½ PMF to PMF PMF
High Hazard	Small Intermediate Large	PMF PMF PMF

Notes:
[1]PMF is Probable Maximum Flood.
Hazard Classification
Low hazard dams are defined as those dams where failure may damage farm buildings, limited agricultural improvements, and county roads. For low hazard dams, no loss of life would be expected.
Significant hazard dams are defined as those dams where failure would not be expected to cause loss of human life, but may cause damage to isolated homes, secondary highways, minor railroads, or cause interruption of service or use of relatively important public utilities.
High hazard dams are defined as those dams where failure would be expected to cause loss of human life, extensive damage to agricultural, industrial, or commercial facilities, important public utilities, main highways, or railroads.
Size Classification
Small size dams are classified as those dams which have a total height less than 40 ft and have total reservoir storage at top of dam of less than 1,000 acft.
Intermediate size dams are classified as those dams which have a total height equal to or greater than 40 ft and less than 100 ft and total reservoir storage at the top of dam equal to or greater than 1,000 acft and less than 50,000 acft.
Large size dams are classified as those dams which have a total height equal to or greater than 100 ft and have total reservoir storage at top of dam of equal to or greater than 50,000 acft.

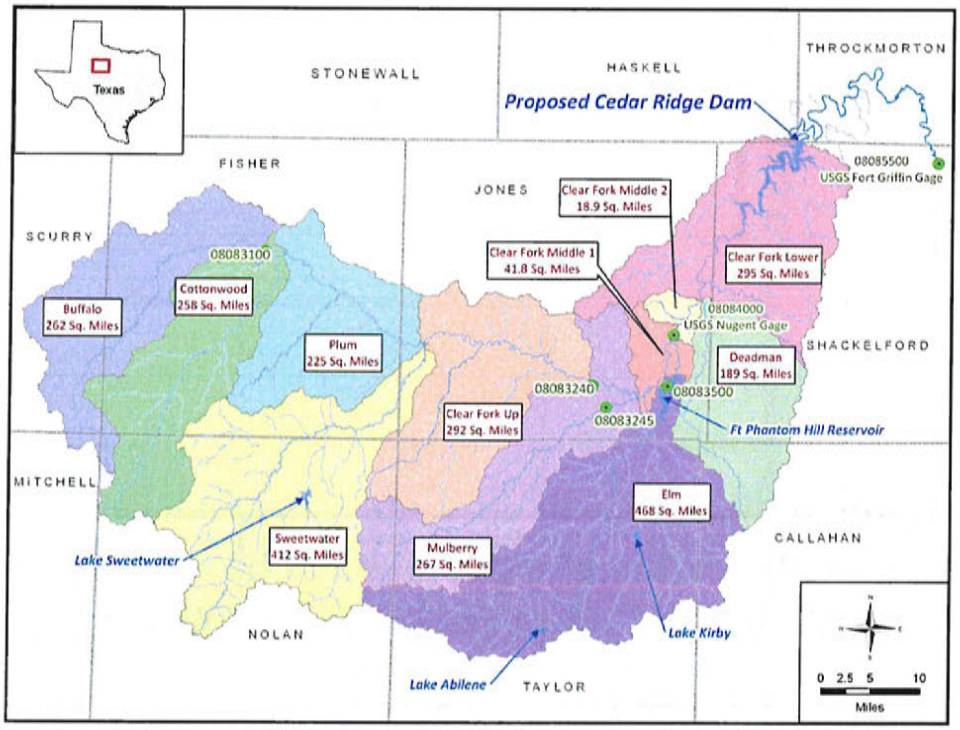


Figure 4-5. Cedar Ridge Reservoir Watershed Sub-basins

4.2.3 Historical Flood Events

4.2.3.1 Clear Fork at Nugent, Texas

The USGS has operated a stream gage on the Clear Fork at Nugent, Texas (Nugent gage) since 1924. This gage is located approximately 41 river miles upstream of the proposed dam site. The USGS reports the drainage area at the Nugent gage to be 2,199 square miles, which represents about 81 percent of the drainage area at the proposed dam site. The period of record for the Nugent gage includes periods both before and after Fort Phantom Hill Reservoir became operational in 1938. The maximum annual instantaneous peak flows reported by the USGS are shown in Figure 4-6.

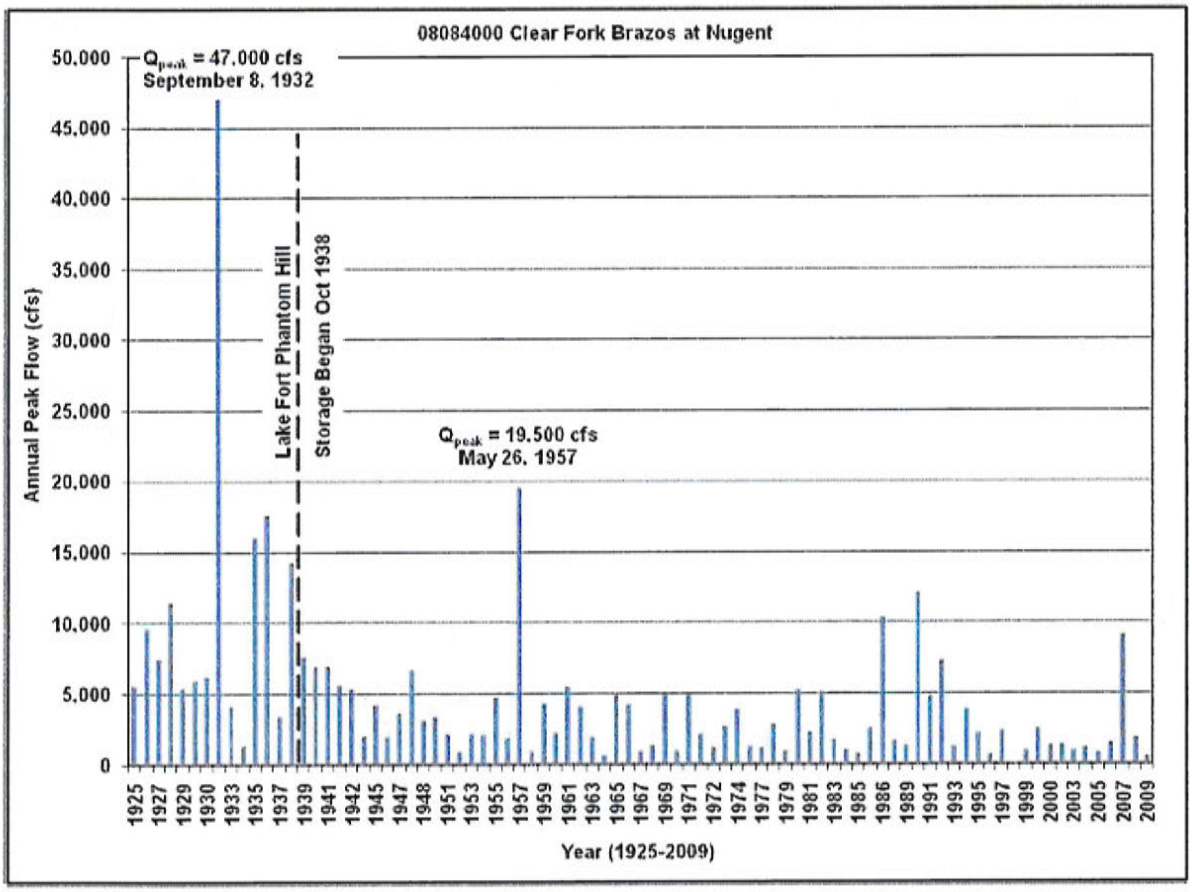


Figure 4-6. Maximum Annual Peak Flow for USGS Gage on Clear Fork at Nugent

The highest peak flow prior to Fort Phantom Hill Reservoir occurred on September 8, 1932 (47,000 cfs with a stage of 27.05 feet). The highest peak flow after Fort Phantom Hill Reservoir was constructed occurred May 26, 1957 (19,500 cfs). Based on USGS interviews of

local residents, three extreme events occurred outside of the period of record including a maximum stage of 30 feet in 1876, 24 feet in 1900, and 24.5 feet in 1923.

4.2.3.2 Clear Fork at Fort Griffin, Texas

The USGS has operated a stream gage on the Clear Fork at Fort Griffin, Texas (Fort Griffin gage) since 1924. This gage is located approximately 55 river miles downstream of the proposed dam site. The USGS reports the drainage area at the Fort Griffin gage to be 3,988 square miles of which about 68 percent is located upstream of the proposed dam site. The maximum annual instantaneous peak flows reported by the USGS are shown in Figure 4-7. The highest peak flow occurred on August 4, 1978 (149,000 cfs with a stage of 38.88 feet). The second highest peak flow occurred on September 10, 1932 (33,600 cfs with a stage of 35.09 feet). The USGS reports two extremes outside the period of record including a maximum stage of 36.2 feet in 1876, and a stage of 38 feet on September 24, 1900.

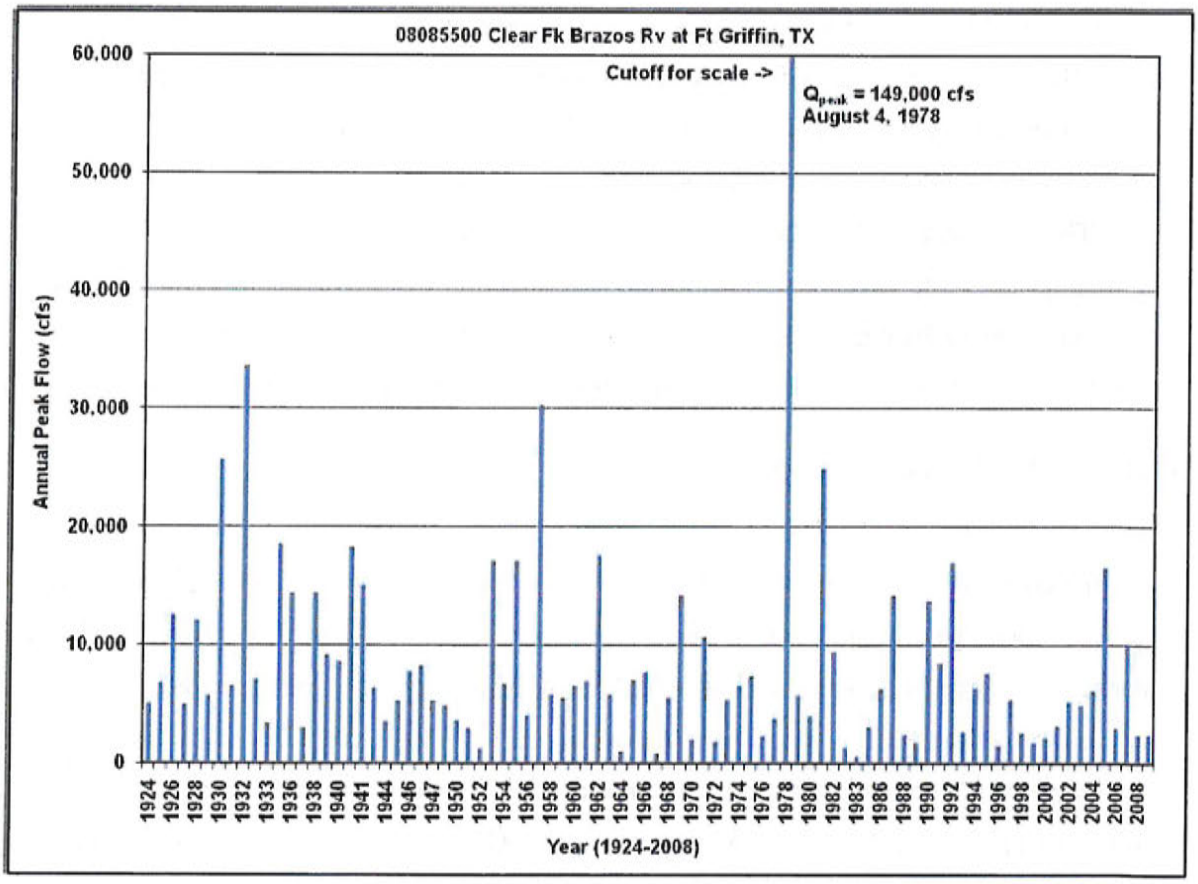


Figure 4-7. Maximum Annual Peak Flow for USGS Gage on Clear Fork at Ft. Griffin

4.2.4 Development of Rainfall/Runoff Model

The US Army Corps of Engineers (USACE) Hydrologic Engineering Center's hydrologic model HEC-HMS (version 3.3) was used to model the hydrology for the study area. The primary input components of the HEC-HMS model include rainfall, soil loss parameters, runoff transformation parameters and reach routing parameters. A full description of this model including a schematic, model inputs and model calibration is included in Appendix B.

4.2.5 Rainfall/Runoff Model Results

4.2.5.1 PMF Event and Selection of Top of Dam Elevation

The PMF design flood for Cedar Ridge Reservoir was selected in accordance with TCEQ guidelines considering runoff from the 24-, 48-, and 72-hour PMF storms to determine which resulted in the highest reservoir stage. The elevation-storage-discharge data for Cedar Ridge Reservoir shown in Table 4-2 was used in these analyses. As shown in Figure 4-8, the 72-hour PMF event produced the highest reservoir level with a peak reservoir inflow of 428,900 cfs, a peak outflow of 415,700 cfs, and a peak reservoir elevation of 1,513.5 ft-msl. The peak outflow was split between the principal and emergency spillways with 58% being discharged through the principal spillway and 42% through the emergency spillway.

The selected top of dam elevation was calculated using the PMF level of 1,513.5 ft-msl and adding adequate freeboard to prevent overtopping by waves considering long-term settlement of the embankment. Based on the PMF level of 1,513.5 ft-msl, 5.0 feet of freeboard for waves and 1.5 feet of long-term settlement, the top of dam was set at 1,520.0 ft-msl.

4.2.5.2 Other Frequency Storms

In addition to the PMF storm event, the rainfall/runoff model was used to estimate peak flows and corresponding reservoir levels for the 50-, 100-, and 500-year frequency storm events. The peak discharges for these events are summarized in Table 4-3 and compared to the two historical storm events at both the Nugent and Fort Griffin gages that produced the highest peak flows as well as the PMF event. Flows at the Nugent and Fort Griffin gages are scaled to the reservoir site using drainage area ratios and routed through the reservoir using a daily time step. This comparison shows that the 1978 storm at the Fort Griffin gage, when scaled to the reservoir site, would have produced a peak reservoir stage of 1,500.2 ft-msl which is only 0.4 feet lower than the 100-year peak reservoir stage of 1,500.6 ft-msl computed by the model.

Table 4-2.
Elevation-Storage-Discharge Data for Cedar Ridge Reservoir

Elevation (ft-msl)	Storage (acft)	Outflow (cfs)		
		Primary Spillway	Emergency Spillway	Total
1489	227,127	0	0	0
1490	233,271	1,597	0	1,597
1491	240,145	4,629	0	4,629
1492	247,189	8,698	0	8,698
1493	254,405	13,727	0	13,727
1494	261,793	19,628	0	19,628
1495	269,331	26,351	0	26,351
1496	277,077	33,921	0	33,921
1497	285,026	42,200	0	42,200
1498	293,178	51,277	0	51,277
1499	301,534	60,906	0	60,906
1500	310,066	71,130	0	71,130
1502	327,807	93,116	9,874	102,990
1504	346,389	116,436	28,026	144,462
1506	368,352	140,582	51,417	191,999
1508	388,619	166,029	79,231	245,260
1510	407,002	192,682	110,620	303,302
1512	429,114	220,691	145,440	366,130
1514	452,389	249,963	183,374	433,337
1516	480,321	280,241	223,926	504,167
1518	505,923	311,752	267,279	579,031
1520	528,910	344,250	313,007	657,257

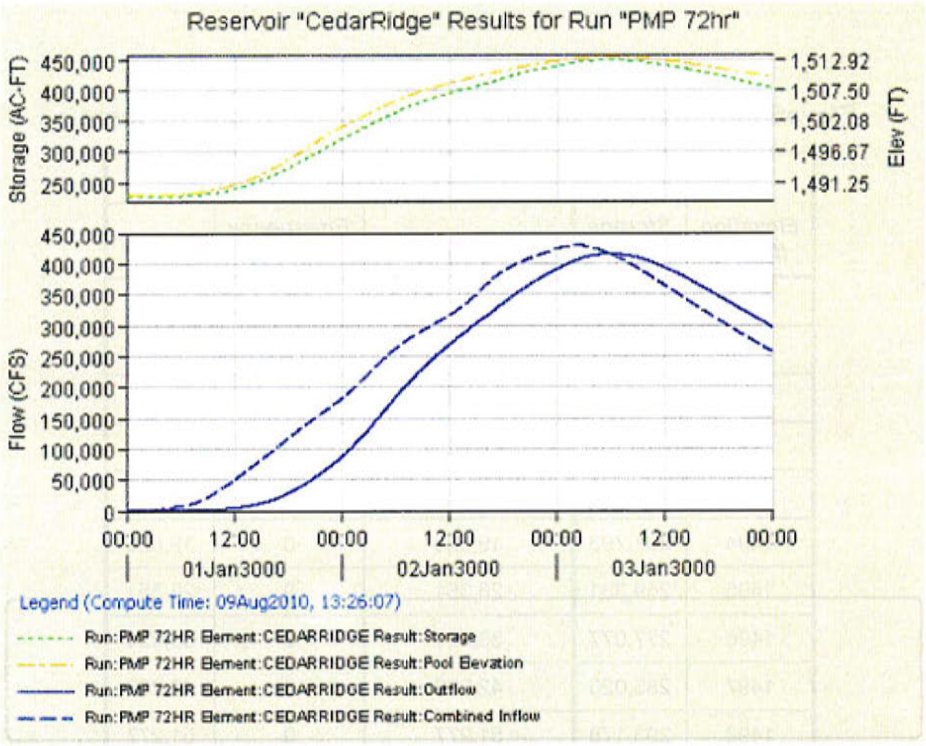


Figure 4-8. Computed Reservoir Stage, Storage, and Inflow and Outflow Hydrographs for PMF

Table 4-3.
Comparison of Peak Inflows, Outflows and Stages for Cedar Ridge Reservoir for Historical and HEC-HMS Model Storm Events

Historical and Computed Storm Events	*Estimated Peak Reservoir Inflow (cfs)*	*Estimated Peak Discharge (cfs)*			*Estimated Peak Reservoir Stage (ft-msl)*
		Primary Spillway	*Emergency Spillway*	*Total*	
Sept. 1932 Storm (Fort Griffin gage)	22,982[A]	19,812	0	19,812[B]	1,494.0[B]
May 1957 Storm (Nugent gage)	24,180[A]	20,583	0	20,583[B]	1,494.2[B]
Sept.1932 Storm (Nugent gage)	58,280[A]	42,408	0	42,408[B]	1,497.0[B]
50-year (HEC-HMS model)	63,484	58,923	0	58,923	1,498.8
100-year (HEC-HMS model)	84,313	77,121	1,474	78,595	1,500.6
August 1978 Storm (Fort Griffin gage)	101,916[A]	72,860	233	73,093[B]	1,500.2[B]
500-year (HEC-HMS model)	154,510	117,512	28,975	146,487	1,504.1
PMF(HEC-HMS model)	428,900	242,300	173,400	415,700	1,513.5

Notes:
A. *Represents observed instantaneous peak flow at gage scaled to the reservoir site.*
B. *Daily mean hydrograph scaled to reservoir site and routed through proposed reservoir to estimate discharge and peak stage.*

Section 5
Water Availability Analyses

Water availability analyses were performed to determine the firm yield[1] of the reservoir, potential impacts, if any, on other water rights and effects on downstream flows. The latest version of the Brazos Water Availability Model (BWAM) was requested from TCEQ and TCEQ directed HDR staff to TCEQ's ftp site[2] to obtain the September 9, 2008 version of the BWAM and to Dr. Wurbs' website for the March 2010 version of WRAP[3]. These versions of the BWAM and WRAP models were used by HDR for all analyses. A spreadsheet containing all pending water right applications was also obtained from the TCEQ, and a check of this document showed that there were no pending applications in the vicinity of the proposed project, other than the City's pending reuse application (Certificate of Adjudication 12-4161C). The version of the BWAM provided by TCEQ did not include the Brazos River Authority's (BRA) pending systems operation permit (Application No. 5851). However, modeling this permit was not necessary as the City has entered into an interlocal agreement with BRA (see Appendix A) which effectively relieves the City from having to make pass-throughs for BRA's Possum Kingdom Lake authorization and BRA's pending systems operation permit. The following sections describe the modeling approach for this application.

5.1 Abbreviations and Definitions

Throughout this section numerous terms are used that refer to components of the BWAM that are referenced using modeling terminology. These terms and their definitions include:

- WRAP – Water Rights Analysis Package. This is computer program utilized for the TCEQ Water Availability Models (WAM).
- BWAM – Brazos River Basin Water Availability Model. This is model maintained by TCEQ to determine estimates of water availability in the Brazos River Basin. The BWAM consists of various input files that communicate data to the WRAP model.
- *dat* – Main input file for WAM's that includes the flow network, water rights, reservoirs, job control options, and other information.

[1] Firm yield is the maximum quantity of water that can be diverted from a reservoir, without shortage, using the entire reservoir storage volume during the critical drought. The critical drought for a reservoir is that period in a sequential hydrologic record that when the reservoir is drafted at the firm yield rate results in zero storage remaining in the reservoir.

[2] ftp://ftp.tceq.state.tx.us/pub/WaterResourceManagement/WaterQuantity/WAM/

[3] Water Rights Analysis Package (WRAP) Model - http://ceprofs.civil.tamu.edu/rwurbs/wrap.htm

- *dis* – Another input file for the WAM's that includes watershed parameters and flow distribution information for control points.
- WR/WS records - data for water rights and reservoirs.
- CP records - data for each control point including flow network and other key inputs.
- PX/BU records - data for priority circumvention and back up water supply and dual simulation options.
- IF records - information for environmental instream flow requirements.
- TS records - time series of targets that can be used by WR or IF records.
- DI/IS/IP records - Drought Index Reservoir, Drought Index Storage, and Drought Index Percentages, respectively. Data is used in model to adjust environmental instream flow targets based upon reservoir storage.
- FD records - flow distribution data used in calculating naturalized flows at ungaged control points.
- WP records - watershed data including drainage area, for all control points.
- Regulated Flow – output of the BWAM that represents total flow at a control point including pass-throughs for senior water rights, pass-throughs for environmental flow requirements, return flows (if applicable), reservoir passes, and unappropriated flow.
- HEFR – Hydrology-Based Environmental Flow Regime. The HEFR methodology consists of statistical calculations of hydrologic data for the purpose of populating an environmental flow regime matrix that covers the entire hydrologic spectrum from base flows to high flow pulses.
- HFP – High Flow Pulse. The highest tier of the HEFR flow regime matrix considered applicable to the reservoir.
- Q_p – Peak flow that triggers a HFP event under the HEFR flow regime.

5.2 Elevation, Surface Area, and Capacity Data for Cedar Ridge Reservoir

Figure 5-1 and Table 5-1 include elevation-area and elevation-capacity data for Cedar Ridge Reservoir. Surface area data were obtained from USGS digital 7.5 minute quadrangle maps with 10 ft. elevation contours.

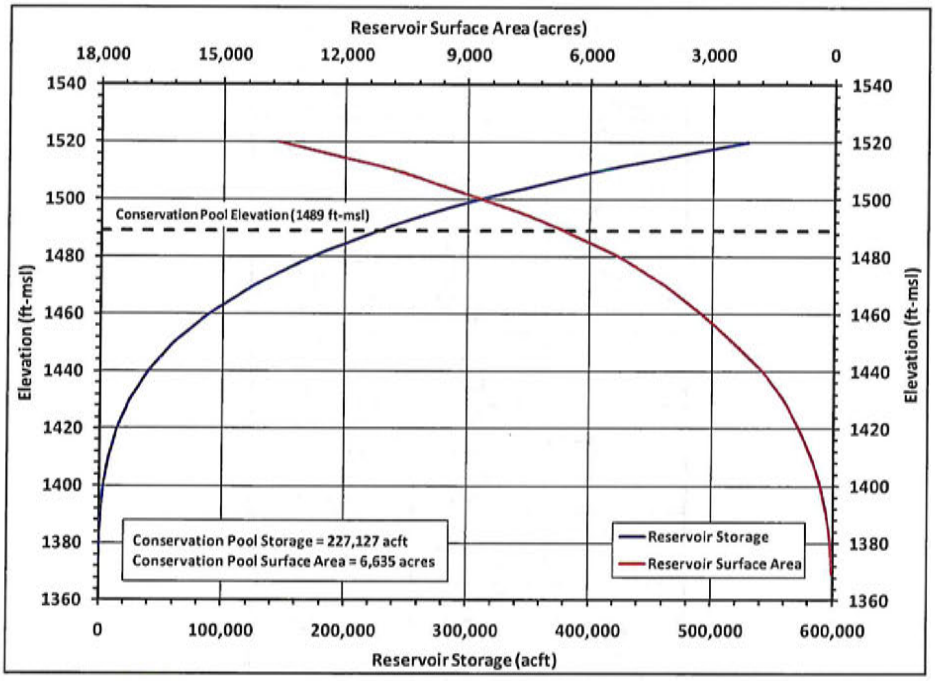


Figure 5-1. Elevation-Area and Elevation-Capacity Curves for Cedar Ridge Reservoir

Table 5-1.
Elevation-Area-Capacity Data for
Cedar Ridge Reservoir

Elevation (ft-msl)	Surface Area (acres)	Capacity (acft)
1369	0	0
1370	12	4
1375	30	145
1380	48	286
1385	103	772
1390	157	1,259
1395	232	2,400
1400	308	3,542
1405	423	5,629
1410	538	7,717
1415	693	11,151
1420	848	14,586
1425	1,032	19,719
1430	1,216	24,853
1435	1,482	32,223
1440	1,748	39,594
1445	2,106	50,072
1450	2,464	60,550
1455	2,857	74,789
1460	3,250	89,029
1465	3,706	107,513
1470	4,162	125,996
1475	4,721	149,544
1480	5,279	173,092
1485	6,034	203,182
1489[1]	6,635	227,127
1490	6,788	233,271
1495	7,645	269,331
1500	8,660	310,066
1500.6[2]	8,786	315,325
1504.1[3]	9,523	347,604
1505	9,713	358,534
1510	10,765	407,002
1513.5[4]	11,784	446,498

[1]Conservation Level
[2]100-Year Flood Level
[3]500-Year Flood Level
[4]Probable Maximum Flood Level

5.3 Water Availability Modeling Approach

All analyses were performed using BWAM Run 3 (no return flows with all water rights simulated at their full authorizations) and included the following three model runs:

- Baseline (Run 1) — Existing conditions without proposed reservoir with Possum Kingdom Lake (CA 12-5155) operating at its authorized annual diversion of 230,750 acft/yr.
- Run 2 — Includes proposed reservoir with conservation storage of 227,127 acft without an environmental instream flow (IF) requirement with an annual demand of 34,400 acft/yr, with Possum Kingdom Lake operating at an annual diversion of 225,750 acft/yr (Note: subordination agreement between the City and BRA (Appendix A) calls for the City to make annual payments to BRA based on a reduction in supply from Possum Kingdom Lake.)
- Run 3 — Includes proposed reservoir with an annual demand of 34,400 acft/yr with environmental IF requirement, with Possum Kingdom Lake operating at an annual diversion of 225,750 acft/yr (Note: subordination agreement between the City and BRA (Appendix A) calls for the City to make annual payments to BRA based on a reduction in supply from Possum Kingdom Lake.)

Comparisons of the outputs from these three runs allows for an evaluation of the changes associated with the reservoir. Figure 5-2 shows the location of the reservoir and BWAM primary control points where changes in flow resulting from the implementation of the project are evaluated. WRAP input files are included in the CD in Appendix C.

5.3.1 Development of Baseline Run without Cedar Ridge Reservoir (Run 1)

The BWAM files, as downloaded from TCEQ, served as the baseline run or Run 1 for this evaluation. The only modification made to the TCEQ data files for the baseline run was inclusion of a new control point at the location of the reservoir. Adding this control point allows for data from the baseline run to be saved so it can be compared to subsequent runs. This included information for FD and WP records in the *dis* file and the CP records in the *dat* file. The CP records were also modified so that the channel losses in the reach were distributed correctly between control points 417501, CEDARR (the proposed reservoir) and CON029. After

the changes were made to the BWAM, the baseline run was executed and outputs recorded to compare against the two subsequent runs.

5.3.2 Development of Run 2 - Cedar Ridge Reservoir with no Environmental IF Requirement

For Run 2 the BWAM files from the baseline run were modified to include the reservoir without an environmental IF requirement. Several additions and modifications were made to the baseline *dat* file for this run and included:

- WR/WS records for the reservoir with an authorized diversion of 34,400 acft/yr and a storage capacity of 227,127 acft;
- Monthly evaporation data specific to the reservoir (developed using TWDB evaporation data for TWDB quads 408 and 508);
- Modification of the CP record to adjust channel losses along the Clear Fork to account for the reservoir footprint and evaporation data;
- PX/BU records to simulate the subordination of Possum Kingdom Lake;
- SV/SA records for the reservoir; and
- The authorized diversion of Possum Kingdom Lake was reduced by 5,000 acft/yr to 225,750 acft/yr on the WR records as part of the City's subordination agreement with BRA.

The methodology used in the subordination of Possum Kingdom Lake (PX and BU records) is the same methodology used by the TCEQ in the BWAM for subordination agreements associated with Lake Whitney and Lake Waco.

5.3.3 Development of Run 3 - Cedar Ridge Reservoir with an Environmental IF Requirement

For Run 3 the BWAM *dat* file from Run 2 was modified to include an environmental IF requirement and the following changes:

- IF records were added to the file just ahead of the reservoir's WR records for the three hydrologic conditions (i.e., wet, average, and dry);
- TS records were added with each of the IF records representing a time series of environmental instream flow requirement targets; and
- DI/IS/IP records were added to activate one of the three sets of IF records depending on the storage level and associated hydrologic condition in the reservoir.

The annual demand on the reservoir's WR record was set to 34,400 acft/yr, which represents the firm yield of the reservoir with the environmental IF requirements as described above.

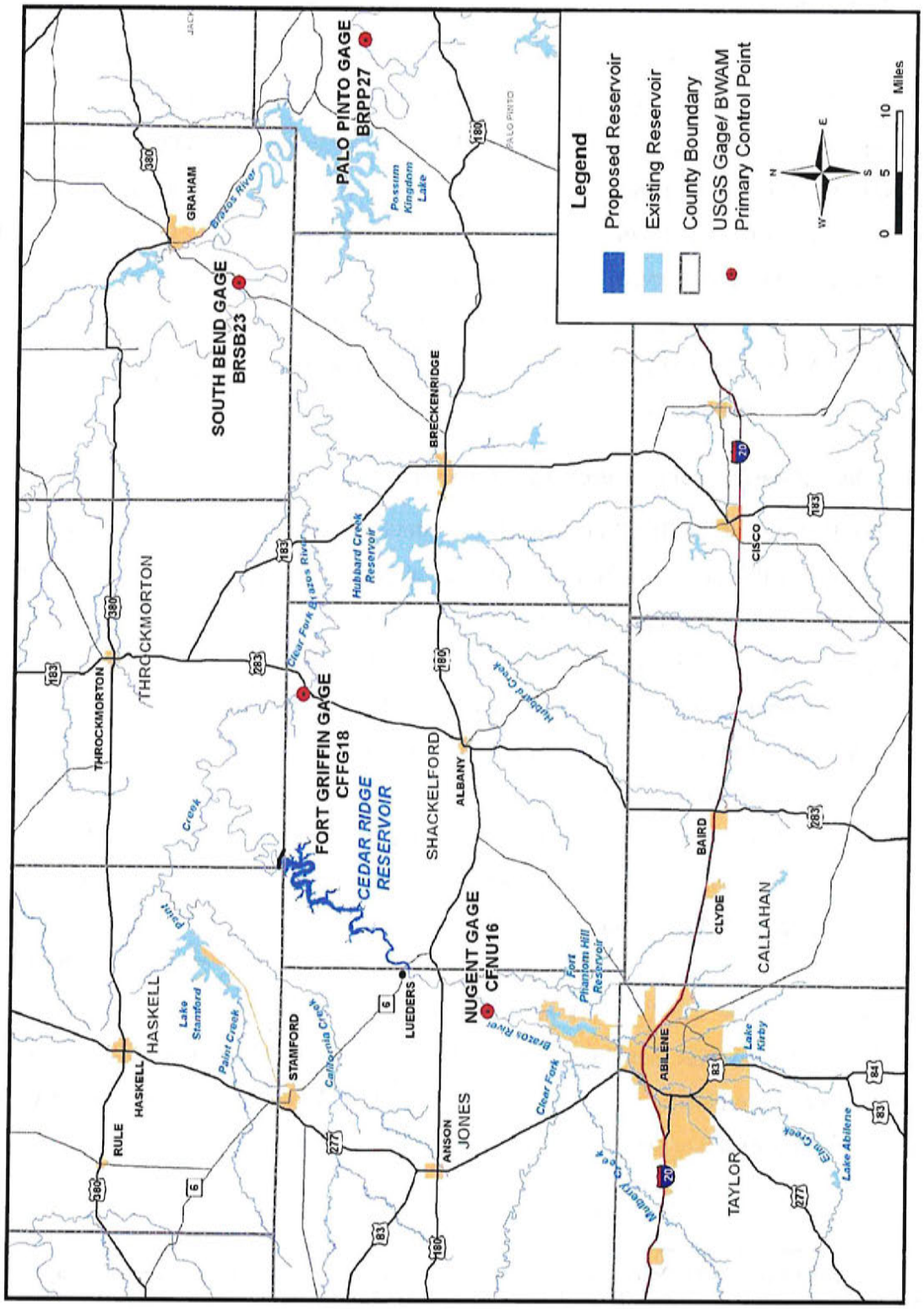


Figure 5-2. Location of Cedar Ridge Reservoir, Nugent Gage and Key BWAM Primary Control Points

5.3.4 Development of Environmental Instream Flow Requirement for Cedar Ridge Reservoir

An environmental instream flow requirement was developed for the proposed reservoir using the HEFR methodology as initiated by Texas Parks and Wildlife Department (TPWD) with input from other agencies and organizations.[4] The HEFR methodology produces a multi-tiered set of seasonal flow recommendations consisting of subsistence, baseflows and HFP using a statistical analysis of average daily flows for a long-term historical period. For this project, the HEFR recommendations served as the starting point for the development of seasonal environmental instream flow requirements and were only slightly modified (during wet conditions in August) by HDR biologists to minimize adverse impacts to juvenile Brazos water snakes associated with high flows.

5.3.4.1 Daily Flow Data and Hydrograph Separation

The first step of the HEFR process involves developing daily streamflow estimates at the reservoir site. For this project daily flows were developed using data from the Clear Fork near Nugent, Texas streamflow gage (USGS gage No. 08084000 or Nugent gage). This gage has an 86-year period of record (1924 – current) with a USGS published drainage area of 2,199 square miles. A drainage area ratio was applied to the daily flows at the Nugent gage to estimate flows at the Cedar Ridge Reservoir location which has a drainage area of 2,728 square miles. Since Lake Fort Phantom Hill spills infrequently, the selected drainage area ratio was adjusted to not include the drainage area above Lake Fort Phantom Hill. The 71-year period from 1939 through 2009 was utilized in the HEFR process to represent the time frame after Lake Fort Phantom Hill became fully operational.

This daily flow data was then parsed using the Nature Conservancy's Indicators of Hydrologic Alternation[5] (IHA). IHA parses a hydrograph and assigns daily flows into one of five flow regime categories including: extreme low flow, low flow, high flow pulse, small flood, and large flood. The parsing and categorizing of the daily flow is the output from IHA and is used by the HEFR model to develop the flow regime matrix.

[4] Use of Hydrologic Data in the Development of Instream Flow Recommendations for the Environmental Flows Allocation Process and the Hydrology-Based Environmental Flow Regime (HEFR) Methodology. Senate Bill 3 Science Advisory Committee for Environmental Flows. April 20, 2009.
[5] Ibid.

5.3.4.2 Development of HEFR-Based Environmental Flow Pass-Through Regime

A HEFR analysis was prepared using the IHA output and several user defined options including:

- The following seasons:
  - Winter = November – February
  - Spring = March – May
  - Summer = June – August
  - Fall = September – October
- Subsistence Flow or Water Quality Protection Flow was set equal to 1.5 cfs, which is the published 7Q2 value for this reach of the Clear Fork.
- The *Frequency Approach* was selected under the Episodic Events Option.

Seasons were selected based on analysis of statistical hydrological data with input from HDR biologists familiar with aquatic species of the Clear Fork considering seasonal aquatic spawning patterns and Brazos water snake birthing and juvenile activity. The statistical data comparing monthly median flow values were used as the starting point for determining seasons, and then a biological overlay was provided by the biologists to highlight key biological indicators. Additional discussion of the seasonal determination can be found in Section 6.7.4.2.2 *Downstream Effects on Aquatic Biota.*

The results of the HEFR-based analysis are shown in Table 5-2. Hydrologic conditions (wet, average and dry) are defined on the basis of the volume of water in storage in the reservoir and the annual demand on the reservoir as shown in Table 5-3. Using the reservoir storage as the hydrologic condition indicator was determined to be appropriate as it is representative of the hydrologic condition of the Clear Fork watershed upstream of the reservoir. Wet conditions are associated with reservoir storage that is exceeded about 25 percent of the time. Similarly, dry conditions occur when storage drops below levels that are exceeded about 75 percent of the time. Average conditions apply when neither wet nor dry conditions are applicable, about 50% of the time. Additional information on how these reservoir storage volumes were selected for three reservoir demand scenarios is included in the following section. The highest HFP tier applies when wet hydrologic conditions occur and are characterized by larger one per season events. The second HFP tier applies when average hydrologic conditions occur and are characterized by smaller events that occur with a frequency of two per season. The last HFP tier applies when dry hydrologic conditions occur and are the same magnitude and duration as those for the average

condition, but occur with a frequency of one per season. No overbank flows are recommended as these will be met with reservoir spills.

Table 5-2.
HEFR-Based Environmental Flow Pass-Through Regime for Cedar Ridge Reservoir

		Winter				Spring			Summer			Fall	
		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Overbank Flows		To be met from spill events from the reservoir, not controlled passes.											
High Flow Pulses	Wet[1]	Qpeak: 50 cfs Freq.: 1 per season Volume: 314 acft Duration: 5 days				Qpeak: 384 cfs Freq.: 1 per season Volume: 2,224 acft Duration: 9 days			Qpeak: 421 cfs[2] Freq.: 1 per season Volume: 2,157 acft Duration: 7 days			Qpeak: 184 cfs Freq.: 1 per season Volume: 843 acft Duration: 5 days	
	Avg [1]	Not Recommended				Qpeak: 65 cfs Freq.: 2 per season Volume: 311 acft Duration: 4 days			Qpeak: 119 cfs Freq.: 2 per season Volume: 501 acft Duration: 4 days			Qpeak: 22 cfs Freq.: 2 per season Volume: 77 acft Duration: 2 days	
	Dry[1]	Not Recommended				Qpeak: 65 cfs Freq.: 1 per season Volume: 311 acft Duration: 4 days			Qpeak: 119 cfs Freq.: 1 per season Volume: 501 acft Duration: 4 days			Qpeak: 22 cfs Freq.: 1 per season Volume: 77 acft Duration: 2 days	
Baseflows (cfs)	Wet[1]	16				14			11			12	
	Avg [1]	9.0				8.0			6.0			6.0	
	Dry[1]	5.0				4.0			2.0			2.0	
Subsistence Flows (7Q2)[3] (cfs)		1.5				1.5			1.5			1.5	

Note: All values shown in cfs (cubic feet per second) and are based on average daily flows and not instantaneous flows. Period of Record used: 1/1/1939 to 12/31/2009.

[1]Wet, average and dry hydrologic conditions are determined based on annual demand and reservoir storage on day 1 of each season. Reservoir storage transition points are summarized in Table 5-3.

[2]High Flow Pulses in August are limited to a peak flow of 184 cfs, a volume of 843 acft, and duration of 5 days for juvenile snake considerations (same as the Fall season).

[3]Subsistence flow is equal to the published 7Q2 value for the Clear Fork at Nugent Gage.

Table 5-3.
Cedar Ridge Reservoir Storage Triggers for Determining Hydrologic Conditions for HEFR-Based Environmental Instream Flow Pass Throughs for Three Annual Reservoir Demands

Annual Reservoir Demand (acft/yr)	*25th Percentile – Reservoir Storage(for transition from wet to average hydrologic conditions)*	*75th Percentile – Reservoir Storage(for transition from average to dry hydrologic conditions)*
0 to 17,200	98%	85%
17,201 to 25,800	96%	74%
25,801 to 34,400	91%	60%

The baseflow tiers apply when the indicated HFP flows are not applicable. When reservoir inflow exceeds the listed baseflow rate for the applicable hydrologic condition, then pass-throughs will be made at the listed baseflow rate. When reservoir inflow is less than the listed baseflow rate during wet and average hydrologic conditions, then the previous day's measured inflow will be passed. When reservoir inflow is less than the listed baseflow rate during dry hydrologic conditions, then the minimum of the subsistence flow[6] of 1.5 cfs or the previous day's measured inflow will be passed. The 1.5 cfs rate is the published 7Q2 flow for this reach of the Clear Fork. When there are no reservoir inflows as measured at the Lueders gage, then there will be no pass-throughs.

Pass-throughs of baseflows and HFPs will be made on a daily basis and based on average daily reservoir inflows as measured by the gage located near Lueders, Texas (USGS gage No. 08084200). Flows as measured on the previous day at the Lueders gage will be compared to the HEFR flows in Table 5-2 for the applicable hydrologic condition to determine how much water will be passed. As shown in Table 5-2, each HFP has a peak flow (Qp in cfs), volume (acft) and duration (days). If the previous day's flow exceeds the Qp and Qp pass targets have not previously been met for that season, then a pass will be made at the specified Qp rate. Passes of inflows continue for the next several days at the maximum rate of either the Qp target or the previous day's measured inflow (whichever is less) until either the volume or duration targets are met, whichever occurs first. Once a HFP pass has been made for a one per season event, the HFP requirement is satisfied until the next season. For a two per season event, two HFP pass-throughs events would need to occur before the HFP requirement is satisfied for that season.

HDR biologists reviewed the initial HEFR recommendations considering aquatic, herpetological, other lotic ecological indicators associated with the Clear Fork and determined that the initial HEFR results provided a reasonable set of flow recommendations that would be acceptable to the existing biological communities of the Clear Fork. However, one change was recommended by the biologists and is footnoted in Table 5-2. HFPs occurring during wet conditions in August are limited to a peak flow of 184 cfs, a volume of 834 acft and a duration of 5 days (same as for wet condition during the Fall season) to minimize the displacement of juvenile Brazos water snakes.

[6] Sabine and Neches Rivers and Sabine Lake Bay Basin and Bay Expert Science Team, Environmental Flows Recommendations Report, Final Submission to the Sabine and Neches Rivers and Sabine Lake Bay Basin and Bay Area Stakeholder Committee, Environmental Flows Advisory Group, and Texas Commission on Environmental Quality, November 30, 2009.

5.3.4.3 Inclusion of HEFR-Based Environmental Instream Flows

The modeling of daily flows in the BWAM requires pre-processing daily flow data in a spreadsheet outside the BWAM as the BWAM is a monthly model. HDR has developed a spreadsheet tool, referred to as the Flow Regime Application Tool (FRAT) that develops monthly flow targets using estimated daily flows and HEFR flow recommendations. The FRAT is designed to apply the HEFR flow recommendations on a daily time series of streamflow data. In the case of Cedar Ridge Reservoir, estimated daily stream flow at the proposed dam location served as the input for this analysis. The FRAT was used to determine the amount of flow needed to be passed to meet the HEFR flow recommendations for all flow conditions. The FRAT is designed to recognize the number of events per season and the changing of the seasons. The FRAT summarizes daily pass-through volumes into monthly pass-through volumes, which are converted into three sets of TS records for inclusion in the WAM. The three sets of TS records are incorporated into the BWAM associated with the IF/DI/IS/IP records.

The BWAM determines which hydrological condition is in effect each month (i.e., wet, average, or dry) using the beginning month storage in the reservoir. Hydrologic condition will be defined on Day 1 of a season and will remain at that condition regardless of the storage in the reservoir until the first day of the next season when the hydrologic condition will be reevaluated based on the storage in the reservoir. Three hydrologic conditions are tied to three different Cedar Ridge Reservoir storage levels. Storage targets were determined using a reservoir storage frequency plot and selecting reservoir storage levels occurring at the 25th and 75th percentiles for the wet and dry hydrological conditions in accordance with default percentiles described in the HEFR documentation.[7] Figure 5-3 illustrates the storage frequency in the reservoir under three different demand scenarios including 17,200, 25,800 and 34,400 acft/yr. Under the full 34,400 acft/yr requested annual diversion rate, wet hydrologic conditions occur when reservoir storage is above 207,700 acft (about 91 percent). Average conditions occur when reservoir storage is between 207,700 and 135,900 acft (about 60 percent). Dry conditions occur when storage is below 135,900 acft. Table 5-3 shows this information for three different levels of demand on the reservoir. The 34,400 acft/yr demand and the resulting 91 percent and 60 percent storage triggers were utilized for the Run 3 analysis.

[7] Ibid.

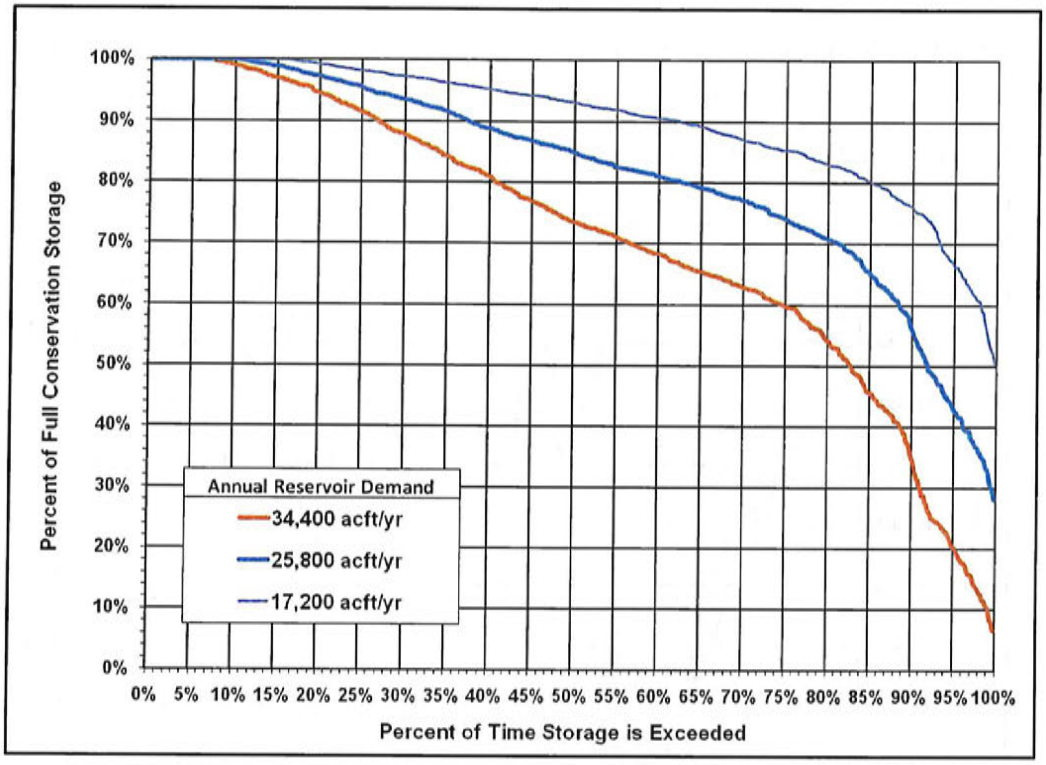


Figure 5-3. Storage Frequency Curves for Cedar Ridge Reservoir Used to Identify the Hydrologic Condition Triggers for Three Annual Reservoir Demands

5.4 Comparisons of Runs

To determine the hydrologic effects of the reservoir, output parameters from Runs 2 and 3 were compared against the baseline run (Run 1). The following BWAM outputs were compared:

- Storage traces (timeline and frequency figures) for both Cedar Ridge Reservoir and Possum Kingdom Lake;
- Regulated flow frequency figures showing the magnitude and occurrence of regulated flows at the proposed reservoir dam site and three downstream primary control points including: the Clear Fork near Fort Griffin, the Brazos River near South Bend, and the Brazos River near Palo Pinto as shown on Figure 5-2.

5.4.1 Reservoir Storage Comparisons

Figure 5-4 shows two time series storage traces for the proposed reservoir for the 1940 – 1997 period comparing Runs 2 and 3 (without and with environmental IF scenarios) under a demand of 34,400 acft/yr. The two storage traces demonstrate how the environmental IF requirement impacts storage in the proposed reservoir. Figure 5-5 shows a storage frequency plot for the same two scenarios. Run 2 (without IF scenario) results in average reservoir storage

levels higher than Run 3 (with IF scenario). Figure 5-6 shows a time series storage trace for Possum Kingdom Lake for all three runs and Figure 5-7 shows storage frequency traces. Both figures illustrate that the impact on Possum Kingdom Lake levels are minimal.

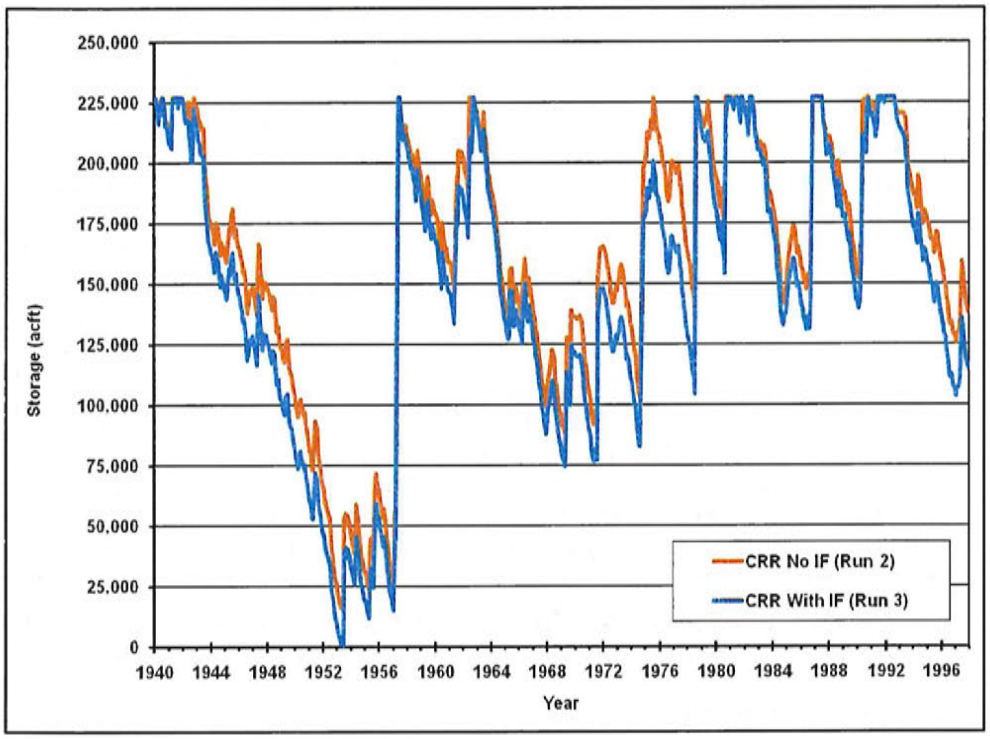


Figure 5-4. Comparison of Time Series of Cedar Ridge Reservoir Storage

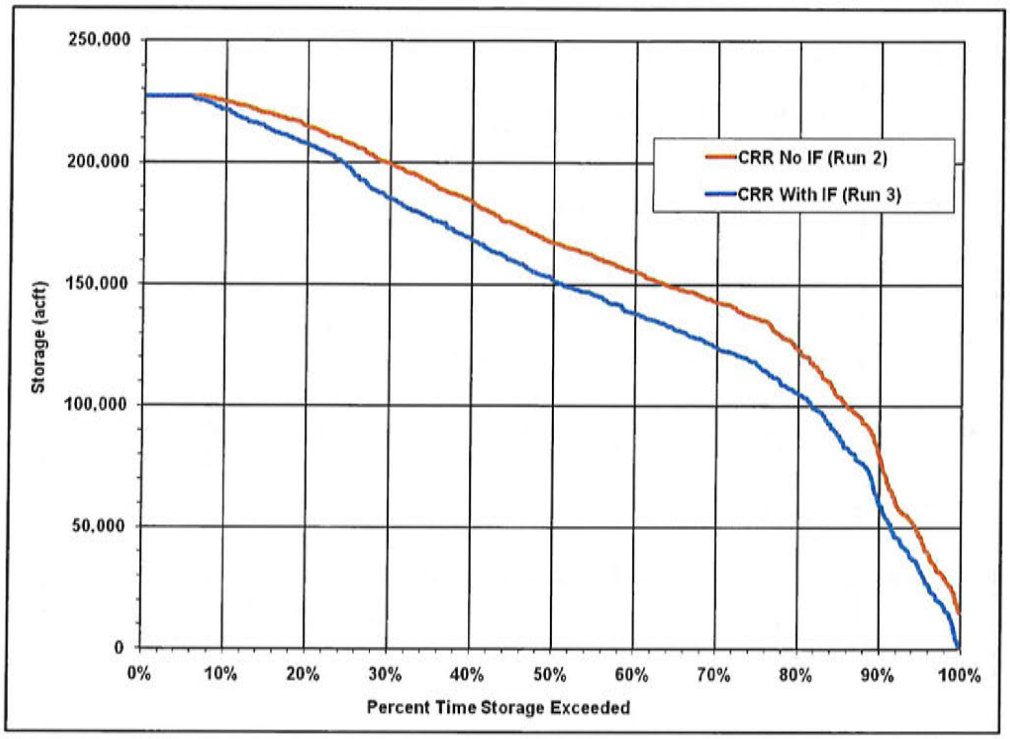


Figure 5-5. Comparison of Storage Frequency of Cedar Ridge Reservoir Storage

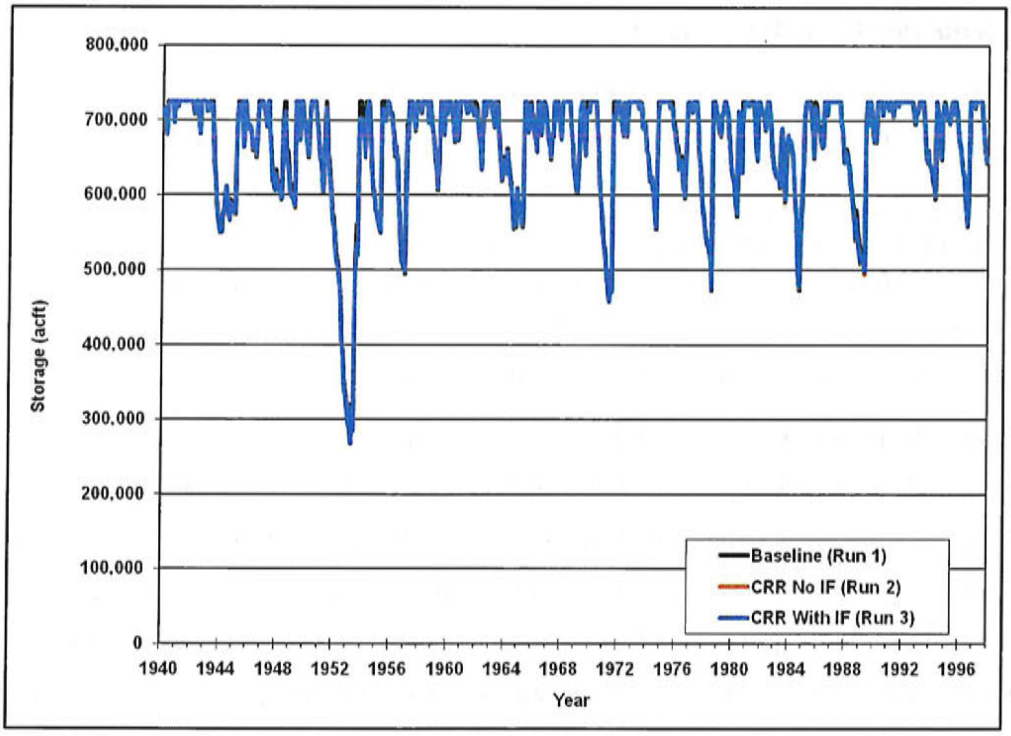


Figure 5-6. Comparison of Time Series of Possum Kingdom Lake Storage

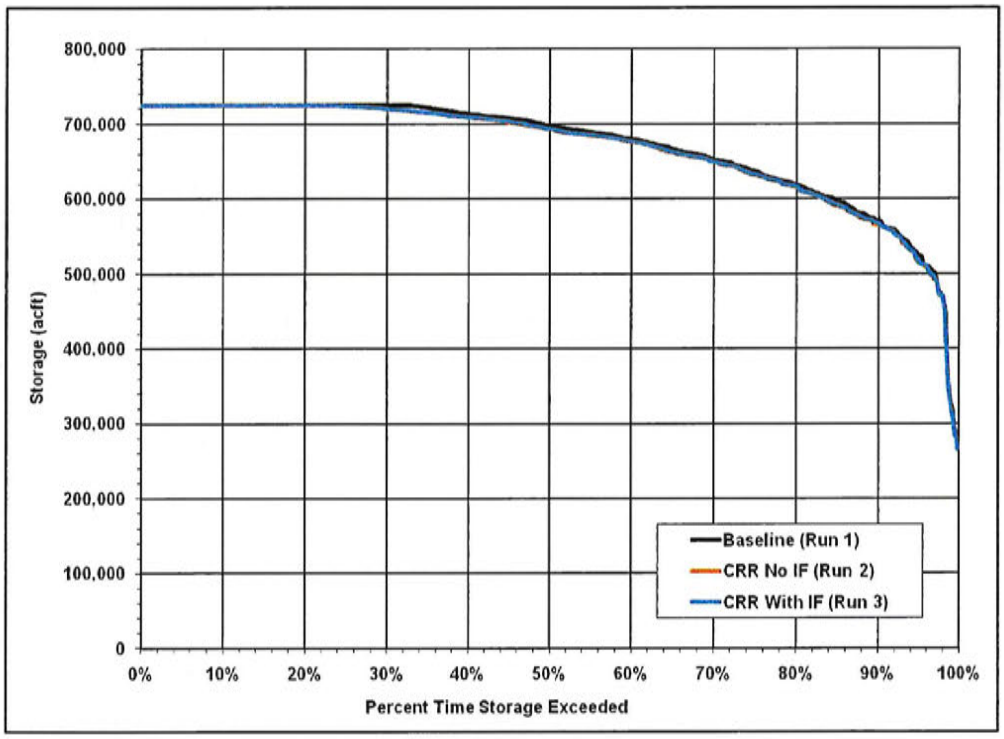


Figure 5-7. Comparison of Storage Frequency of Possum Kingdom Lake

5.4.2 Regulated Flow Comparisons

Changes in streamflow were evaluated by comparing the regulated flow outputs from the BWAM at the following control points:

- Cedar Ridge Reservoir dam location,
- Clear Fork near Fort Griffin primary control point (USGS gage site),
- Brazos River near South Bend primary control point (USGS gage site), and
- Brazos River near Palo Pinto primary control point (USGS gage site).

Table 5-4 summarizes the monthly regulated flow statistics at each of these locations and shows how effects from Cedar Ridge Reservoir on regulated flow decrease at each downstream control point. The largest impact on regulated flow is at the reservoir dam location with average monthly streamflow being reduced from 6,406 to 2,405 acft/mo or about 62 percent. The impacts to average monthly streamflow are reduced by more than half, on a percentage basis, at the next downstream control point (Clear Fork near Fort Griffin) being reduced from 10,375 to 7,483 acft/mo or about 28 percent. At the Brazos River near South Bend control point, located below the Clear Fork confluence with the main stem of the Brazos, monthly average streamflow is reduced from 45,726 to 43,915 acft or 4.0 percent as the main stem of the Brazos contributes a

significant amount of flow at this point compared to the Clear Fork. At the Brazos River near Palo Pinto, located just downstream of Possum Kingdom Lake, average monthly streamflow are reduced from 33,939 to 33,828 acft/mo or 0.3 percent. The data in the table shows that flow changes at the South Bend location and downstream of Possum Kingdom Lake are expected to be minimal. This is due to several factors including channel losses along the Clear Fork, the subordination agreement with BRA and the City, and the HEFR based environmental instream flow pass throughs.

Figures 5-8 through 5-19 are frequency plots of regulated streamflow at the four locations presented in Table 5-4. Three figures are presented for each control point, one for high flows, one for flows below 5,000 acft/mo and one for flows below 1,000 acft/mo. All figures include the results of all three runs with the black line representing pre-reservoir conditions (Run 1), the orange line representing conditions with the proposed reservoir without an environmental IF requirement (Run 2) and the blue line representing conditions with the proposed reservoir with the recommended environmental IF requirements (Run 3). The difference between the orange and blue lines (Runs 2 and 3) demonstrates the benefit the environmental IF requirement has on streamflow at each location.

Figures 5-8, 5-9 and 5-10 compare regulated flows at the Cedar Ridge site. Figures 5-11, 5-12, and 5-13 compare regulated flows at the Clear Fork at Fort Griffin. Figures 5-14, 5-15, and 5-16 show the same information for the Brazos River near South Bend. Figures 5-17, 5-18, and 5-19 show the same information for the Brazos River near Palo Pinto.

Table 5-4.
Comparison of Regulated Streamflow Statistics

Monthly Streamflow Statistic	Baseline (Run 1)	With HEFR IF (Run 3)	Difference Between Run 1 and Run 3	Percent Difference
	Monthly Regulated Flow (acft/mo)			
Cedar Ridge Reservoir Location				
Max	344,541	231,458	-113,083	-33%
Min	0	0	0	0.0%
Median	1,503	429	-1,074	-71%
Average	6,406	2,405	-4,001	-62%
Clear Fork at Fort Griffin				
Max	459,098	377,344	-81,753	-18%
Min	0	0	0	0.0%
Median	1,874	1,212	-663	-35%
Average	10,375	7,483	-2,892	-28%
Brazos River at South Bend				
Max	1,217,022	1,214,717	-2,305	-0.2%
Min	0	0	0	0.0%
Median	12,613	12,074	-539	-4.3%
Average	45,726	43,915	-1,811	-4.0%
Brazos River at Palo Pinto				
Max	1,609,844	1,610,266	423	0.0%
Min	0	0	0	0.0%
Median	872	911	39	+4.5%
Average	33,939	33,828	-111	-0.3%

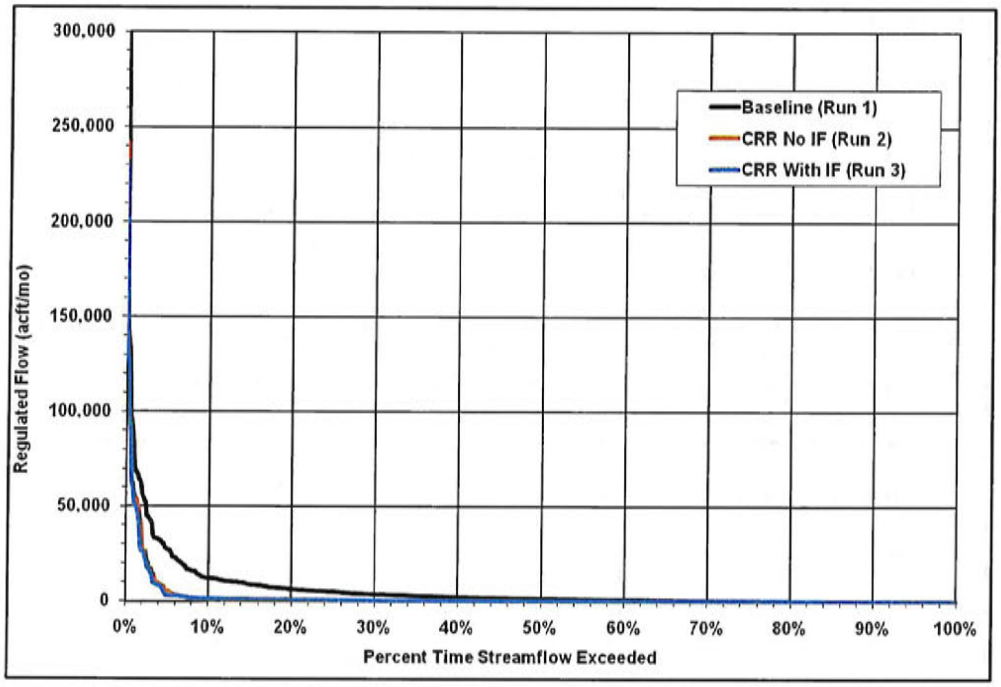


Figure 5-8. Comparison of Regulated Flow Frequency at Cedar Ridge Reservoir (High Flows)

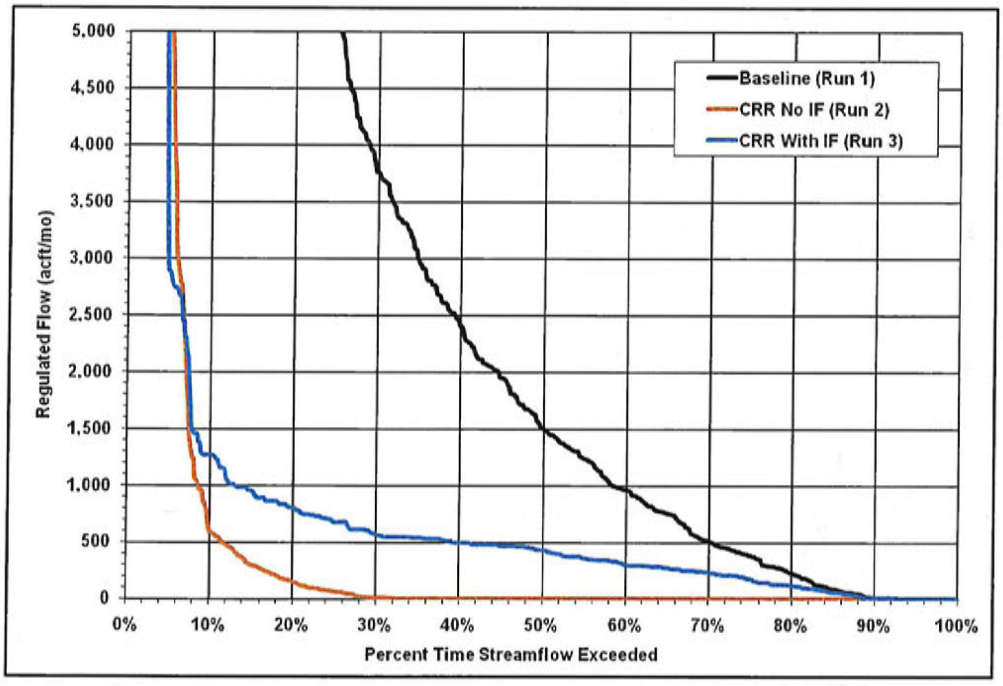


Figure 5-9. Comparison of Regulated Flow Frequency at Cedar Ridge Reservoir (Flows below 5,000 acft/mo)

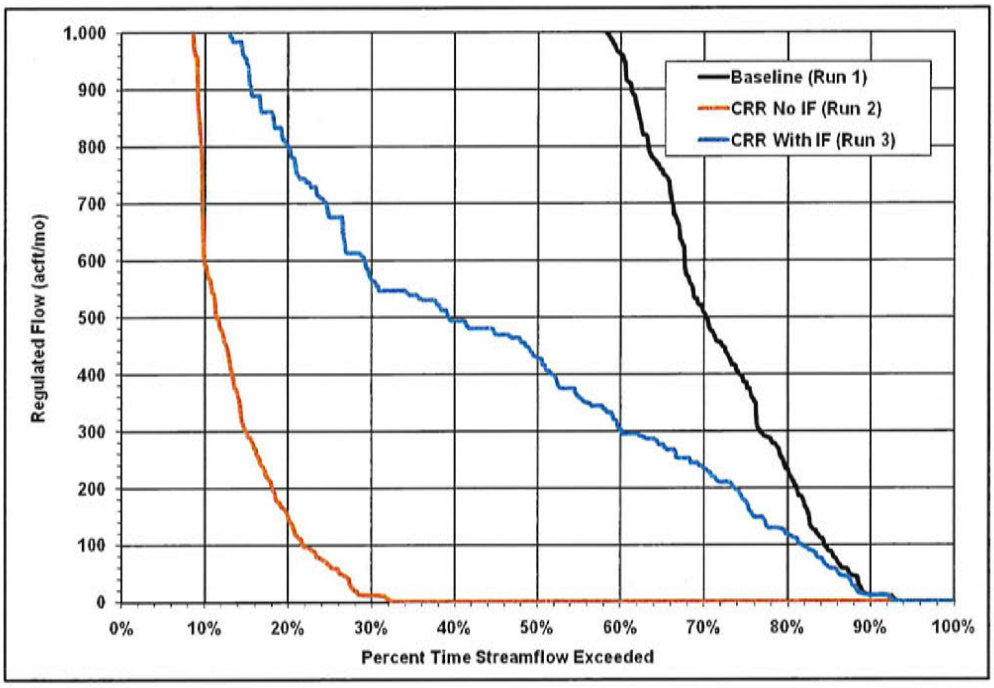


Figure 5-10. Comparison of Regulated Flow Frequency at Cedar Ridge Reservoir (Flows below 1,000 acft/mo)

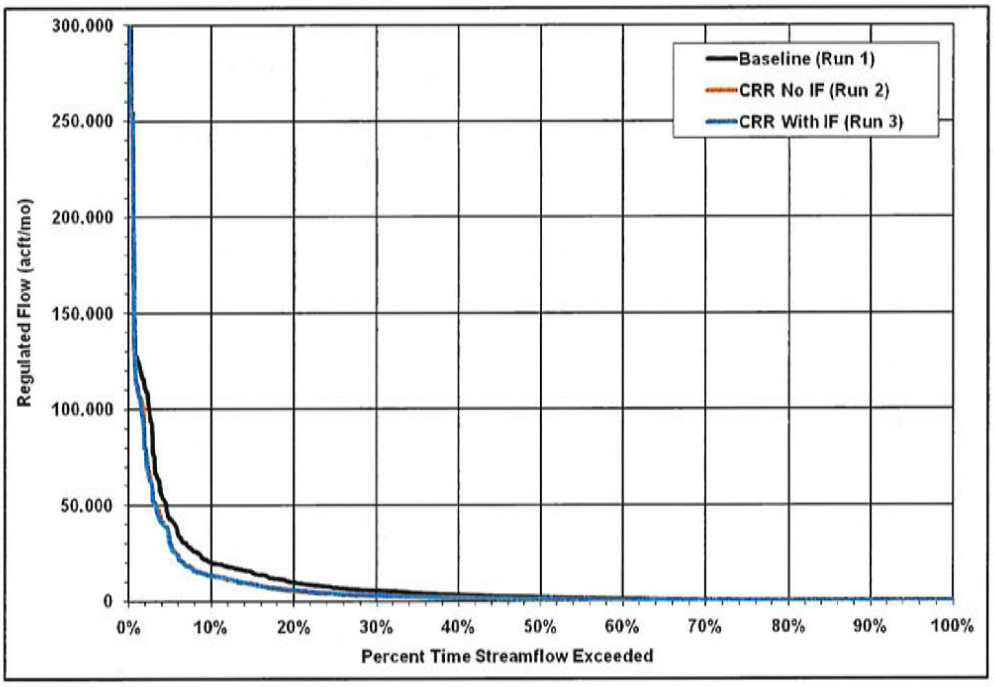


Figure 5-11. Comparison of Regulated Flow Frequency at Clear Fork near Fort Griffin (High Flows)

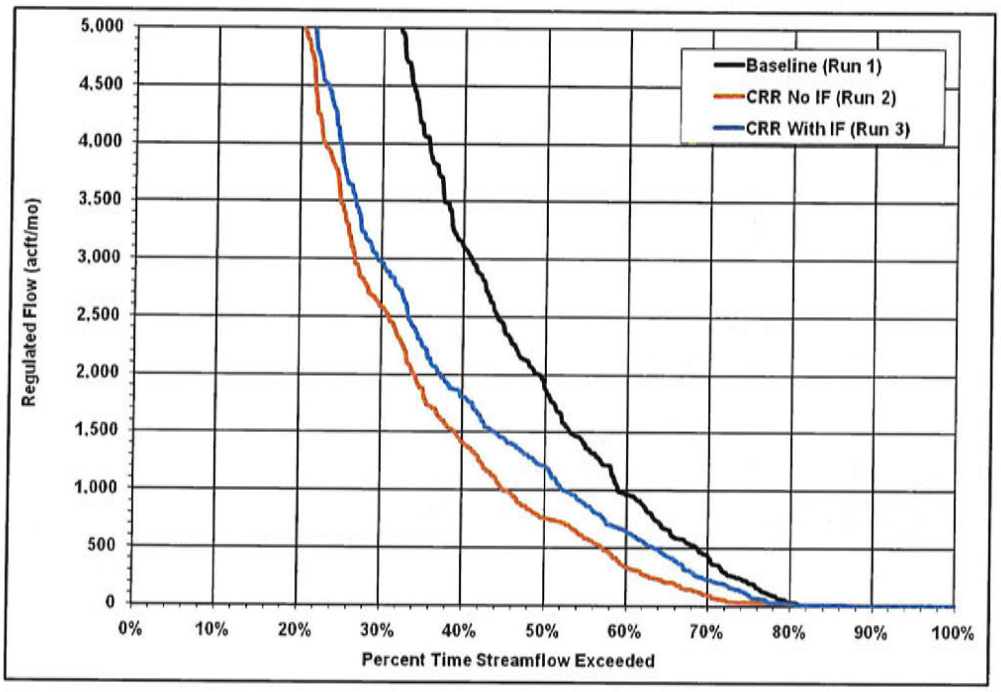


Figure 5-12. Comparison of Regulated Flow Frequency at Clear Fork near Fort Griffin (Flows below 5,000 acft/mo)

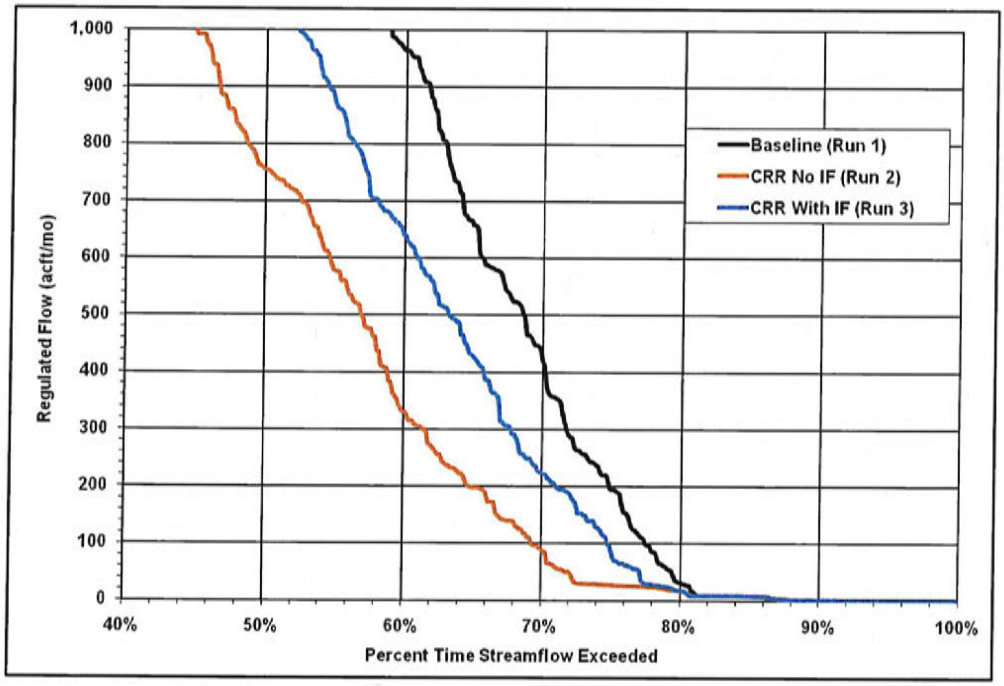


Figure 5-13. Comparison of Regulated Flow Frequency at Clear Fork near Fort Griffin (Flows below 1,000 acft/mo)

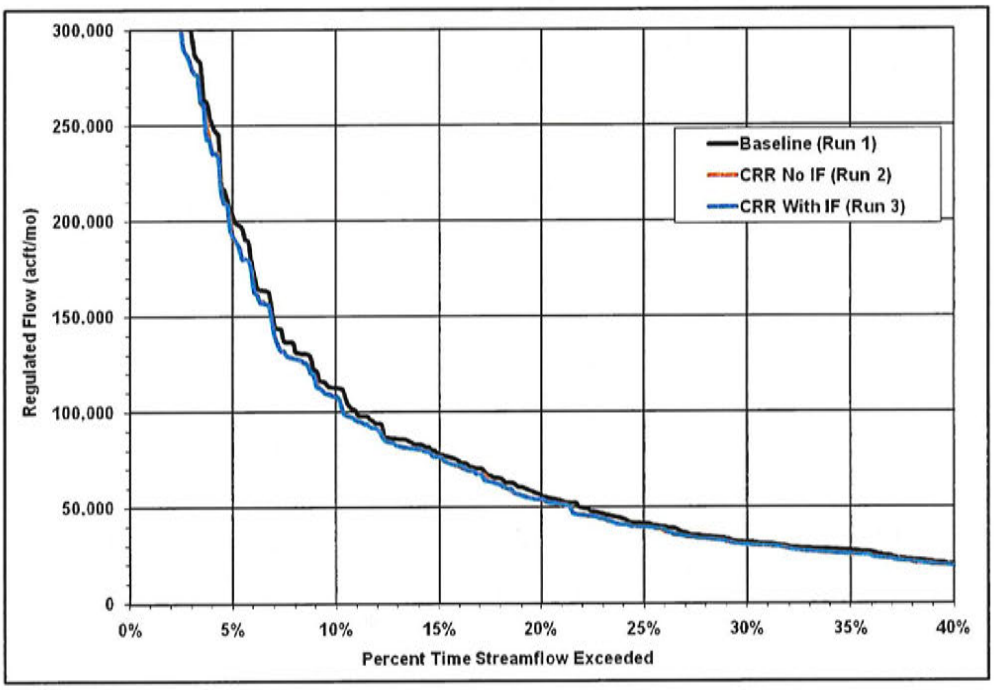


Figure 5-14. Comparison of Regulated Flow Frequency at Brazos River near South Bend (High Flows)

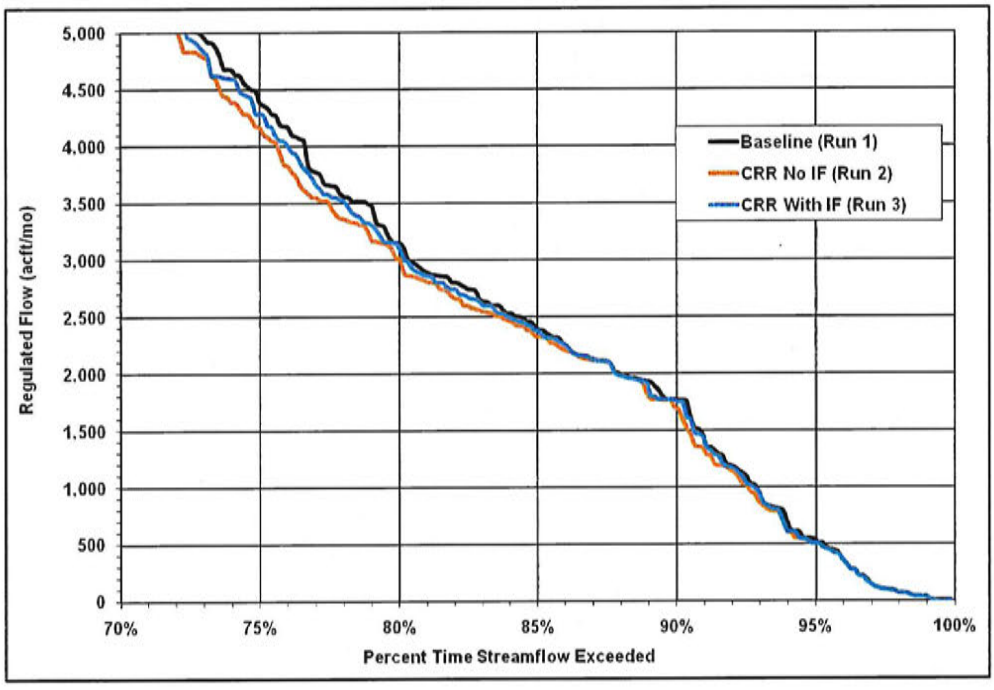


Figure 5-15. Comparison of Regulated Flow Frequency at Brazos River near South Bend (Flows below 5,000 acft/mo)

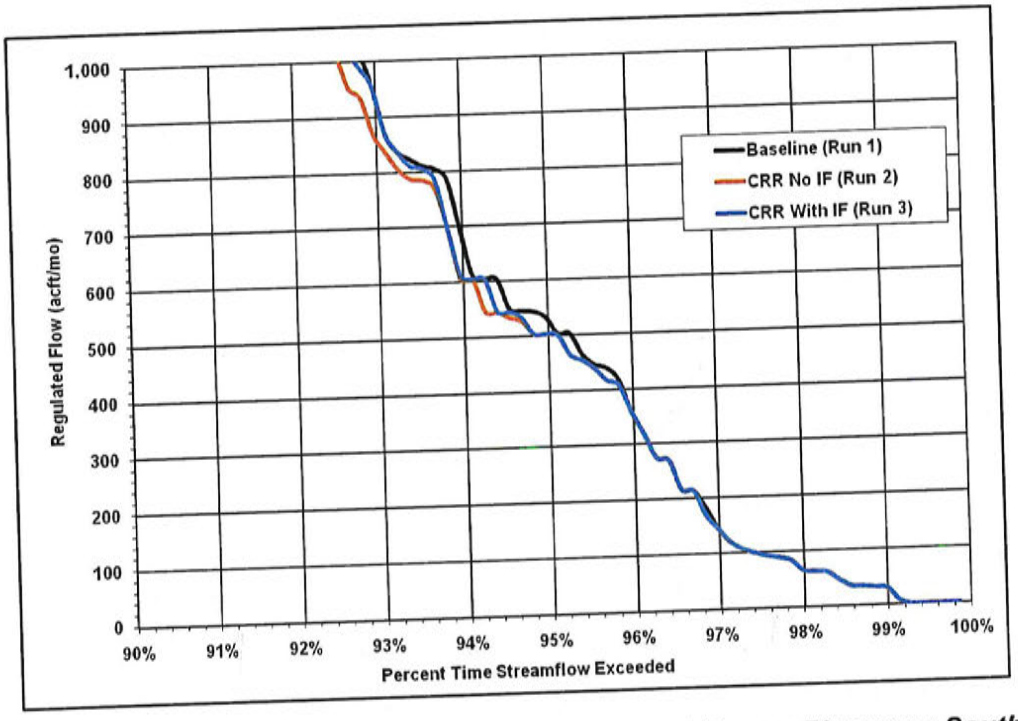


Figure 5-16. Comparison of Regulated Flow Frequency at Brazos River near South Bend (Flows below 1,000 acft/mo)

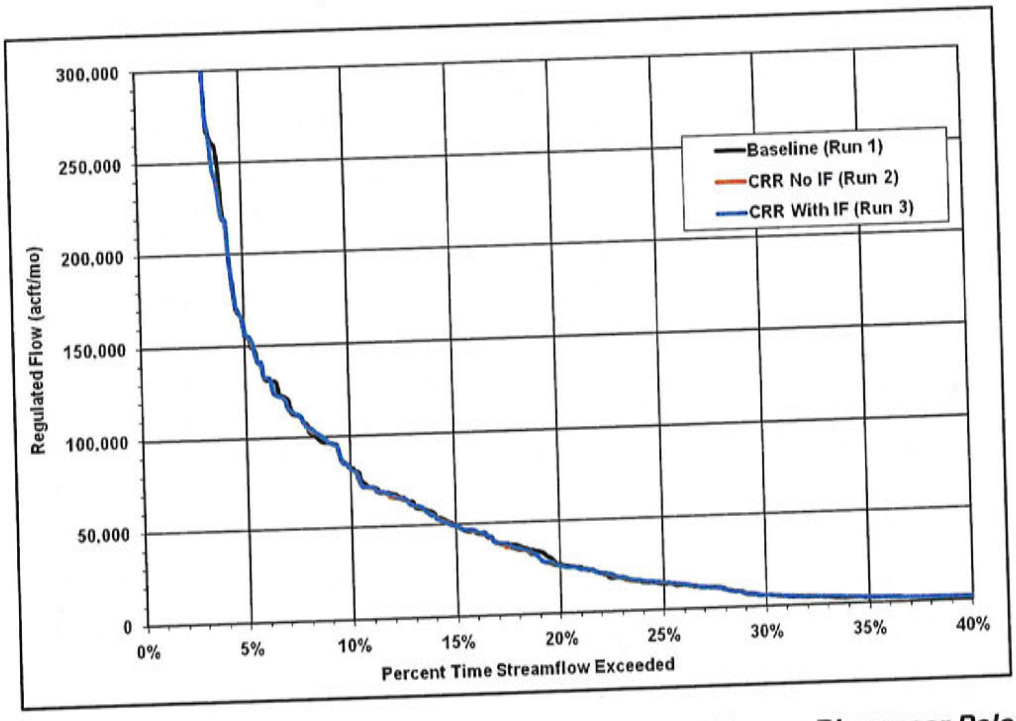


Figure 5-17. Comparison of Regulated Flow Frequency at Brazos River near Palo Pinto (High Flows)

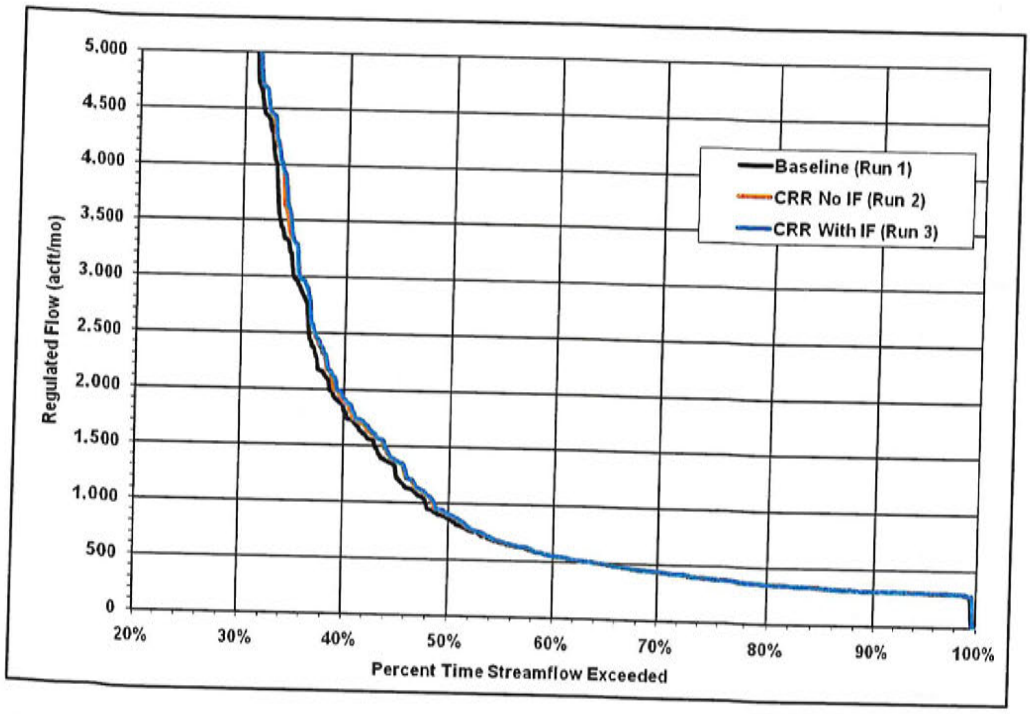


Figure 5-18. Comparison of Regulated Flow Frequency at Brazos River near Palo Pinto (Flows below 5,000 acft/mo)

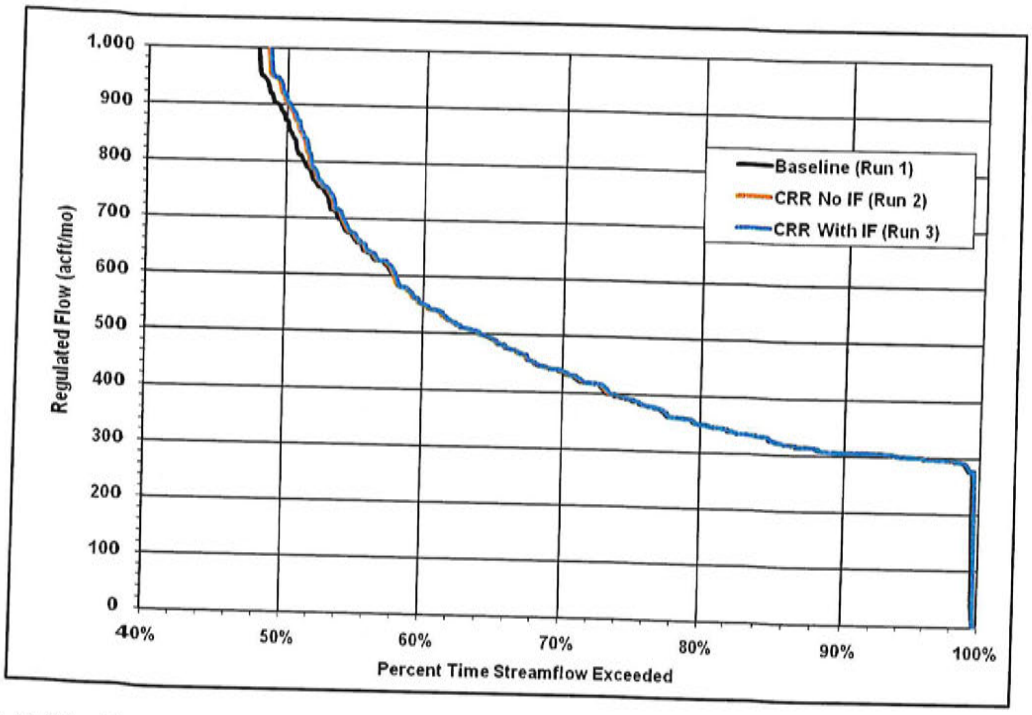


Figure 5-19. Comparison of Regulated Flow Frequency at Brazos River near Palo Pinto (Flows below 1,000 acft/mo)

5.5 No Impacts to Other Water Rights

The water availability analyses showed that there are no practical impacts to any water rights from the inclusion of Cedar Ridge Reservoir using the TCEQ WAM Run 3 version described in this section and executed with the March 2010 version of the WRAP model. Minor changes in mean annual diversion were identified for some water rights when comparing the with and with out Cedar Ridge Reservoir scenarios; however, these impacts were associated with water rights located downstream of Possum Kingdom Lake and along tributaries not directly affected by the project. These changes are linked to water rights affected by the modeling of downstream subordination agreements contained in the BWAM, which appear to be simulated incorrectly by the current version of WRAP.

This page is intentionally left blank.

Section 6
Affected Environment, Potential Effects, and Measures to Minimize Impacts

6.1 Introduction

The Cedar Ridge Reservoir site is located within the Brazos River system, on the Clear Fork Brazos River (Clear Fork). The proposed dam is located approximately 130 river miles upstream of the confluence with the Brazos River and approximately 28 miles upstream of the confluence with Paint Creek (Figure 6-1). The reservoir lies predominantly within Shackelford County with small portions in Haskell and Throckmorton counties. Approximately 29 miles of the Clear Fork will be inundated by the conservation pool of the reservoir including the section of the river upstream of the proposed dam location to the existing dam at Lueders, Texas. The following subsections provide an overview of the existing environmental conditions within the project area and include discussions of the affected environment, potential project impacts, and preliminary concepts for mitigation. A summary of permitting and regulatory requirements is also provided.

6.2 Project Description

The reservoir will inundate approximately 6,635 acres at its conservation storage level of 1,489 ft-msl; contain approximatley 227,127 acft of conservation storage; and drain a watershed area of approximately 2,728 square miles. Water diverted from the reservoir will be used to meet water supply shortages as described in Section 3 for Abilene including existing and future customers. The project area includes a total affected area of approximately 8,903 acres and includes the following areas: the conservation pool with a footprint of approximately 6,635 acres (elevation of 1489.0 ft-msl); the 100-year flood pool (elevation of 1500.6 ft-msl) which includes an additional 2,151 acres above the conservation level; and the construction area for the dam and spillways which includes an additional 117 acres. Impacts will primarily occur within the approximately 6,635 acres located below the conservation pool level and the construction area of 117 acres. The evaluation of potential impacts includes those anticipated to occur within the conservation pool and construction areas, and those within the 100-year flood pool above the conservation pool.

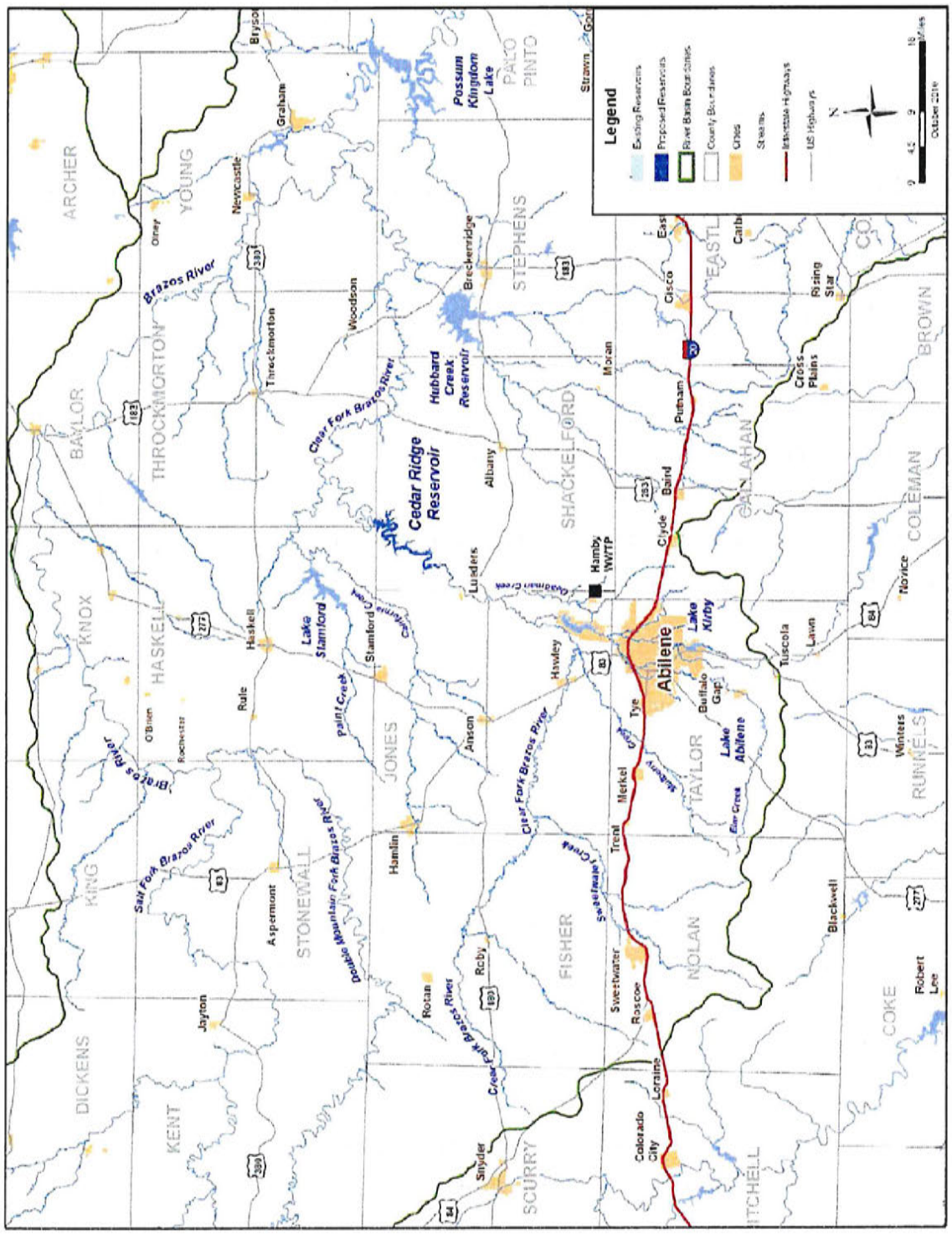


Figure 6-1. Location of Cedar Ridge Reservoir

6.3 Geological Elements

The topography of the area consists of gently sloping to undulating plains (generally west of the reservoir area) interrupted by steep escarpments (generally within and east of the reservoir area). Elevations in the project area vary from about 1,350 ft-msl in the Clear Fork channel just downstream of the dam location to more than 1,550 ft-msl in the Lueders area.

The physiography of the reservoir area includes shale, siltstone, limestone, fluviatile terrace deposits, and alluvial areas.[1] The prevalent outcropping geologic unit in Shackelford and Throckmorton counties includes the Wichita-Albany Group of the Early Permian period. The Wichita-Albany Group consists primarily of gray and red shale with minor amounts of limestone, sandstone, siltstone, conglomerates, and coal.[2] Within the project area the Wichita-Albany Group primarily contains the Lueders, Grape Creek, Bead Mountain, and Talpa Formations. Water wells within the Wichita-Albany Group commonly cannot sustain extended pumping and are primarily used for domestic and livestock purposes. Well water is of poor quality in some areas which limits its use for human consumption.

Steep canyon walls are present in portions of the project area, ranging from 5 to 30 percent slopes. The slopes are predominantly vegetated, but some near-vertical rock cliffs occur in some areas. Soils in the study area are predominantly loamy and clayey with clayey soils occurring primarily in the upstream portions of the study area. Approximately one-third of the mapped soils in this area are described as gravelly to extremely stony. General soil map units in the project area include the Palopinto-Throck and Clairemont-Grandfield-Clearfork soil units. Palopinto-Throck soils include shallow, very shallow or deep soils located on locales which range from steep to gently undulating. Generally found on uplands, these soils are primarily loamy and clayey but can be stony at times. Palopinto-Throck soil unit areas are mainly used for rangeland and as habitat for wildlife. These areas contain rough terrain which is more easily accessible to livestock than to most vehicles. Most of this area is managed by ranchers for hunting, and contains abundant numbers of deer and turkey with some introduced exotic species.[3]

---

[1] Bureau of Economic Geology (BEG). 1972. Geologic Atlas of Texas, Abilene Sheet. University of Texas at Austin. Austin, Texas.
[2] Duffin, Gail L. and Barbara E. Beynon, 1992. Evaluation of Water Resources in Parts of the Rolling Prairies Region of North-Central Texas, Report 337, Texas Water Development Board.
[3] Lowther, A.C. 1990. Soil Survey of Shackelford County, Texas. United States Department of Agriculture, Soil Conservation Service in cooperation with Texas Agricultural Experiment Station and Texas State Soil and Water Conservation Board.

Clairemont-Grandfield-Clearfork soils are deep, loamy, clayey, and sandy soils found on nearly level to gently sloping bottomland and terraces. The soils in this map unit are normally used for cropland, rangeland, and pastureland, with some areas of recreational use and wildlife habitat. The main types of wildlife found within these areas include deer, turkey, quail, dove, and squirrels.[4]

6.4 Hydrological Elements

The project area is located on the Clear Fork of the Brazos River (Clear Fork), a tributary to the Brazos River. The total length of the Clear Fork is almost 180 miles, and the Cedar Ridge Reservoir dam location is located about 130 river miles above its confluence with the main stem of the Brazos River. From its headwaters in eastern Scurry County near the City of Snyder, the Clear Fork flows in an easterly direction through central Fisher County and southern Jones County and then turns northeast near Lake Fort Phantom Hill. It continues in a northeast direction through Jones and Shackelford counties and enters Throckmorton County where Paint Creek joins it, and then the channel turns generally east. About 102 river miles downstream of its confluence with Paint Creek, the Clear Fork joins the main stem of the Brazos River near the town of South Bend in Young County, just above Possum Kingdom Lake. A discussion of water quality of the Clear Fork is provided in Section 6.7.5.

The Brazos River is the longest river in Texas, and carries the largest annual discharge. It has a drainage area of approximately 45,000 square miles, 42,000 of which are in Texas with the remaining area in New Mexico.[5] A total of 39 reservoirs with capacities of greater than 5,000 acre-feet are currently located in the Brazos River Basin, which is one of the most highly developed river systems in Texas.[6] The main stem of the Brazos River originates northwest of the project area at the confluence of the Double Mountain and Salt Forks in eastern Stonewall County, and continues 840 river miles to its mouth at the Gulf of Mexico. Below Possum Kingdom Lake, the Brazos River is impounded by two additional main stem reservoirs—Lakes Granbury and Whitney.

---

[4] Ibid. .
[5] Handbook of Texas Online (HTO), s.v. "Brazos River,". 2010a. http://www.tshaonline.org/handbook/online/articles/BB/rnb7.html (accessed July 23, 2010).
[6] Vogl, A. L., D. T. Runyan, V. L. Lopes, and T.H. Bonner. 2007. COS 44-1: Evaluating social-ecological change in the Brazos River Basin, Texas. Texas State University. Presented at the ESA/SER Joint Meeting, 5 August–10 August, 2007.

Within Shackelford and Throckmorton counties, the valleys cut by the Brazos River and its tributaries are deeply trenched with steep sides or bluffs. Several major reservoirs are located within 50 miles of the project area including Lake Fort Phantom Hill, Lake Stamford, Hubbard Creek Reservoir, and Possum Kingdom Lake (Figure 6-1). No major or minor aquifers underlie the project area. The Trinity Aquifer lies south of the project area and consists of interbedded sandstone, sand, limestone, and shale of Cretaceous Age. The Seymour Aquifer is located west and north of the project area and is composed of isolated areas of alluvium.[7]

6.5 Climatic Elements

The climate in the study area is subtropical, subhumid, with hot, dry summers and mild, dry winters. Temperatures range from an average low of 31°F in January to an average maximum of 97°F in July with a mean average temperature of 64°F.[8] The growing season is approximately 224 days, and annual precipitation averages between 25 and 28 inches with peaks in May–June and September–October. Most precipitation occurs from April to October during thunderstorms of short duration and high intensity. Recurring droughts are common and can last many years. The two most severe droughts each lasted 14 years and occurred between 1943 and 1956 and 1993 through 2006. Average annual flows on the Clear Fork during the more recent of these two droughts averaged 82 percent of the annual flow that occurred during the 1943 through 1956 drought as shown in Figure 2-1. Temperature and rainfall extremes are believed to have a greater influence on the plant communities in this region than the averages.[9]

Air quality in the project area meets current National Ambient Air Quality Standards[10] with prevailing winds generally blowing from the south-southeast at an average of 14 miles per hour in the spring.[11]

---

[7] Texas Water Development Board (TWDB). 2010a. Major and Minor Aquifers of Texas; Maps online at http://www.twdb.state.tx.us/mapping/index.asp, Accessed July 2010.

[8] Handbook of Texas Online (HTO), s.v. "Shackelford County, Texas,". 2010b. http://www.tshaonline.org/handbook/online/articles/SS/hcs8.html (accessed July 26, 2010).

[9] U.S. Environmental Protection Agency (USEPA). 2009. Biological Indicators of Ecosystem Health: Ecoregions of the United States. http://www.epa.gov/bioindicators/html/usecoregions.html. Last updated February 13, 2009. (accessed July 26, 2010).

[10] Texas Commission on Environmental Quality (TCEQ). 2010. Texas Attainment Status by Region. http://www.tceq.state.tx.us/implementation/air/sip/siptexas.html (accessed July 26, 2010).

[11] Lowther, A.C. 1990. Soil Survey of Shackelford County, Texas. United States Department of Agriculture, Soil Conservation Service in cooperation with Texas Agricultural Experiment Station and Texas State Soil and Water Conservation Board.

6.6 Floodplains, Wetlands, and Stream Stability

6.6.1 Floodplains

6.6.1.1 Affected Environment

Floodplains within the project area are primarily found along the Clear Fork and its major tributaries such as Antelope Creek, Fish Creek, Swager Creek, Bluff Creek, and Post Oak Creek. Available floodplain information for Haskell, Shackelford, and Throckmorton counties from the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps shows 100-year floodplain designations (Zone A—No Base Flood Elevations Determined) along the entire river channel below the Lueders dam. Small scattered areas designated as Zone C, which are defined as areas of minimal flooding, are also located within the project area.

6.6.1.2 Potential Effects

With the construction of the Cedar Ridge Reservoir, the current floodplains along the Clear Fork and its major tributaries within the reservoir's conservation pool area, up to an elevation of 1489 ft-msl, will be inundated. The 100-year flood level for the reservoir will be approximately 1500.6 ft-msl, and at this level, the reservoir will temporarily inundate approximately 2,151 acres above the conservation pool. The City intends to either purchase the property in the 100-yr flood pool or obtain flood easements to limit future flood impacts to infrastructure in this area.

6.6.2 Waters of the U.S., including Wetlands

6.6.2.1 Affected Environment

The project area includes only 8 acres of wetlands or less than 0.1 percent. These are typically small fringe habitats associated with stream channels, small impoundments, natural depressions, and areas excavated by rock quarry operations. Wetlands within stream channels and along their fringes are located immediately adjacent to and within the saturation zone caused by the normal median flows of the streams, including the Clear Fork and many of its larger tributaries. Other wetlands occur on the fringe of man-made impoundments and result from the inundation and saturation of these areas by impounded water. Wetlands found in natural depressions in the floodplain outside of stream banks are typically small (i.e., less than 0.5 acre) and have possibly formed in old remnant channels. Wetlands in the project area are primarily

non-forested and dominated by species such as spikerush (*Eleocharis* spp.), switchgrass (*Panicum virgatum*), knotgrass (*Paspalum distichum*), narrowleaf cattail (*Typha angustifolia*), American water-willow (*Justicia americana*), and buttonbush (*Cephalanthus occidentalis*).

Waters of the U.S. were delineated based on a combination of aerial photograph interpretation and on-site delineation methods from May 24–28, 2010. The survey was conducted in accordance with the U.S. Army Corps of Engineers (USACE) 1987 Wetlands Delineation Manual and the Regional Supplement for the Great Plains Region.[12] The on-site delineation included collecting data on stream characteristics (e.g., ordinary high water mark width, flow type) and wetland vegetation, soils, and hydrology. The on-site delineations were recorded using a sub-meter Geo XT Global Positioning System (GPS) unit and mapped using ArcGIS 9.3.

Waters of the U.S. within the project area (i.e., the conservation pool, the 100-year flood pool, and the construction areas) as defined by Section 404 of the Clean Water Act requiring authorization by the USACE for the discharge of dredged or fill material include: the Clear Fork, a perennial stream (approximately 29 miles); intermittent tributaries (approximately 22 miles); ephemeral tributaries (approximately 29 miles); non-forested wetlands (approximately 8 acres); and on-channel impoundments/open water (approximately 36 acres).

The conservation pool area of the reservoir will inundate approximately 29 miles of perennial stream (Clear Fork), approximately 18 miles of intermittent tributaries, approximately 23 miles of ephemeral tributaries, approximately 6 acres of non-forested wetland, and approximately 25 acres of on-channel impoundment/open water. An existing low head dam in the project area impounds approximately 2 miles of the Clear Fork riverbed. Although some stream and wetland functions will be impacted due to inundation by the conservation storage area, the creation, enhancement, and/or protection of aquatic habitat resulting from the reservoir will likely replace some of the biological, chemical, and physical functions of the impacted resources and habitats. On-channel impoundments and open water habitat will not be functionally altered by inundation. The 2,151 acres of flood pool area of the reservoir will periodically floodfor periods of short duration. The short duration flooding of habitats in the flood pool area is not anticipated to have adverse impacts to these areas.

[12] U.S. Army Corps of Engineers (USACE). 2010. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region (Version 2.0). Ed. J.S. Wakeley, R.W. Lichvar, and C.V. Noble. ERDC/EL TR-10-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

6.6.3 Stream Stability

6.6.3.1 Affected Environment

A stable channel is defined as a channel where the planform, cross section, and longitudinal profile are sustainable over time. A quantitative assessment of these three measures is required to make a determination of channel stability. Qualitative observations provide insight into the past, present, and future stability of the Clear Fork. The stability of the approximately 57 miles of Clear Fork channel from the Lueders dam downstream to the Paint Creek confluence was assessed through historical photography and field reconnaissance surveys. Sequences of historical aerial photography were examined to determine horizontal changes in the river channel. Additionally, this segment was observed by boat and/or at accessible private road crossings during March and May 2009 and May 2010 field reconnaissance surveys to photo-document the bed and bank conditions.

Available historical aerial photography from 1953, 1974, 1996, and 2008 was evaluated using GIS methods by digitizing the river thalweg,—a line defining the deepest points in a stream or river valley,—for each year. The resulting thalwegs were compared (see Figures 6-2, 6-3, and 6-4) to estimate the stability of this reach of the Clear Fork channel. The comparison of the historical creek thalwegs shows that the spatial and temporal changes in planform geometry have been minimal for this river segment over the past 55 years. The location of the historical river thalweg is very similar to the current thalweg determined from 2008 aerial photography. The primary deviations in thalweg location were observed near gravel bars where the channel appears to have moved slightly along the gravel bar. The largest shift in the channel appears to have occurred approximately 5 miles downstream of the Lueders dam. At this location the thalweg appears to have shifted approximately 400 feet between 1974 and 1996 to form a new main channel in the location of a previous overflow channel in the floodplain.

There is a potential for minor spatial error in the photo-analysis of available historical photographs due to varying quality, low resolution, and lack of orthorectified images. Nonetheless, the available photography does show that meander migration and planform changes in the approximately 57-mile reach downstream of the Lueders dam have been limited in the past 55 years indicating stable channel conditions.

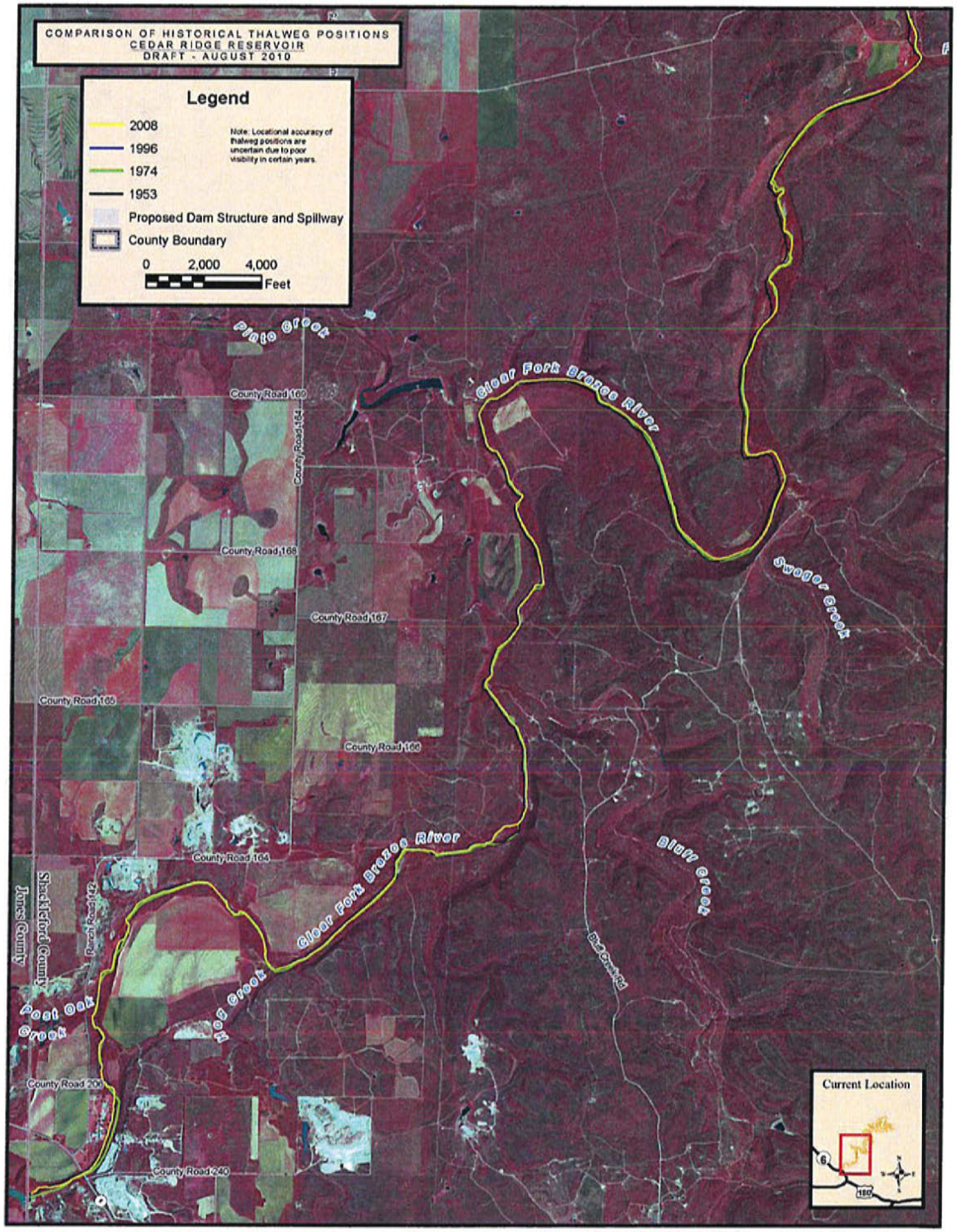


Figure 6-2. Comparison of Historical Thalweg Positions for the Clear Fork

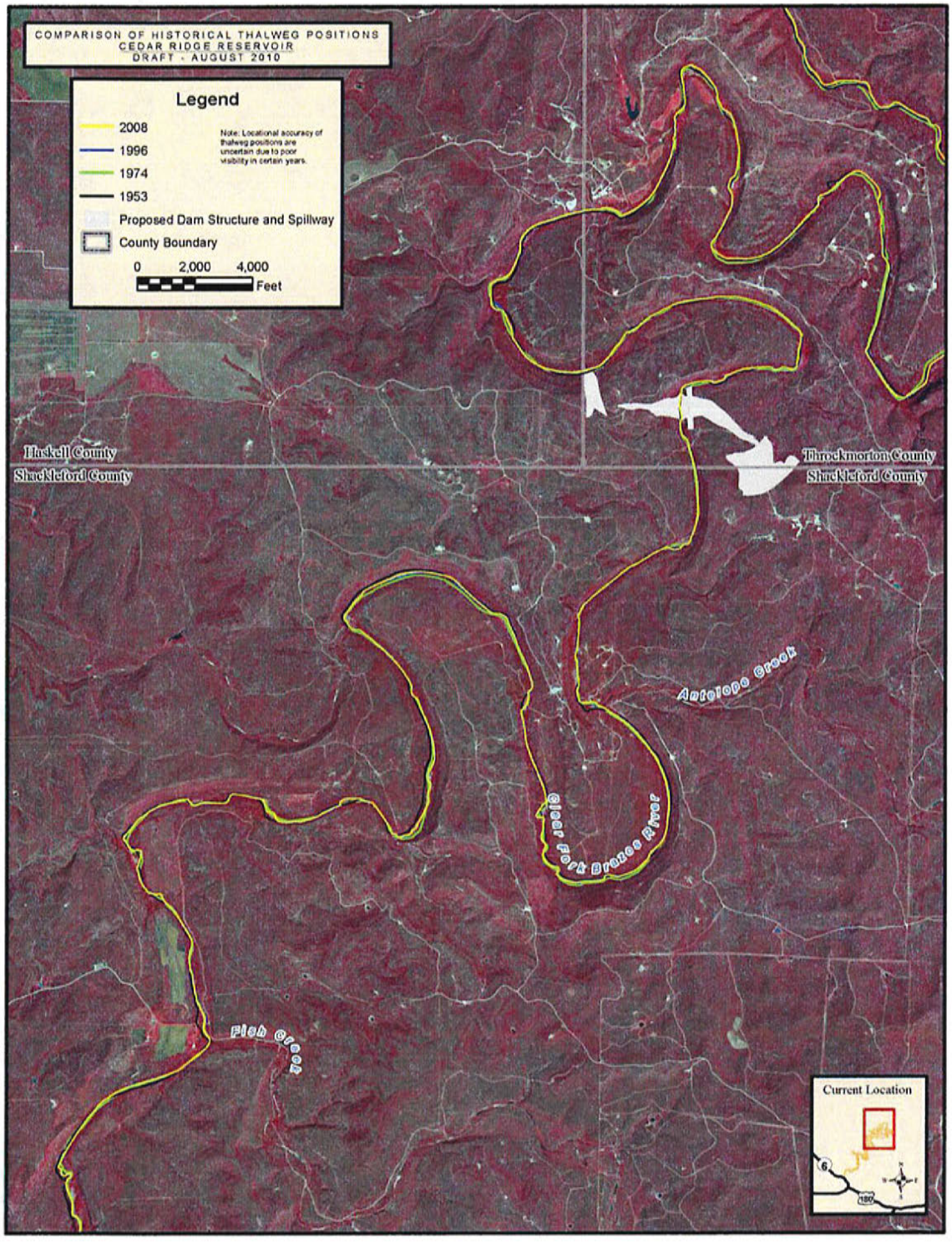


Figure 6-3. Comparison of Historical Thalweg Positions for the Clear Fork

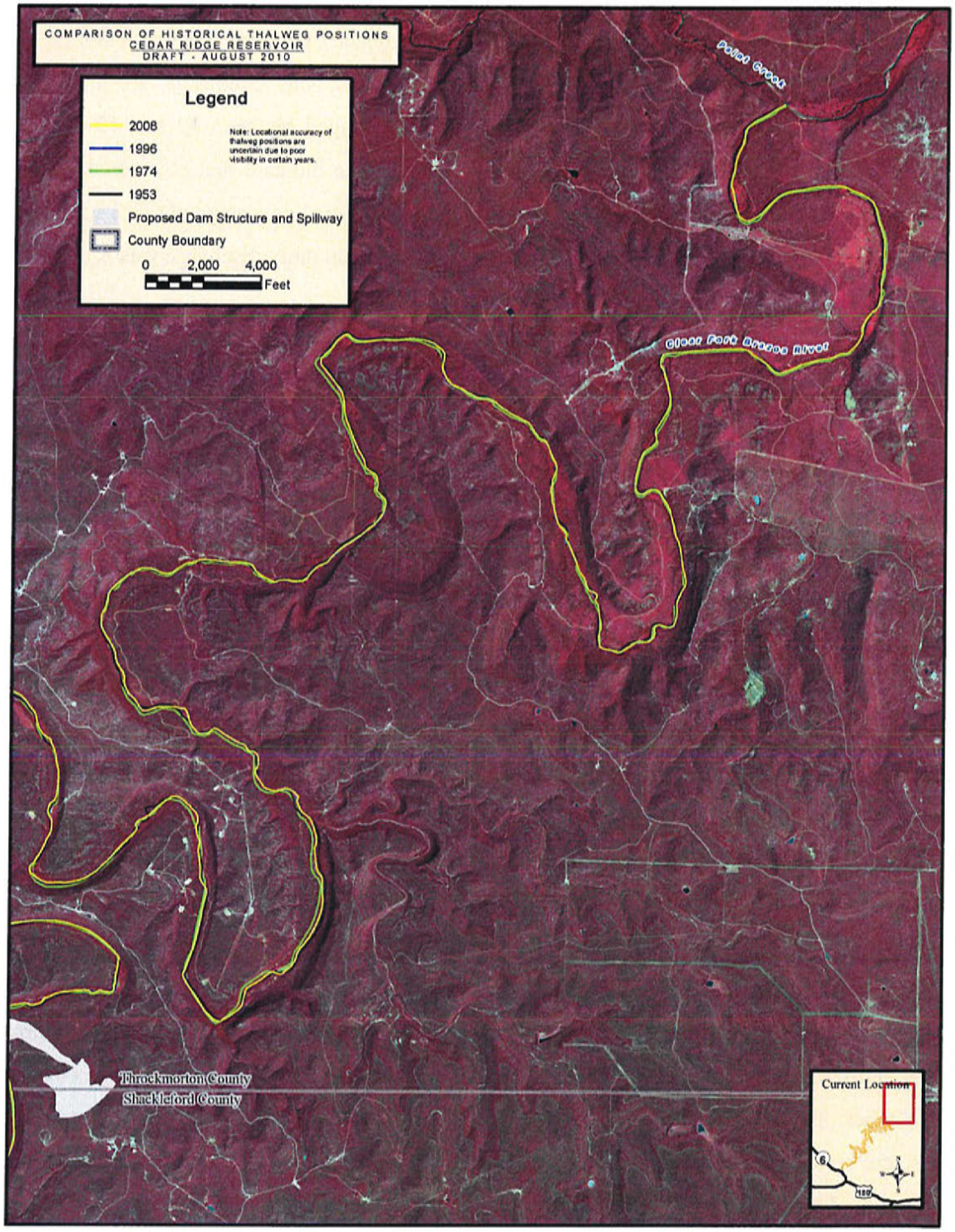


Figure 6-4. Comparison of Historical Thalweg Positions for the Clear Fork

Field reconnaissance was performed by boat and/or at accessible private road crossings to observe bed and bank stability and record reach-scale evidence of erosion, sediment storage, and deposition. Photographs taken to document the channel and bank conditions are included as Appendix D. The measured flow during the field work ranged between 12 and 15 cfs. The records for the U.S. Geological Survey (USGS) Nugent gage indicate that between January 1, 2007, and March 9, 2010, the river exceeded flood stage (defined as a stage above 18 feet) only once. This occurred on August 20 and 21, 2007, when the mean daily discharge was 8,180 cfs on August 20 and 8,140 cfs on August 21, respectively.

Approximately 70 percent of the study reach consists of pools with moderate to steep banks ranging from approximately 4 to 12 feet high and covered with herbaceous and woody vegetation. Woody debris and submerged logs are present in the pool areas, but vegetation leaning due to scour was not prevalent. The pool areas typically have mature, upright trees hanging over the channel from the banks. The Clear Fork has a moderately incised channel throughout most of the study reach, primarily in the pooled areas. However, low gravel bars, which are regularly flooded by the river, are scattered throughout the study reach. Many of these gravel bars also have associated side channels that flow whenever the river rises. The gravel bars consist primarily of colonizing plant species such as willow and switchgrass. Throughout the study reach, the river varies from about 20 feet wide in some riffle areas to approximately 120 feet wide in pool areas. Approximately 11 miles downstream of the Lueders dam, a low-head dam exists that was constructed in 1935 and backs up water approximately 2 miles. One concrete low-water crossing occurs on the study reach near the Hendrick River Ranch complex. Many gravel road crossings also occur in the study reach at shallow areas formed by gravel/cobble or bedrock outcrops. These features all act as grade control structures for the river channel.

The stability of the Clear Fork channel appears to be relatively similar throughout the approximately 57 mile study reach even though this reach consists of alternating geomorphic units. Many reaches of the Clear Fork are sinuous and, at some river meanders, large cut banks occur where the river is eroding into past deposits of fine textured alluvium (sand and silts). These cut banks are typically 10–30 feet high, with near vertical slopes that are virtually void of vegetation. These banks show some evidence of sloughing and mass failure during high flow events. However, in many meander locations, the banks of the river are composed of highly stable outcrops of limestone material. These banks are typically 3 to 8 feet high with moderate slopes covered by herbaceous and woody vegetation.

Although some segments of erosion occur along high cut banks near meanders, overall the Clear Fork appears to be relatively stable and in a state of equilibrium with the current flow regime and sediment load. No evidence of reach-scale stream instability, downcutting, or aggradation is present in the study reach. In addition, no reach-scale signs of migration were noted in the field, which confirms the historical thalweg evaluation. Large, rapid meander and bank migrations do not appear to have occurred over the last 55 years.

This analysis indicates channel movement due to fluvial geomorphologic factors within the floodplain is limited—presumably due to topography, confining geologic layers, bed load diversity, and current flow conditions. Therefore, the post-reservoir hydrologic and hydraulic conditions are not anticipated to result in substantial adverse effects on the downstream stream stability. The exception is the area of localized erosion potential near the principal spillway, for which erosion protection measures will be designed and constructed, as described below.

6.6.3.2 Potential Effects

The stability of the Clear Fork is not expected to change with the anticipated flow regime resulting from the proposed project.

With the construction of the dam, the potential for channel stability issues exists at the principal spillway channel and at its confluence with the Clear Fork. The preliminary plan for the principal spillway is for an alignment directing flow north across an existing ridge that would intersect the Clear Fork approximately 2.6 river miles downstream of the dam. Energy dissipation and scour control measures will be provided to afford long-term protection and stabilization of the river channel in this reach during flood events.

6.7 Biological Elements

6.7.1 Vegetation

6.7.1.1 Affected Environment

The project area lies within the Limestone Plains subregion of the portion of the Central Great Plains ecoregion in Texas[13] and within the vegetational area known as the Rolling Plains.[14]

[13] Griffith, G. E., S. A. Bryce, J. M. Omernik, J. A.Comstock, A. C.Rogers, B.Harrison, and S. L. Hatch, and D. Bezanson. 2004. Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston, VA, U.S. Geological Survey (map scale 1:2,500,000).

[14] Hatch, S. L., N. G. Kancheepuram, and L. E. Brown. 1990. Checklist of the Vascular Plants of Texas. Texas Agricultural Experiment Station. Texas A&M University, College Station.

Although this subregion is principally covered by a mixed grass prairie dominated by grasses such as little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), and buffalograss (*Bouteloua dactyloides*), it also includes scattered trees such as honey mesquite (*Prosopis glandulosa*).

The dominant vegetation type found within the project area as mapped by the TPWD is mesquite brush, which covers approximately 61 percent of the conservation pool area of Cedar Ridge Reservoir.[15] Some variations of these primary types also occur, reflecting changes in the composition of woody and herbaceous species and physiognomy within specific local areas. Within Texas, the mesquite brush vegetation type occurs primarily in the northwest portions of the Rolling Plains with additional occurrences in the eastern Rolling Plains and northwestern Cross Timbers areas. Areas of mesquite brush principally occur near the dam location and along the portions of the reservoir footprint with gently sloped topography. Plants commonly associated with this vegetation type include narrow-leaf yucca (*Yucca glauca*), purple pricklypear (*Opuntia macrocentra*), juniper (*Juniperus* spp.), red grama (*Bouteloua trifida*), Texas grama (*Bouteloua rigidiseta*), sideoats grama (*Bouteloua curtipendula*), hairy grama (*B. hirsuta*), purple three-awn (*Aristida purpurea* var. *purpurea*), buffalograss, red lovegrass (*Eragrostis secundiflora* ssp. *secundiflora*), gummy lovegrass (*Eragrostis curtipedicellata*), sand dropseed, tobosagrass, western ragweed, James' rushpea (*Caesalpinia jamesii*), scurfpea (*Psoralidium* spp.), and wild buckwheat (*Eriogonum* spp.).[16]

The mesquite-lotebush shrub vegetation type is also found within the project area. This vegetation type is dispersed relatively evenly along the reservoir site, covering approximately 39 percent of the conservation pool area. The mesquite-lotebush shrub vegetation type is distributed in the uplands of the northwestern Edwards Plateau, the northeastern Trans-Pecos east of the Pecos River, the Rolling Plains, and the western Cross Timbers and Prairies areas of the state. Commonly associated plants in this vegetation type include mesquite, lotebush, yucca (*Yucca* spp.), fragrant sumac (*Rhus aromatica*), agarito, elbowbush (*Forestiera pubescens*), juniper, Christmas cactus, cane bluestem (*Bothriochloa barbinodis*), silver bluestem (*Bothriochloa laguroides* ssp. *torreyana*), little bluestem, sand dropseed, Texas grama, sideoats grama, hairy grama, red grama, tobosagrass, buffalograss, Texas wintergrass (*Nassella*

[15] McMahan, C. A., R. G. Frye, K. Brown. 1984. The Vegetation Types of Texas, Including Cropland. Wildlife Division, Texas Parks and Wildlife Department, Austin.
[16] Ibid.

leucotricha), purple three-awn, Engelmann's daisy (*Engelmannia peristenia*), broom snakeweed (*Gutierrezia sarothrae*), and bitter rubberweed (*Hymenoxys odorata*).[17] The large-scale TPWD mapping designates a small portion (0.4 percent) of the project area as crops. Aerial photography from 2008 indicates that approximately 5 percent of the floodplain alluvial soils in the project area have been recently planted in cover crops and/or forage grasses (i.e., non-row crops). Approximately half of these areas are outside of the conservation pool area but are located within the proposed flood pool; however, the majority of these areas are within the existing 100-year floodplain (Zone A) as designated on FEMA Flood Insurance Rate Maps.[18]

Vegetation communities along the Clear Fork were initially surveyed March 23–26, 2009. Common plant species and communities present along the Clear Fork and within upland areas of the reservoir area were documented during this field survey. Review of the most current annotated lists of threatened and endangered species for counties within the project area revealed no listing for any federal or state threatened or endangered plant species.

Vegetation communities surveyed within the reservoir area were contained within four general areas. A relatively narrow riparian corridor of trees, shrubs, and grasses found along the riverbank, vegetation found on gravel bars along the river, taller trees with their associated shrubby understory located within the broader floodplain, and scrub and shrub vegetation located on slope areas along the river corridor and within upland areas. Appendix E includes a list of the vegetation species observed during the March 2009 field survey of the project area.

Riparian areas found along the river were primarily limited to a narrow corridor. Trees found within the riparian area included mainly mesquite, common hackberry (*Celtis laevigata*), and pecan (*Carya illinoinensis*). Limited numbers of buttonbush (*Cephalanthus occidentalis*), American elm (*Ulmus americana*), black willow (*Salix nigra*), tamarix (*Tamarix gallica*), and juniper (*Juniperus* spp.) were also observed within this area. Species density and variety varied widely within reaches of the river, with some areas dominated by a single species and other areas containing a greater diversity. Understory shrubs including povertyweed (*Baccharis neglecta*), forestiera (*Forestiera pubescens*), and Oklahoma plum (*Prunus gracilis*) were present within most of the riparian areas, although some riparian areas contained only understory grasses, forbs, or cactus beneath the larger trees. The most common grass species observed within the riparian

[17] Ibid.
[18] Federal Emergency Management Agency. 1985. Flood Insurance Rate Map, Panel Number 4810020100B. Shackelford County, Texas. National Flood Insurance Program. Effective Date: June 19, 1985.

areas were switchgrass (*Panicum virgatum*), Johnsongrass (*Sorghum halepense*) and bermudagrass (*Cynadon dactylon*). These grass species were found to be particularly dense near the water's edge and within most river road crossings. Herbaceous species noted within the riparian corridor included curly dock (*Rumex crispus*), cocklebur (*Xanthium strumarium*), Texas prickly pear (*Opuntia engelmannii* var. *lindheimeri*), Christmas cactus (*Cylindropuntia leptocaulis*), and greenbriar (*Smilax bona-nox*) among others. A few riparian areas which were formerly associated with residences have been greatly modified and contain only larger trees and mown lawns.

Vegetation found on gravel bars along the Clear Fork included those species which require a wetter environment. Species observed within these areas during the field survey included eleocharis (*Eleocharis parvula*), fragrant flat sedge (*Cyperus odoratus*) and William Emory's sedge (*Carex emoryi*). Gravel bar areas also commonly included herbaceous species such as curly dock, celery-leaf buttercup (*Ranunculus sceleratus*), and a range of grass species. These areas were not generally heavily vegetated but contained a relatively open scattering of plants.

The broader floodplain region contained most of the larger trees found within the study area. Tree species most commonly observed within this area included mesquite, hackberry, pecan, and American elm. Understory species noted included grasses and small shrubs such as forestiera and povertyweed. Large clumps of prickly pear were common within this area, as were numerous grass species. Evidence of grazing by cattle and disruption of vegetation by wild hogs was abundant within both the riparian and broader floodplain areas. Large piles of cleared brush and other vegetation were present within some of the more level floodplain areas. Although there were a few areas which appeared to contain remnants of old pecan orchards, no evidence of any crops was observed along the floodplain during this vegetation survey.

Vegetation observed on slope areas located above the river floodplain or within upland areas contained more xeric species. Mesquite and lotebush were abundant in most of these areas, along with limited occurrences of Mexican buckeye (*Ungnadia speciosa*) and hackberry. Shrubs were abundant with dense occurrences of forestiera, povertyweed, and aromatic sumac within many of the slope and upland areas. Texas pricklypear and Christmas cactus were abundant within most of the open areas in addition to cocklebur (*Xanthium strumarium*), ephedra (*Ephedra antisyphilitica),* prairie tea (*Croton monanthogynus*), and numerous grass species including switchgrass, silver bluestem, and King Ranch bluestem (*Bothriochloa ischaemum* var.

songarica). No unique or limited vegetation areas were observed within the study area during this field survey.

Utilizing information gained in the initial vegetation survey, the most current aerial photography (2008) was then used to photo-interpret the vegetation cover types found within the reservoir area. This action was followed by specific field mapping to confirm accessible representative locations and refine the mapped cover types. The specific vegetation cover type information collected during the second vegetation survey focused on recording data to be used in the completion of the Wildlife Habitat Appraisal Procedure (WHAP) developed by TPWD. This procedure is used in the evaluation of wildlife habitat for specific tracts of land within the state.

The second, more detailed vegetation survey was conducted on May 24–28, 2010, within the Cedar Ridge Reservoir site. This investigation included specific site surveys representing the seven vegetation cover types identified within the conservation pool of the project area (Figure 6-5).

Vegetation cover type sites, as defined by WHAP, surveyed included brush, shrub, crop (i.e., forage grasses and hayland), forest, grass/forbs, marsh, and park (i.e., savannah with tree and grassland mix) vegetation types. Wetland areas were surveyed separately and in more detail than the other vegetation cover types, as previously discussed in Section 6.6.2. All tree and shrub species found within an 80-foot radius of the selected sample site point were identified, along with all herbaceous species present in a one square meter subsample area. A discussion of the results of this second survey and the WHAP analysis is included in Section 6.7.2.2.

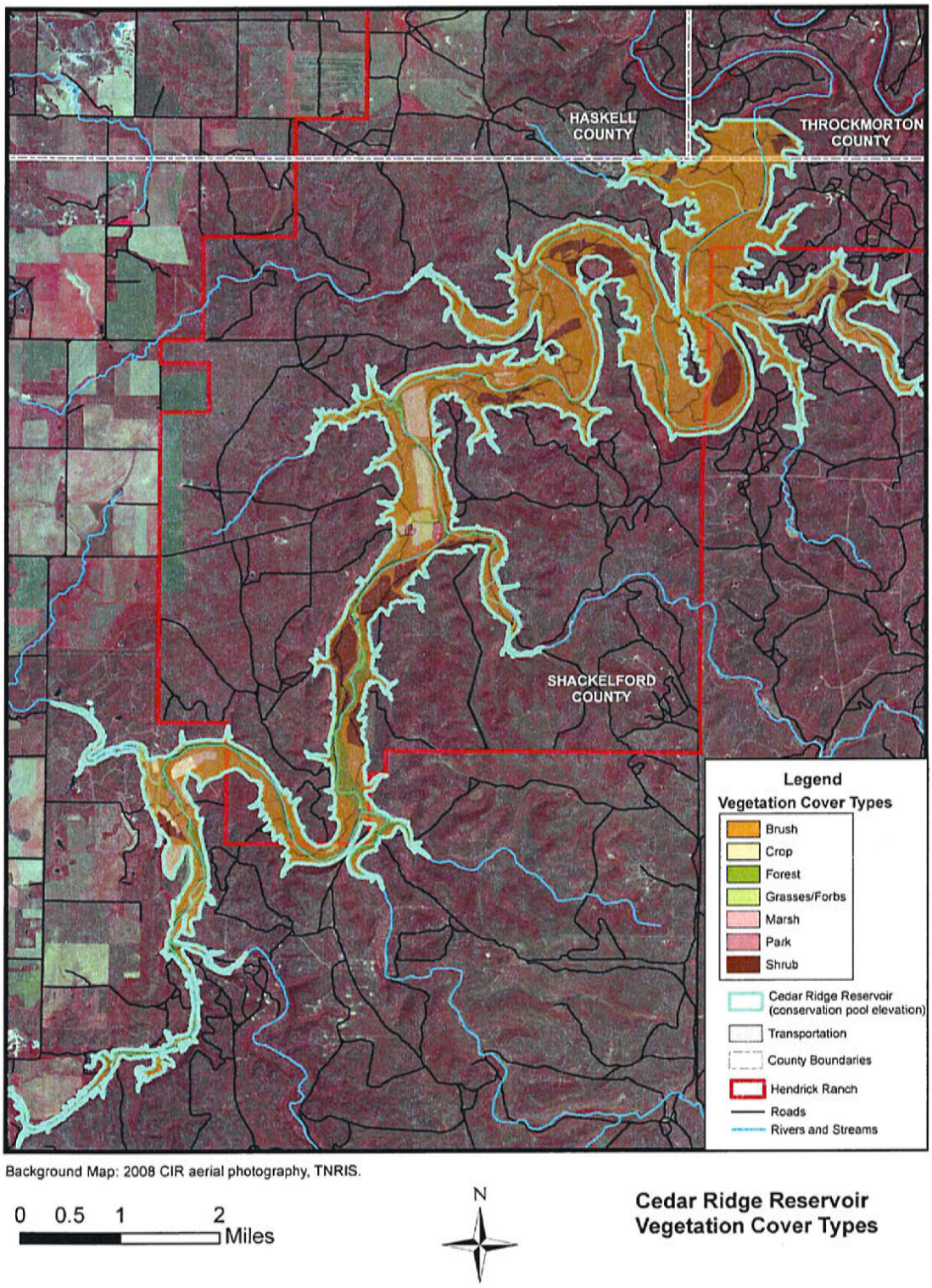


Figure 6-5 Vegetation Cover Types within Cedar Ridge Reservoir Conservation Pool

6.7.1.2 Potential Effects

Table 6-1 includes estimated acreages for vegetation cover types, transportation, and water areas within the project area. Representative photographs of each vegetation type are provided in Appendix F. Permanent impacts will occur to vegetation located within the conservation pool of the reservoir and some portions of the construction area. This vegetation will be impacted either by clearing at the dam location or inundation by the reservoir. Temporary impacts may also occur to the vegetation located outside of the conservation pool area but within the flood pool area; however, due to the infrequent and brief duration of the anticipated flooding these are predicted to be minor. These areas will be inundated and saturated only occasionally for a few days as floods will be passed through an un-gated spillway set at the conservation pool level. While invasive species, such as salt cedar (*Tamarix* spp.), frequently colonize the alluvial areas that develop near the upstream areas of reservoir sites in areas to the west of the project site, the existing impoundment by the Lueders dam is anticipated to capture most sediment before it enters the Cedar Ridge Reservoir. If needed, the mitigation plan developed as part of the Section 404 permitting process will include provisions for invasive species in accordance with Executive Order 13112 (Invasive Species).

The reservoir will result in beneficial effects in some portions of the post-construction shoreline by providing conditions conducive to the growth of existing native tree and brush species, as well as the development of fringe wetland habitat in shallow, protected areas. These areas are anticipated to serve as habitat for fish and wildlife species that will utilize the reservoir and the shoreline.

Croplands, including the cover crops found in the project area, are prevalent in the higher plateau immediately to the west within the Rowena-Leeray-Nuvalde soil association. Therefore, adverse impacts to crops in the vicinity of the project area would be minimal.

Table 6-1.
Estimated Acres of Vegetation Cover Types Found within the Project Area

Vegetation Cover Type	Conservation Pool (acres)	Construction Area (acres)	100-year Flood Pool (acres)	Total Project Area* (acres)	Percent of Project Area
Brush	4,763	82	1,626	6,471	73
Shrub	625	27	267	919	10
Crop	261	0	142	404	5
Forest	514	4	59	577	6
Grass/Forbs	76	3	4	83	1
Park	28	0	18	46	1
Water	362	1	33	396	4
Nonforested wetlands	6	0	2	8	<0.1
Inert Materials	<0.1	0	<0.1	<0.1	<0.001
Total	6,635	117	2,151	8,903	100
*Project Area equals combined areas of the conservation pool, construction area, and flood pool.					

6.7.2 Wildlife

6.7.2.1 Affected Environment

The project area is located within the Kansan biotic province.[19] The Kansan is the largest and one of the most diverse biotic provinces in the state of Texas, and encompasses nearly all of the High Plains, Rolling Plains, and the western edge of the Cross Timbers ecoregions.[20] Due to its large size and diversity, the Kansan Province is divided into three districts that include (from west to east) the short-grass plains, mixed-grass plains, and the mesquite plains. The project area is situated along the eastern boundary of the Rolling Plains ecoregion within the mesquite plains district. Within this district the typical vegetation community generally consists of clusters of mesquite and other shrubs interspersed with open areas of grasses. The faunal diversity supported within the Kansan province is largely a result of the region serving as an area of transition between grassland species from the west and woodland species from the east, particularly along the more heavily vegetated stream floodplains that drain through the region. Common wildlife species found in the Kansan Biotic Province are listed in Table 6-2.

[19] Blair, W. F. 1950. The biotic provinces of Texas. Texas Journal of Science 2:93–117.
[20] Gould, F. W., G. O. Hoffman, and C. A. Rechenthin. 1960. Vegetational areas of Texas. Texas Agricultural Experiment Station Leaflet 492, Texas A&M University, College Station.

Table 6-2.
Common Wildlife Species of the Kansan Biotic Province

Common Name	Scientific Name	Common Name	Scientific Name
Amphibians			
Barred tiger salamander	*Ambystoma tigrinum mavortium*	Bullfrog	*Lithobates catesbeianus*
Blanchard's cricket frog	*Acris blanchardi*	Plains leopard frog	*Lithobates blairi*
Great plains toad	*Anaxyrus cognatus*	Spotted chorus frog	*Pseudocris clarkii*
Green toad	*Anaxyrus debilis*	Couch's spadefoot toad	*Scaphiopus couchii*
Red spotted toad	*Anaxyrus puncatatus*	Plains spadefoot toad	*Spea bombifrons*
Texas toad	*Anaxyrus speciosus*	New Mexico spadefoot toad	*Spea multiplicata*
Woodhouse's toad	*Anaxyruswoodhousii*	Great Plains narrowmouth toad	*Gastrophryne olivacea*
Birds			
Pied-billed Grebe	*Podilymbus podiceps*	Black-chinned Hummingbird	*Archilochus alexandri*
Snowy Egret	*Egretta thula*	Belted Kingfisher	*Ceryle alcyon*
Swainson's Hawk	*Buteo swainsoni*	Ash-throated Flycatcher	*Myiarchus cinerascens*
Turkey Vulture	*Cathartes aura*	Western Meadowlark	*Sturnella neglecta*
American Kestrel	*Falco sparverius*	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Scaled Quail	*Callipepla squamata*	Rock Wren	*Salpinctes obsoletus*
Northern Bobwhite	*Colinus virginianus*	European Starling	*Sturnus vulgaris*
Wild Turkey	*Meleagris gallopavo*	Lark Sparrow	*Chondestes grammacus*
Ring-necked Pheasant	*Phasianus colchicus*	Dark-eyed Junco	*Junco hyemalis*
Sandhill Crane	*Grus canadensis*	Savannah Sparrow	*Passerculus sandwichensis*
Killdeer	*Charadrius vociferous*	Chipping Sparrow	*Spizella passerina*
Greater Roadrunner	*Geococcyx californianus*	Bullock's Oriole	*Icterus bullockii*
Mammals			
Big brown bat	*Eptesicus fuscus*	Prairie vole	*Microtus ochrogaster*
Western pipistrelle	*Pipistrellus hesperus*	Plains harvest mouse	*Reithrodontomys montanus*
Eastern cottontail	*Sylvilagus flaoridanus*	Coyote	*Canis latrans*
Black-tailed prairie dog	*Cynomys ludovicianus*	Swift fox	*Vulpes velox*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	Raccoon	*Procyon lotor*
Plains pocket gopher	*Geomys bursarius*	Striped skunk	*Mephitis mephitis*
Texas kangaroo rat	*Dipodomys elator*	White-tailed deer	*Odocoileus virginianus*
Reptiles			
Yellow mud turtle	*Kinosternon falvescens*	Great plains rat snake	*Pantherophis emoryi*
Ornate box turtle	*Terrapene ornata ornata*	Gopher snake	*Pituophis catenifer*
Eastern collared lizard	*Crotaphytus collaris*	Western hognose snake	*Heterodon nasicus*
Greater earless lizard	*Cophosaurus texanus*	Plainbelly water snake	*Nerodia erythrogaster*
Great plains skink	*Eumeces obsoletus*	Western ribbon snake	*Thamnophis proximus*
Six-lined racerunner	*Aspidoscelis sexlineata*	Prairie rattlesnake	*Crotalus viridis*

Wildlife species inhabiting the project area utilize it to varying extents depending on their specific biologic needs. Migratory bird pathways, stopover habitats, wintering areas, and breeding areas may occur within and adjacent to the project area, and may be associated with wetlands, ponds, shorelines, riparian corridors, fallow fields and grasslands, and woodland areas.

6.7.2.2 Wildlife Habitat Appraisal Procedure (WHAP) Evaluation

The TPWD developed the Wildlife Habitat Appraisal Procedure (WHAP) to allow for the evaluation of wildlife habitat for specific tracts of land within the state without requiring large amounts of time for field work or compilation of the resulting data. The WHAP was designed to be used to evaluate impacts upon wildlife populations from specific development projects, to establish baseline data prior to changes in habitat conditions within specific areas, to compare tracts of land proposed for land acquisition or mitigation, and to evaluate the general habitat quality and wildlife management potential of tracts of land within large geographical areas. The WHAP data assembled for the Cedar Ridge Reservoir site was collected during a second vegetation field survey performed within the conservation pool area from May 24-28, 2010. A detailed description of the methods and results of the Cedar Ridge WHAP survey and representative photos of the vegetation types are included in Appendix F.

The WHAP procedure includes three primary sections. Section 1, which utilizes vegetation cover types, is designed to measure key components contributing to the ecological condition of the evaluated tract and the resulting overall suitability for wildlife. This section results in an Average Habitat Quality Score (AHQS) for all sites found within each cover type which are then multiplied by their corresponding acreage values to generate available Habitat Units (HU). HU values are used to determine the extent of projected impacts upon a tract and establish the amount of habitat required to adequately compensate for unavoidable adverse impacts.[21]

Section 2 of the WHAP, the Significance of Protected Flora and Fauna, does not require field data collection but rather an evaluation of protected fauna and flora, their distributional range and potential for occurrence in the study area. Section 3 of WHAP was originally developed as a tool to evaluate lands for potential acquisition, management and conservation by TPWD or other agencies. Since the evaluation was conducted to evaluate the baseline conditions

[21] Texas Parks & Wildlife Department. 1995. Wildlife Habitat Appraisal Procedure. PWD RP – W7000 –0145 (12/06)

of vegetation communities as wildlife habitat in planning for an infrastructure project, Section 3 is not applicable to this project.

The final product of this procedure is the Wildlife Habitat Appraisal Summary for the evaluated tract, which utilizes the values developed in the WHAP. For the Cedar Ridge Reservoir site, this procedure estimates that approximately 3,241 Habitat Units are anticipated to be permanently affected by the reservoir.

The WHAP survey in 2010 occurred during a spring season which had an unusually heavy amount of rainfall. The project area received about 5 inches of rain more than its normal spring amount, resulting in vegetation abundance and diversity which could be considered uncharacteristically robust. A total of 106 different plant species were documented within the 27 sites surveyed. No federal or state threatened or endangered plants are listed for any of the counties in the study area.

6.7.2.3 Potential Effects

The proposed Cedar Ridge Reservoir will inundate approximately 6,635 acres of terrestrial habitat at conservation pool (elevation 1,489 ft-msl) and approximately 2,151 additional acres within the 100-year flood pool (elevation 1,500.6 ft-msl) would be infrequently inundated for short durations. Non-aquatic species inhabiting the conservation pool areas would be able to relocate to surrounding suitable habitats unaffected by reservoir filling. Adverse impacts could occur to those wildlife species that currently utilize riparian habitats within the reservoir's footprint; however, additional riparian habitat will develop along portions of the reservoir shoreline with gentle slopes subsequent to reservoir filling.

6.7.3 Rare, Threatened, and Endangered Species

Plants and animals with Federal classifications of Endangered, Threatened, Proposed Endangered, and Proposed Threatened are protected under the provisions of Sections 7 and 9 of the Endangered Species Act (ESA), as amended. In addition, species listed with a classification of Candidate (C1) are protected as listed species under federal law because information exists to support a listing of Threatened or Endangered. The USFWS and TPWD maintain a list of endangered, threatened, and candidate species listed by county for their area of responsibility which includes the proposed project area.

The Federal Endangered Species Act of 1973, as amended (ESA; 16 USC 1531 *et seq.*), prohibits the "take" of any threatened or endangered species. The term "take" under the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." The term "harm" was further defined to include "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering" (50 CFR 17.3). Additional federal protection is extended to migratory birds, and bald and golden eagles under the Migratory Bird Treaty Act (MBTA) as amended (16 USC 703–712), and the Bald and Golden Eagle Protection Act (16 USC 668–668d), respectively. Protection is also afforded to Texas state-listed species (Parks and Wildlife Code Chapters 68 and 88; 31 TAC 65.171–176 and 69.1–9) and is enforced by the TPWD. The MBTA protects most bird species, including but not limited to, cranes, ducks, geese, shorebirds, raptors, and songbirds.

A search of the Texas Natural Diversity Database (TNDD)[22] identified the state threatened Brazos water snake as the only threatened or endangered species with documented occurrences within or near the reservoir site. The plains spotted skunk (*Spilogale putorius interrupta*), a species of concern, was also documented in the vicinity of the reservoir, once in Jones County and once in Haskell County; however, this species is not state or federally protected. While based on the best information available to TPWD, TNDD data do not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area.

6.7.3.1 Affected Environment

Table 6-3 lists the state and federally threatened, endangered, or otherwise rare species that could occur in Haskell, Jones, Shackelford, and Throckmorton counties. This table includes the listing status of these taxa, as well as descriptions of suitable habitat, a determination of whether suitable habitat occurs within or near the project area, and pertinent project information for each species. Inclusion in Table 6-3 does not mean that a species will occur within the project area but acknowledges the potential for its occurrence within one of the four counties within the project area.

[22] Texas Parks and Wildlife Department (TPWD). 2010*e*. Element occurrence records for Haskell, Jones, Shackelford, and Throckmorton Counties. Texas Natural Diversity Database, Texas Parks and Wildlife Department, Austin. Received 10 August 2010.

6.7.3.2 Potential Effects

General habitat requirements and pertinent information as it relates to the reservoir for those species listed in Table 6-3 as federally or state threatened or endangered are discussed here. This detailed discussion in the sections below does not include those species listed in Table 6-3 without federal or state status notation. These species are considered to be rare, or of special concern, and generally constitute those species with restricted ranges or specific habitat requirements that limit their populations.

Table 6-3
Federal and State-Listed Threatened, Endangered, and Rare Species of Potential Occurrence in Haskell, Jones, Shackelford, and Throckmorton Counties

Species	*Federal Status*	*State Status*	*Description of Suitable Habitat*	*Suitable Habitat Present*	*Pertinent Project Information*
Birds					
Baird's Sparrow *Ammodramus bairdii*	--	--	Inhabits short-grass prairie with scattered low bushes and matted vegetation. Mostly migratory in western half of state. Winters in Mexico and in Texas from Brewster through Hudspeth counties.	No	Could occur as a migrant traveling between wintering grounds to the south and breeding grounds to the north.
Western Burrowing Owl *Athene cunicularia hypugaea*	--	--	Open grasslands such as prairie, plains, and savanna. Nests and roosts in abandoned burrows.	No	Documented as a breeding resident of Haskell, Shackelford, and Throckmorton counties. Suitable habitat is lacking overall within the reservoir footprint.
Ferruginous Hawk *Buteo regalis*	--	--	Primarily inhabits prairies, plains, and badlands. Nests in tall trees along streams or steep slopes, cliff ledges, cut banks, hillsides, or power line towers. Year-round resident in northwestern high plains and winters throughout western two-thirds of state.	No	Suitable habitat is lacking overall within the reservoir footprint.
Snowy Plover *Charadrius alexandrinus*	--	--	Formally an uncommon breeder in the Texas Panhandle. Inhabits sandy beaches, dry mud or salt flats, and sandy shores of rivers, lakes, and ponds. Nests in shallow depressions on bare, open ground. Winters along Pacific and Gulf coasts.	No	Only listed for Jones and Haskell counties. Could occur as a migrant. Suitable nesting habitat is lacking within the reservoir footprint.
Western Snowy Plover *C. a. nivosus*	--	--	Uncommon breeder in the Texas Panhandle. Inhabits sandy beaches, dry mud or salt flats, and sandy shores of rivers, lakes, and ponds. Nests in shallow depressions on bare, open ground. Winters along Pacific and Gulf coast.	No	Only listed for Jones and Haskell counties. Could occur as a migrant. Suitable nesting habitat is lacking within the reservoir footprint.
Mountain Plover *C. montanus*	PT	--	Nests on the ground in shallow depressions on high plains or short grass prairies. Winters in short-grass plains and bare, plowed fields.	No	Could occur as a migrant. Suitable habitat is lacking within the reservoir footprint.
Peregrine Falcon *Falco peregrinus*	DL	T	Listed because subspecies are not easily distinguished at a distance. See subspecies for habitat preferences.	No	Could occur as a rare to uncommon migrant. Suitable nesting habitat is lacking within the reservoir footprint.

Table 6-3
Federal and State-Listed Threatened, Endangered, and Rare Species of Potential Occurrence in Haskell, Jones, Shackelford, and Throckmorton Counties (Continued)

Species	*Federal Status*	*State Status*	*Description of Suitable Habitat*	*Suitable Habitat Present*	*Pertinent Project Information*
Birds					
American Peregrine Falcon *F. p. anatum*	DL	T	Year-round resident and local breeder in west Texas. Nests in tall cliff eyries. Migrant across the state from northern breeding areas. Utilizes leading landscape edges (e.g., lake shores and coastlines) during migration.	No	Could occur as a rare to uncommon migrant. Suitable nesting habitat is lacking within the reservoir footprint.
Arctic Peregrine Falcon *F. p. tundrius*	DL	--	Migrant throughout state from northern breeding range. Utilizes leading landscape edges (e.g., lake shores and coastlines) during migration. Winters along gulf coast and further south.	No	Could occur as a rare to uncommon migrant. Suitable nesting habitat is lacking within the reservoir footprint.
Whooping Crane *Grus americana*	LE	E	Potential migrant via plains throughout most of state down to coast. Winters in coastal marshes of Aransas, Calhoun, and Refugio counties.	No	Could occur as a migrant. Suitable habitat for migratory stopovers is lacking overall within reservoir footprint.
Bald Eagle *Haliaeetus leucocephalus*	DL	T	Winter migrant found primarily near rivers and large lakes. Nests in tall trees or on cliffs near water.	No	Could occur as a rare to uncommon migrant. Suitable nesting habitat is lacking within the reservoir footprint.
Interior Least Tern *Sterna antillarum athalassos*	LE	E	Nests along sand and gravel bars within braided streams, rivers, and on man-made structures (e.g., inland beaches, wastewater treatment plants, gravel mines, etc.).	No	Only listed for Haskell County. Could occur as a transient during migration on large water bodies. Suitable nesting habitat is lacking within the reservoir footprint.
Fishes					
Sharpnose shiner *Notropis oxyrhynchus*	C	--	Endemic to Brazos River drainage. Prefers large turbid river areas with a bottom of sand, gravel, and clay-mud.	No	Cedar Ridge is in the Brazos River drainage; however, suitable habitat is apparently lacking within the reservoir footprint.
Smalleye shiner *N. buccula*	C	--	Endemic to upper Brazos River system and its tributaries. Prefers medium to large prairie streams with sandy substrate and turbid to clear warm water.	No	Cedar Ridge is in the upper Brazos River drainage; however, suitable habitat is lacking within the reservoir footprint.
Mammals					
Gray wolf *Canis lupus*	LE	E	Extirpated. Formally known from forests, brush lands, or grasslands of western two-thirds of the state.	Yes	Historically occurred in the area but now considered extinct in Texas.
Red wolf *C. rufus*	LE	E	Extirpated. Formerly known throughout eastern half of Texas inhabiting brushy and forested areas, as well as coastal prairies.	Yes	Historically occurred in the area but now considered extinct in Texas.

Table 6-3
Federal and State-Listed Threatened, Endangered, and Rare Species of Potential Occurrence in Haskell, Jones, Shackelford, and Throckmorton Counties (Continued)

Species	Federal Status	State Status	Description of Suitable Habitat	Suitable Habitat Present	Pertinent Project Information
Mammals					
Pale Townsend's big-eared bat *Corynorhinus townsendii pallescens*	--	--	Roosts in caves, abandoned mine tunnels, and old buildings.	No	Only listed for Haskell County. Suitable habitat is lacking within the reservoir footprint.
Black-tailed prairie dog *Cynomys ludovicianus*	--	--	Inhabits dry, flat, short grasslands with low, sparse vegetation.	No	Suitable habitat is lacking within the reservoir footprint.
Black-footed ferret *Mustela nigripes*	LE	--	Extirpated; inhabited prairie dog towns in the general area.	No	Only listed for Haskell and Jones counties. Historically occurred in the area but now considered extinct in Texas.
Cave myotis bat *Myotis velifer*	--	--	Roosts colonially in caves, but also found in rock crevices, old buildings, carports, and under bridges. Hibernates during winter in limestone caves of Edwards Plateau and gypsum caves of the Panhandle.	No	A county record exists from Jones County. Could forage within reservoir footprint; however, suitable roosting habitat is lacking overall.
Plains spotted skunk *Spilogale putorius interrupta*	--	--	Occurs largely in wooded areas and tall-grass prairies, but can be found in varied habitats including open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands. Prefers rocky canyons and outcrops when available.	Yes	A county record exists from Haskell County. Potentially suitable habitat is present within the reservoir footprint.
Mollusks					
Smooth pimpleback *Quadrula houstonensis*	--	T	Inhabits stable substrates of mud, sand, and fine gravel within small to moderate streams and rivers as well as reservoirs. Occurs in the Brazos and Colorado River basins.	Yes	Only listed for Shackelford County. Potentially suitable freshwater mussel habitat is present within the reservoir footprint; however, only a single record exists from Shackelford County downstream of the project. Recent surveys indicate that this mussel does not likely inhabit the Clear Fork within the reservoir footprint. Species is tolerant of impoundment.
Pistolgrip *Tritogonia verrucosa*	--	--	Inhabits stable substrate of rock, hard mud, silt, and soft bottoms in medium to large rivers of east and central Texas. Ranges from the lower Guadalupe River north to the Red River.	Yes	Potentially suitable freshwater mussel habitat is present within the reservoir footprint, and shells have been found.

Table 6-3
Federal and State-Listed Threatened, Endangered, and Rare Species of Potential Occurrence in Haskell, Jones, Shackelford, and Throckmorton Counties (Concluded)

Species	*Federal Status*	*State Status*	*Description of Suitable Habitat*	*Suitable Habitat Present*	*Pertinent Project Information*
Mollusks					
Texas fawnsfoot *Truncilla macrodon*	--	T	Endemic to the Brazos and Colorado rivers. Little known about preferred habitat.	Yes	Potentially suitable freshwater mussel habitat is present within the reservoir footprint. The closest known locality of a live specimen is approximately 57 miles downstream of the project. Species is intolerant of impoundment.
Reptiles					
Brazos water snake *Nerodia harteri harteri*	--	T	Upper Brazos River drainage. Found in shallow water with rocky bottoms and rocky shorelines.	Yes	Suitable habitat is present within the reservoir footprint, and populations have been documented at a number of locations within the footprint and downstream of it.
Texas horned lizard *Phrynosoma cornutum*	--	T	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush, or scrubby trees. Soil may vary in texture from sandy to rocky.	Yes	Potentially suitable habitat is present within the reservoir footprint.

Sources: Schmidley 1994[23], AOU 1998[24], McIntyre 2004[25], Howells 2009[26]), McBride 2009[27], Howells 2010,[28] TPWD 2010a,b,c,d.[29]

LE = Federally listed endangered
PT = Federally proposed threatened
C = Federal candidate for listing

DL = Federally delisted
E, T = State listed endangered/threatened
-- = Rare, but with no regulatory listing status

[23] Schmidley, D. J. 1994. The mammals of Texas. University of Texas Press, Austin.
[24] American Ornithologists' Union (AOU). 1998. Checklist of North American birds. 7th edition. American Ornithologists' Union, Washington, D.C.
[25] McIntyre, N. E. 2004. Historical and current status of breeding and wintering western burrowing owls (*Athene cunicularia hypugaea*) in Texas. Journal of Raptor Research 38:91–95.
[26] Howells, R. G. 2009. Freshwater Mussels of the Clear Fork: Cedar Ridge Project. Report prepared for HDR Engineering, August 2009.
[27] McBride, D. M. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.
[28] Howells, R. G. 2010. Guide to Texas freshwater mussels. BioStudies, Kerrville, Texas.
[29] Texas Parks and Wildlife Department (TPWD). 2010*a*. Annotated county lists of rare species for Haskell County. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx. Accessed 28 July 2010.
_____.2010*b*. Annotated county lists of rare species for Jones County. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx. Accessed 28 July 2010.
_____.2010*c*. Annotated county lists of rare species for Shackelford County. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx. Accessed 28 July 2010.
_____.2010*d*. Annotated county lists of rare species for Throckmorton County. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx. Accessed 28 July 2010.

6.7.3.2.1 Bird Species

Two bird species, the Whooping Crane (*Grus americana*) and the Interior Least Tern (*Sterna antillarum athalassos*), are federally listed as endangered and could occur within the project vicinity during the spring and fall migrations. The primary Whooping Crane flock nests in Canada and migrates annually to their wintering grounds on the Texas coast in and around the Aransas National Wildlife Refuge near Rockport, Texas.[30] During migration Whooping Cranes primarily utilize wetland areas as rest stops.[31] However, wetland habitat (non-forested) within the conservation pool is limited to a total of approximately 6 acres, comprised of several small fringe habitats as opposed to the larger emergent marsh wetland areas more typically utilized by cranes. Therefore, the project is not anticipated to affect Whooping Crane habitat.

The Interior Least Tern typically nests on bare or sparsely vegetated areas associated with streams or lakes, such as sand and gravel bars, beaches, islands, and salt flats.[32] Un-vegetated bars within wide river channels or open flats along lake or reservoir shorelines are preferred habitats and provide suitable nesting areas and access to adjacent open water for foraging. The Clear Fork is a narrow river within the reservoir footprint with limited numbers of rock riffles, and there are few un-vegetated sand or gravel bars within the river channel. While occasional migrants of this species are possible within the proposed reservoir site, observations during completed field work revealed no suitable nesting habitat within or downstream of the project area. Following reservoir development, gently sloping areas of the shoreline of the reservoir below the conservation pool will not be densely vegetated. Those portions not dominated by rocks may provide nesting and foraging habitat for Interior Least Terns.

Although not currently listed, the Mountain Plover (*Charadrius montanus*) has been petitioned to be federally listed as threatened.[33] The Mountain Plover is a migratory bird that inhabits xeric shrublands, short-grass prairies, barren agriculture fields, and other areas with sparse vegetation.[34] Mountain Plovers breed in the western Great Plains and Rocky Mountain States and winter in California, southern Arizona, Texas, and Mexico. While a rare migrant is possible within the project area, suitable habitat is lacking overall.

[30] American Ornithologists' Union (AOU). 1998. Checklist of North American birds. 7th edition. American Ornithologists' Union, Washington, D.C.
[31] Ibid
[32] Ibid.
[33] U.S. Fish and Wildlife Service (USFWS). 2010. Endangered and threatened wildlife and plants; listing the mountain plover as threatened. Federal Register 75:37353–37358.
[34] U.S. Fish and Wildlife Service (USFWS). 2010. Endangered and threatened wildlife and plants; listing the mountain plover as threatened. Federal Register 75:37353–37358.

Avian species listed as endangered or threatened by the State of Texas include the Peregrine Falcon (*Falco peregrinus*) and Bald Eagle (*Haliaeetus leucocephalus*). The Peregrine Falcon is listed as state threatened and includes two subspecies, the Arctic Peregrine Falcon (*F. p. tundrius*) and American Peregrine Falcon (*F. p. anatum*). The American Peregrine Falcon is a resident in west Texas where it nests along steep cliff walls; however, both subspecies are known migrants across the state from more northern breeding areas in the U.S. and Canada down to wintering grounds along the Gulf Coast and further south.[35] During migration, Peregrine Falcons will utilize leading landscape edges such as lake shores or coastlines for stopovers. Peregrine Falcons could occur within the project area, but only as rare transients during migration. The Bald Eagle is also listed as threatened in Texas and could also potentially occur as a winter migrant within and around the project area. In Texas, the majority of currently reported nesting Bald Eagle pairs are found along major rivers and near reservoirs in the eastern half of the state.[36] Bald Eagles utilize tall trees near perennial water as roosting or nesting sites. Given the lack of potentially suitable habitat in the area, it is not anticipated that either the Peregrine Falcon or the Bald Eagle would be adversely affected by the construction of the reservoir.

6.7.3.2.2 Mammals

The gray wolf (*Canis lupus*) and red wolf (*C. rufus*) are federally and state listed endangered mammals which historically may have occurred in the area of the reservoir; however, today both species are considered to be extinct within the state of Texas (Schmidley 1994). The black-footed ferret is also a species that is listed as federally endangered and historically occurred in the area. As with the gray and red wolf, the black-footed ferret is considered to be extinct in Texas.[37] The project will not adversely affect these species.

---

[35] Texas Parks and Wildlife Department (TPWD). 2010*a*. Annotated county lists of rare species for Haskell County. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx. Accessed 28 July 2010.
_____.2010*b*. Annotated county lists of rare species for Jones County. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx. Accessed 28 July 2010.
_____.2010*c*. Annotated county lists of rare species for Shackelford County. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx. Accessed 28 July 2010.
_____.2010*d*. Annotated county lists of rare species for Throckmorton County. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx. Accessed 28 July 2010.
[36] Campbell, L. 2003. Endangered and threatened animals of Texas: their life history and management. Texas Parks and Wildlife Department, Wildlife Division, Austin.
[37] Schmidley, D. J. 1994. The mammals of Texas. University of Texas Press, Austin.

6.7.3.2.3 Fish and Mollusks

The sharpnose shiner (*Notropis oxyrhynchus*) and the smalleye shiner (*N. buccula*) are two small, slender minnows endemic to the Brazos River Basin.[38,39] Historically, these sympatric fishes existed throughout the Brazos River and several of its major tributaries; however, both species have experienced significant population declines. In 2002, both species were placed on the USFWS list of potential candidates for federal protection, yet neither has received federal protection to-date. The population of both species within the upper Brazos River drainage upstream of Possum Kingdom Lake is apparently stable; however, populations within the middle and lower segments of the Brazos River Basin (below Possum Kingdom Lake) may exist only in remnant areas of suitable habitat, or may be completely extirpated.[40] General habitat associations for both species include relatively shallow water with moderate currents flowing through broad, open sandy channels.[41] Surveys of the Clear Fork by HDR biologists in 2009 and 2010 within and downstream of the reservoir footprint indicate that suitable habitat for the sharpnose and smalleye shiner is not present. Furthermore, sampling of the fish assemblages found along the Clear Fork within and downstream of the reservoir footprint also indicated that neither the sharpnose shiner nor the smalleye shiner is present in the project area.

Fifteen of the 52 freshwater mussel species known in Texas are listed as state-threatened by the TPWD.[42] Two of these mussel species, the smooth pimpleback (*Quadrula houstonensis*) and the Texas fawnsfoot (*Truncilla macrodon*), are endemic to the Brazos River Basin and could potentially occur within or in the surrounding vicinity of the reservoir footprint. Both species have also been petitioned, along with nine other species of freshwater mussels, to be federally listed as threatened or endangered.[43] Historically the smooth pimpleback occurred in the Brazos

[38] Cross, F. B. 1953. A new minnow, *Notropis bairdi buccula,* from the Brazos River, Texas. Texas Journal of Science 5:252-259.
[39] Cross, F.B., Mayden, R.L., and J.D. Stewart. 1986. Fishes in the Western Mississippi drainage. Pages 363-412 *in* C. H. Hocutt and E.O. Wiley, editors. The zoogeography of North American Freshwater Fishes. Wiley, New York.
[40] U.S. Fish and Wildlife Service (USFWS). 2009*a*. Endangered and threatened wildlife and plants; review of native species that are candidates for listing as endangered or threatened; annual notice of findings on resubmitted petitions; annual description of progress on listing actions. Federal Register 74:57803-57878.
[41] Moss, R. W., and K. B. Mayes. 1993. Current status of *Notropis buccula* and *Notropis oxyrhynchus* in Texas. River studies report 8. Texas Parks and Wildlife Department, Austin.
[42] Texas Parks and Wildlife Department. 2009. News release entitled 15 Texas Freshwater Mussels Placed on State Threatened List, November 5, 2009. http://www.tpwd.state.tx.us/newsmedia/releases/?req=20091105c&nrtype=all&nrspan=&nrsearch=. Accessed on 7 October 2010.
[43] U.S. Fish and Wildlife Service (USFWS). 2009*b*. Endangered and threatened wildlife and plants; 90-day finding on petitions to list nine species of mussels from Texas as threatened or endangered with critical habitat. Federal Register 74:66260-66271.

and Colorado River systems of central Texas. Today it is known from the central Brazos, central Leon, central Little Brazos, and Navasota Rivers in the Brazos River drainage; and from the central Colorado River in the Colorado River drainage.[44] This species prefers small- to moderate-sized streams and rivers, as well as moderately-sized reservoirs, and is typically found in substrates of mixed mud, sand, and fine gravel in water flowing at a very slow to moderate rate.[45,46] While it is unlikely that the smooth pimpleback inhabits the reach of the Clear Fork to be impacted by the reservoir, this species is known to tolerate impoundment.[47,48]

The Texas fawnsfoot historically occurred in the Brazos and Colorado River drainages. Little is known pertaining to the preferred habitat of this species. While the Texas fawnsfoot is intolerant of impoundment, specimens potentially occurring downstream of the reservoir should not be adversely affected, as this species has been reported to occur downstream of other impoundments along the Brazos River.[49,50,51,52] The nearest location to the proposed Cedar Ridge Reservoir where live and recently dead specimens (i.e., those with soft tissue still present) have been reported along the Clear Fork is near Fort Griffin, approximately 57 river-miles downstream of the proposed dam location (TPWD and HDR survey data).

Mussel surveys by experienced biologists conducted in 2009, 2010 and the spring of 2011 did not identify either the smooth pimpleback or the Texas fawnsfoot in the project area or in downstream areas near the proposed dam. Therefore, the project is not anticipated to adversely affect these mussel species. The results of the 2009 and 2010 surveys are presented in Section 6.7.4.1.1. and Appendices I and J.

---

[44] U.S. Fish and Wildlife Service (USFWS). 2009*b*. Endangered and threatened wildlife and plants; 90-day finding on petitions to list nine species of mussels from Texas as threatened or endangered with critical habitat. Federal Register 74:66260-66271.

[45] Ibid.

[46] Texas Parks and Wildlife Department (TPWD). 2010*c*. Annotated county lists of rare species for Shackelford County. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx. Accessed 28 July 2010.

[47] Howells, R. G., R. W. Neck, and H. D. Murray. 1996. Freshwater Mussels of Texas. Inland Fisheries Division, Texas Parks and Wildlife Department, Austin.

[48] Howells, R. G. 2002. Freshwater mussels (Unionidae) of the pimpleback-complex (*Quadrula* spp.) in Texas. Texas Parks and Wildlife Department, MDS 197, Austin.

[49] Howells, R.G., R.W. Neck, and H.D. Murray. 1996. *Freshwater mussels of Texas*. Texas Parks and Wildlife Press, Austin.

[50] Howells, R.G. 2002. Freshwater mussels (Unionidae) of the pimpleback-complex (*Quadrula* spp.) in Texas. Texas Parks and Wildlife Department, MDS 197, Austin.

[51] Howells, R. G. 2010. Texas fawnsfoot (*Truncilla macrodon*): Summary of selected biological and ecological data for Texas. Prepared for Save Our Springs Alliance, Austin, Texas. Not for internet distribution.

[52] Howells, R. G. 2009. Freshwater Mussels of the Clear Fork: Cedar Ridge Project. Report prepared for HDR Engineering, August 2009. Found in Appendix I, Attachment I-1 of this document.

The zebra mussel (*Dreissena polymorpha*) is an invasive small freshwater mussel species originally native to lakes in Russia. Characteristic of invasive aquatic organisms, zebra mussels exhibit high fecundity, efficient mechanisms for dispersal, potential for rapid population growth, and negative effects on native biota. Human activity introduced the zebra mussel into North America and contributes to its ongoing spread, and they were recently identified in Lake Texoma and Lake Lavon in North Texas. Larval and adult life stages can be transported to new waters by water pipelines, ship ballast water, or boat live wells. Zebra mussels are known to adversely affect native mussels by affixing to their shells and also can foul water infrastructure such as intakes and pipelines. Zebra mussels are generally more problematic in reservoirs and low gradient streams as compared to rivers and streams with frequent high pulse flow events. The continued spread of the zebra mussels into reservoirs in Texas is likely to occur. The Applicant will evaluate future strategies developed by TPWD Inland Fisheries program related to zebra mussels and consider applicability to the proposed project.

6.7.3.2.4 Reptiles

The Texas horned lizard (*Phrynosoma cornutum*) is a relatively small lizard that is known to occur in a variety of habitats including short-grass prairie, mesquite grasslands, shrublands, desert scrub, and desert grasslands.[53,54] Within these habitats, Texas horned lizards typically inhabit relatively flat, open areas lacking dense ground vegetation.[55,56,57,58] These lizards can be found at elevations from sea level to approximately 6,000 feet[59] on a variety of soil types,[60] however, Texas horned lizards prefer soils that facilitate easy excavation such as sandy loams and loamy sands.[61] Preferred habitats also support ample populations of ants, particularly

[53] Price, A. H. 1990. *Phrynosoma cornutum*. Catalogue of American Amphibians and Reptiles. 469:1–7.
[54] Donaldson, W., A. H. Price, and J. Morse. 1994. The current status and future prospectus of the Texas horned lizard (*Phrynosoma cornutum*) in Texas. Texas Journal of Science 46:97–113.
[55] Whiting, M. J., J. R. Dixon, and R. C. Murray. 1993. Spatial distribution of a population of Texas horned lizards (*Phrynosoma cornutum*: Phrynosomatidae) relative to habitat and prey. Southwestern Naturalist 38:150–154.
[56] Fair, W. S., and S. E. Henke. 1998. Habitat use of Texas horned lizards in southern Texas. Texas Journal of Agriculture and Natural Resources 11:73–86.
[57] Henke, S. E. and W. S. Fair. 1998. Management of Texas horned lizards. Caesar Kleberg Wildlife Research Institute Management Bulletin No. 2, Texas A&M University, Kingsville.
[58] Endriss, D. A. 2006. Ecology of an urban population of the Texas horned lizard (*Phrynosoma cornutum*) in central Oklahoma. Thesis, Oklahoma State University, Stillwater.
[59] Conant, R., and J. T. Collins. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Third Edition. Houghton Mifflin, New York.
[60] Price, A. H. 1990. *Phrynosoma cornutum*. Catalogue of American Amphibians and Reptiles. 469:1–7.
[61] Fair, W. S. 1995. Habitat requirements and capture techniques of Texas horned lizards in South Texas. Thesis, Texas A&M University, Kingsville.

harvester ants (*Pogonomyrmex* spp.), which are the primary component of the Texas horned lizard's diet.[62] While no species-specific surveys have been conducted to assess the presence of Texas horned lizard populations or to quantify habitat within the proposed Cedar Ridge Reservoir footprint, field observations during ecological surveys of the area indicate that potentially suitable habitat for the Texas horned lizard is present both within and surrounding the reservoir footprint. Given the mobility of this species and the availability of ample suitable habitat adjacent to the reservoir footprint, impacts to the Texas horned lizard are not anticiapted.

The Brazos water snake (*Nerodia harteri harteri*) is a highly aquatic, endemic Texas snake with a limited and patchy distribution along the upper Brazos River drainage in north-central Texas. The known range of this snake is limited to approximately 440 miles of the upper Brazos River and some of its tributaries[63], giving it one of the most restricted geographic distributions of any North American snake species.[64] Within its restricted range, the population distribution of the Brazos water snake is not contiguous, but rather patchy, and is linked to the availability of suitable habitat. Preferred habitat, particularly for juvenile snakes, consists of shallow rocky riffles along the river that have a gently sloping rocky shoreline free of vegetation.[65] Within reservoir environments, the Brazos water snake is known to occupy portions of shoreline with similar features.[66] While adult Brazos water snakes can utilize a wider range of habitats, including deeper waters, its distribution is limited by their need for secure rocky cover and the distance they can travel from suitable rocky areas for giving birth.[67] In-depth surveys by experienced HDR biologists were initiated in 2009 to assess the presence and habitat of the Brazos water snake within and surrounding the Cedar Ridge Reservoir site. Results to date from this investigation indicate that Brazos water snake populations and suitable habitat exist along the Clear Fork, both within and downstream of the proposed Cedar Ridge reservoir footprint, and along nearby stream reaches up- and downstream of the proposed reservoir that will not be affected by the project. These surveys are on-going and the results will be used to evaluate potential impacts and plan mitigation strategies. A summary of the surveys conducted to date and

[62] Pianka, E. R., and W. S. Parker. 1975. Ecology of horned lizards: a review with special reference to *Phrynosoma platyrhinos*. Copeia 1975:141–162.
[63] Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.
[64] Werler, J. E., and J. R. Dixon. 2000. Texas Snakes: Identification, Distribution, and Natural History. University of Texas Press, Austin.
[65] Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.
[66] Ibid
[67] Ibid.

their results are presented in Appendix G. Figure 6-6 shows the areas surveyed and locations of Brazos water snakes along the Clear Fork and surrounding stream reaches.

The highest concentrations of Brazos water snakes in the vicinity of the project were found within the upper reaches of the reservoir project area along a 7-mile reach of the Clear Fork downstream of the existing dam at Lueders and in riffles approximately 15 to 20 miles downstream of the proposed dam location (Figure 6-6). Surveys conducted to date also demonstrate that Brazos water snake populations occur in suitable habitat within and downstream of the reservoir project, and along nearby stream segments that will not be affected by the Cedar Ridge reservoir. Additionally, Brazos water snake populations occur within Possum Kingdom Lake.

Evidence shows that the Brazos water snake can tolerate impoundment,[68,69,70] and the potential impacts from the Cedar Ridge Reservoir project are being carefully evaluated in order to propose and implement appropriate mitigation measures. Potential adverse effects to the Brazos water snake from the construction of Cedar Ridge Reservoir include: (1) inundation and loss of existing suitable habitat along the Clear Fork; (2) further fragmentation of existing populations and restriction of genetic exchange between these populations, (3) reduction of local or overall population numbers, and (4) the reduction of suitable riverine habitat downstream of Cedar Ridge. Mitigation measures will be evaluated to minimize the potential adverse effects to the snake due to these factors, as described below.

[68] Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.

[69] McBride, D. M. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.

[70] Colorado River Municipal Water District (CRMWD). 1998. Petition to delist the Concho water snake (*Nerodia harteri paucimaculata*). Colorado River Municipal Water District, Big Springs, Texas.

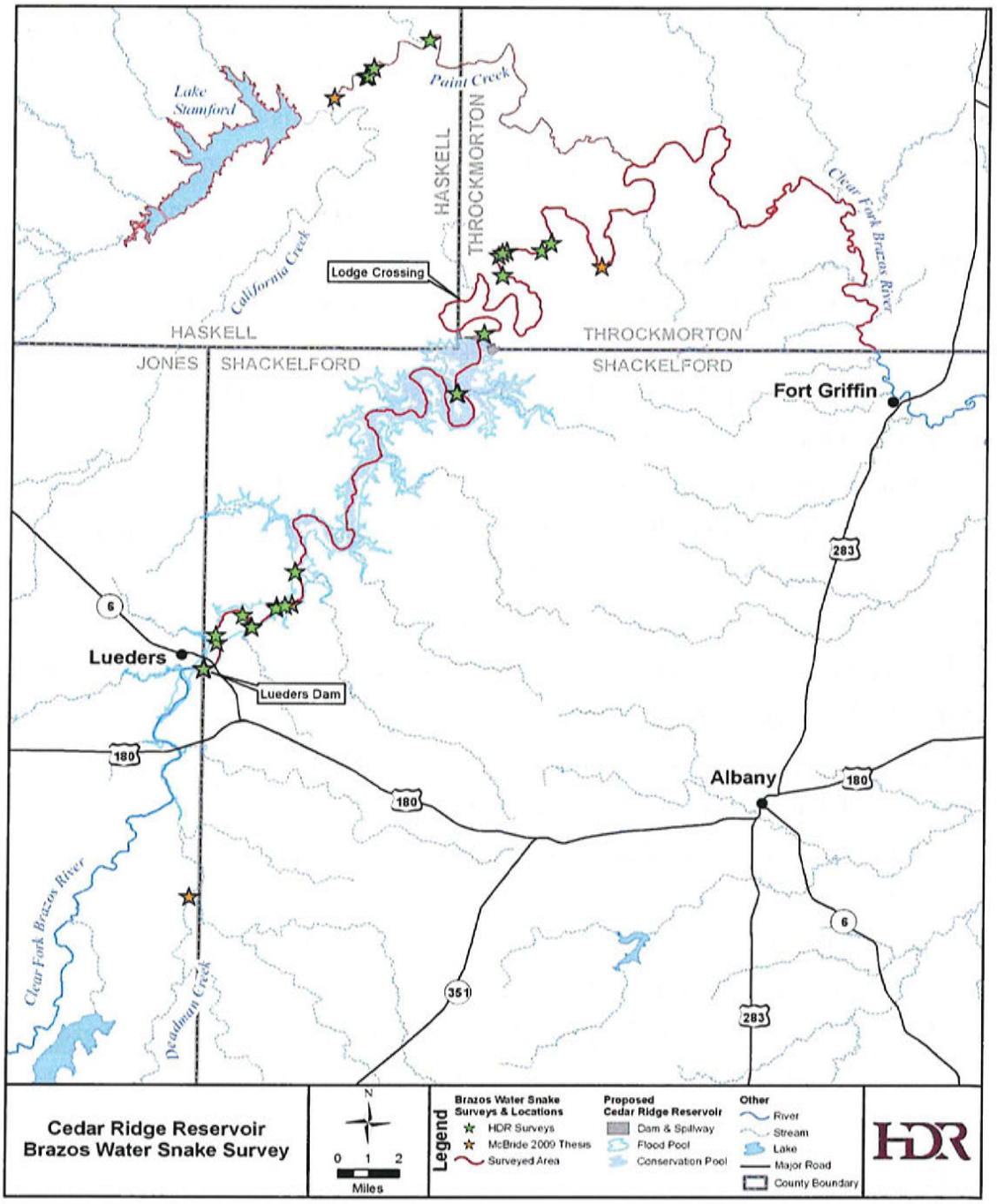


Figure 6-6. Area Surveyed and Locations of Brazos Water Snakes, March 2009–October 2010, Including Locations Reported by McBride [71].

[71] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.

Adult Brazos water snakes can utilize a broader range of aquatic habitats than juveniles, which are limited to the shallow riffle habitats. Along the approximate 29-mile stretch of the Clear Fork that will be inundated by Cedar Ridge Reservoir, there is only a limited amount of existing suitable juvenile Brazos water snake habitat present within approximately 3 linear miles (15 acres) of shallow rocky, riffle habitat. Due to geologic similarities of the proposed reservoir to existing reservoirs that are known to support Brazos or Concho water snake (*Nerodia harteri paucimaculata*—a close relative to the Brazos water snake from the Concho and Colorado River drainages of central Texas) populations, there is high potential for the development of suitable rocky shorelines along the perimeter of Cedar Ridge Reservoir that would likely support Brazos water snake populations and serve as a mitigation measure (Appendix G).

Brazos water snakes have been documented in suitable habitat locations in Possum Kingdom Lake nearly 70 years after construction. Similarly, the Concho water snake has been documented from numerous locations within suitable shoreline habitat within O.H. Ivie Reservoir, which was constructed in 1989. The shoreline habitat conditions at both reservoirs are being studied to allow quantification of anticipated Brazos water snake habitat that will develop at Cedar Ridge Reservoir. Preliminary analysis using USGS mapping indicates the amount of gently sloped (less than 4:1 or 25 percent) shoreline will vary between approximately 235 and 500 acres within the top 10 feet as the lake level fluctuates. The upper portion (to approximately 3 feet in depth) of this water column along rocky shorelines is anticipated to develop into suitable habitat for Brazos water snakes. The location and geology of these shallow areas are currently being evaluated to better understand the spatial relationships and opportunities to serve as juvenile snake habitat.

The construction of a dam along the Clear Fork will fragment the existing Brazos water snake population in the study area between those upstream of the dam in the proposed reservoir footprint and those in downstream reaches of Clear Fork including Paint and California creeks. The Deadman Creek population (1 record in 2008[72] and 3 in 2010) is considered to be isolated due to flow regime and habitat changes resulting from the Lueders Dam constructed in the early 1920's which created Lake Penick. The lake has a heavily vegetated shoreline and impounds water for approximately 6.3 miles upstream to near the confluence of Deadman Creek.

[72] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.

While both the Brazos and Concho water snakes are known to tolerate impoundment and are documented as persisting under these conditions for many decades,[73,74,75,76] the condition of snakes in lacustrine populations may be indirectly affected. When compared to riverine populations, Concho water snake populations from lacustrine environments have been found to exist at lower densities.[77] Concho water snakes inhabiting a large reservoir have also been observed to exhibit decreased growth rates and reproductive potential compared to riverine populations.[78] These observed differences in densities, growth rate, and reproductive potential are likely an artifact of habitat conditions present within reservoirs, such as the gradient of the shoreline and adjacent lake floor, substrate composition, and the prey species that utilize these habitats. Foraging success for Concho and Brazos water snakes is likely greater within shallow riffle habitats along the river corridor compared to reservoir environments. Snakes are potentially able to catch prey more efficiently when fish become concentrated and trapped within rocky shallows; however, within a reservoir environment, this type of habitat is not common, and shorelines generally recede quickly into deeper waters. In a study of the feeding ecology of Concho water snakes in both riverine and lacustrine environments, riverine snakes (particularly juveniles) were observed to feed on prey species in proportion to their availability, whereas lacustrine snakes were found to feed primarily on prey species associated with benthic or shallow water habitats rather than the more abundant open water species.[79] Therefore, a key consideration of a mitigation plan will be the evaluation of methods to enhance both juvenile snake habitat and refugia for potential prey species along the suitable shoreline sections.

The existing riverine habitat within the project area exhibits an approximate 19-mile segment where Brazos water snake habitat is degraded or lacking with no previous occurrence records (see Figure 6-6). Therefore, there is the potential to increase the overall habitat available for the Brazos water snakes in the project area by increasing surface areal coverage and the

[73] Ibid.
[74] Colorado River Municipal Water District (CRMWD). 1998. Petition to delist the Concho water snake (*Nerodia harteri paucimaculata*). Colorado River Municipal Water District, Big Springs, Texas.
[75] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.
[76] HDR Engineering, Inc. 2010. Brazos water snake, Appendix G.
[77] Whiting, M. J., J. R. Dixon, B. D. Greene, J. M. Mueller, O. W. Thornton, Jr., J. S. Hatfield, J. D. Nichols, and J. E. Hines. 2008. Population dynamics of the Concho water snake in rivers and reservoirs. Copeia 2008:438–445.
[78] Whiting, M. J. 1993. Population ecology of the Concho water snake, *Nerodia harteri paucimaculata*, in artificial habitats. Thesis, Texas A&M University, College Station.
[79] Greene, B. D., J. R. Dixon, J. M. Mueller, M. J. Whiting, and O. W. Thornton, Jr. 1994. Feeding ecology of the Concho water snake, *Nerodia harteri paucimaculata*. Journal of Herpetology 28:165–172.

number of shallow rocky habitat locations both within the conservation pool of the reservoir and along the Clear Fork downstream of the dam.

In addition to potential adverse effects caused by inundation of the river corridor, downstream indirect effects also warrant consideration. With the construction of a dam along the Clear Fork and alteration of the flow regime below the dam, degradation of downstream riffle habitat could occur. Reduced flows could allow vegetation to become established within the river channel and cause rocky areas to become covered with silt. Along the Colorado River below E.V. Spence Reservoir, reduced flows have apparently allowed the rocky streambed to become covered in silt and subsequently thick vegetation, thereby eliminating habitat where Concho water snakes were previously known to occur.[80] Therefore, high flow pulses for riffle maintenance is a key consideration of the proposed use of the HEFR-based environmental pass-through flow regime (see Table 5-2) for Cedar Ridge Reservoir.

Mitigation options for the potential impacts to the Brazos water snake as a result of the Cedar Ridge Reservoir are currently being evaluated and may include enhancement or protection of habitat and implementation of an appropriate flow regime to maintain riffle habitat downstream of the reservoir. A final mitigation plan will be developed in coordination with TCEQ, TPWD, and USACE.

6.7.4 Aquatic Resources

6.7.4.1 Affected Environment

The Clear Fork is a 5th-order stream and a major tributary of the Brazos River with a length of almost 180 miles. The section of the river proposed for impoundment in Haskell, Shackelford, and Throckmorton counties is predominately a rural, unmanaged river system characterized by muddy water, steep banks, and low overhanging willow, pecan, elm, and mesquite trees. Except during periods of heavy rainfall, the river moves slowly.

The Clear Fork riverine environment within the study area can be divided into distinct reaches with well-defined units (pools, runs, and riffle areas) according to the prevailing flow regime. Typical of plains streams, the river experiences large variations in discharge, exhibiting an annual pattern of prolonged periods of low flow punctuated by high flow events. The Clear Fork in the project area ordinarily experiences summer (June–October) low flows with periods of

[80] Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.

zero flow lasting from a few days to several months occurring every few years. During those periods, perennial pools continue to occupy substantial areas of streambed. Although the river may be subject to large variations in discharge, it is characteristically a continuously flowing system with species characteristic of, and in some cases restricted to, small riverine systems.

An initial field reconnaissance trip covering 33 miles of river channel by kayak on the Hendrick Ranch from Round Valley Crossing to the Perry Camp Crossing was made during March 23–26, 2009, to evaluate the existing aquatic habitat conditions with emphasis on smalleye shiner and sharpnose shiner distribution and habitat use (Figure 6-7). A 13-mile long examination of the upper river reach between SH 6 and the Round Valley Crossing was also conducted from May 18–22, 2009. An inventory of 10 potential sampling locations observed during these two river excursions was reviewed based on stream access and length of wade-able area exhibiting a variety of microhabitats. A total of five aquatic sampling stations on the Clear Fork were then selected for subsequent Aquatic Life Monitoring (ALM). For this particular study, mile markers (statute) were assigned by HDR to the Clear Fork and indicate the distance upstream from the confluence with the Brazos River beginning with zero at the confluence.

The most prevalent habitat areas available to aquatic organisms in the study area are the long, slow-flowing pools of wide variety relative to widths and depth. The lack of shallow stream reaches needed for sampling by wade-able stream procedures limited the number of river sampling points within the reservoir footprint. The pools, which are often in excess of 1.5 meters in depth, are typically floored by sand, small and large gravel, cobble, rock, boulder, and bedrock. Based on biological conditions, the pool areas were considered to be permanent or usually persistent. In several areas, the river channel is constricted, forming shallow, relatively fast-flowing riffle habitats. The riffle areas tend to be very shallow, ranging from 5 cm to 30 cm and are generally floored by large gravel, cobble, and rock substrates. Riffle areas are located downstream of confining bedrock layers, and their extent is dependent upon the volume of water flowing down the river. The faster flowing habitats and more suitable substrate provide a more diversified and abundant macroinvertebrate food base than occurs in pools, as well as shallow water habitat for many small species of fish. Major riffles exist in areas of relatively large rock substrates and steep stream gradient. The rock size of the substrate was generally large and provided abundant microhabitats for benthic invertebrates and fish. Secondary riffles, subject to repositioning of pea-gravel or pea-gravel-sand substrates were not present.

The tree-lined banks of the Clear Fork contribute leafy detritus to the river and eventually to the Brazos River. Areas not densely shaded supported grasses typical to the area. Small amounts of terrestrial plant debris, ranging from small tree branches to leaf litter, provide the predominant source of in-stream cover. No significant stands of submergent or emergent aquatic vegetation are found along the study reach. The Clear Fork is flashy and floods easily. There was considerable evidence of recent flooding (i.e., decaying algal deposits lodged in tree branches 1 to 4 meters above the water level, sediment deposits on the leaves of terrestrial plants on the upper levels of the steep banks, and patches of terrestrial vegetation along the creek margins pointing downstream). Dense spring and late summer algal blooms, composed primarily of blue-green algae (Cyanobacteria), green algae (Chlorophyta), and diatoms (Bacillariophyta) were present in the river at high relative abundance during the two reconnaissance surveys in 2009 and in the shallow pool and riffle habitats present at each ALM sampling site in 2009 and 2010. The physical nature of attached algae ranged from single, microscopic cells, to massive crusts and masses of filaments many feet in length.

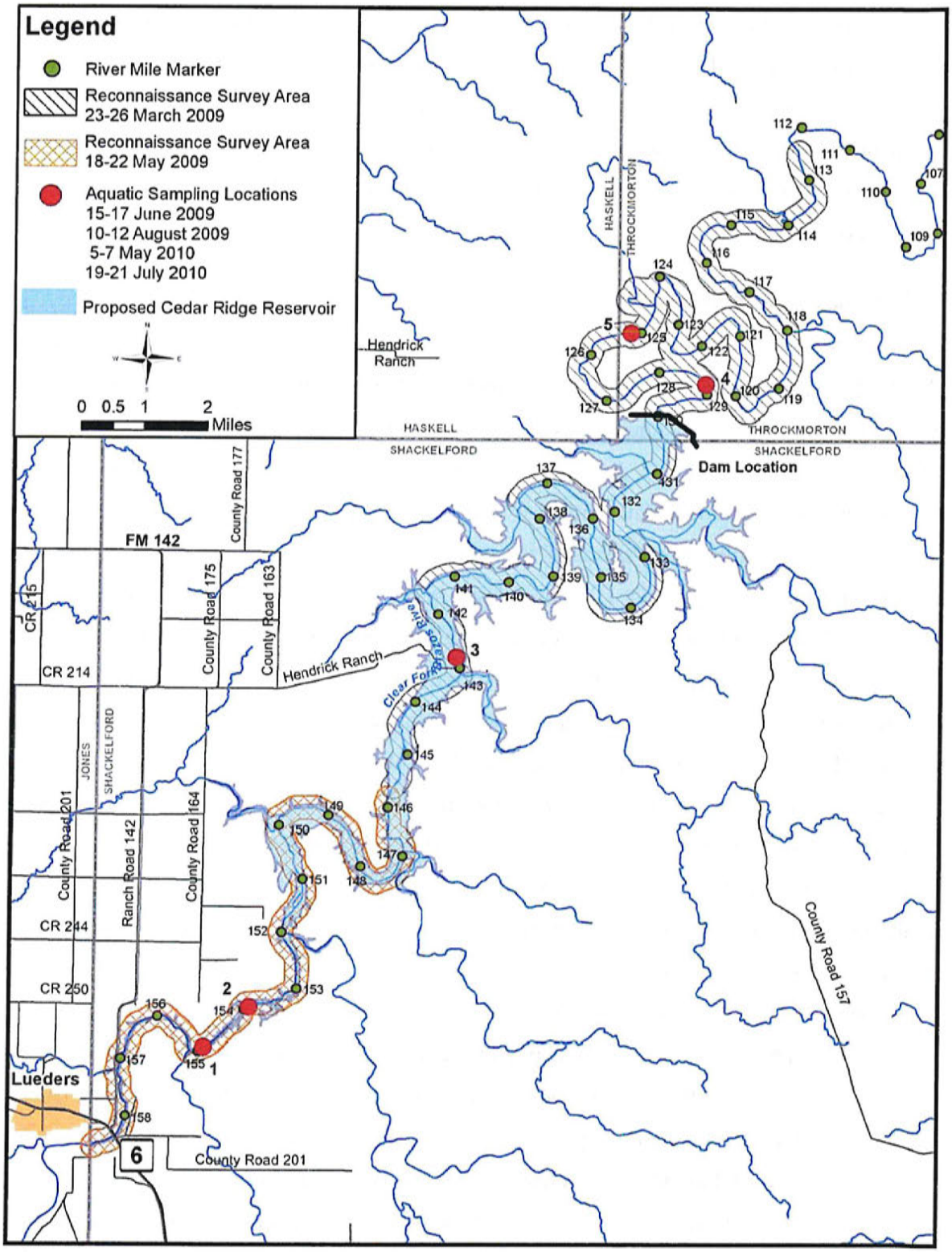


Figure 6-7. Aquatic Sample Locations, 2009 and 2010

Those stream reaches included within the reservoir footprint represented by Stations 1, 2, and 3 will be converted from flowing to standing water habitat. Inundation by the proposed project would also have the effect of replacing the surrounding terrestrial and riparian vegetation communities with aquatic habitat. Data collected from Stations 4 and 5 will serve as a baseline for possible changes in macroinvertebrate and fish populations resulting from construction and operation of the dam.

6.7.4.1.1 Aquatic Life Monitoring

ALM surveys were conducted at five locations during the 2009 index period (June 15–17), the 2009 critical period (August 10–12), and the 2010 index period (May 5–7) (Figure 6-7). ALM surveys were limited to three sites (3, 4 and 5)during the 2010 critical period (July 19–21) due to site access limitations at two of the sites. All site-specific stream-habitat, benthic macroinvertebrate, and fish data collected along the Clear Fork between SH 6 to a point approximately 5.0 miles downstream of the proposed dam in Shackelford and Throckmorton counties, are found in Appendix H. The primary purpose of these field investigations was to provide a better understanding of the existing aquatic environment by identifying and documenting the aquatic communities along the reach of the Clear Fork proposed for impoundment. Another goal of the study was to evaluate the potential habitat available and presence of two imperiled cyprinid species—smalleye shiner and sharpnose shiner as discussed in Section 6.7.3. The methods and materials for the ALM work performed were consistent with the guidelines of the TCEQ's Surface Water Monitoring Procedures.

During each survey, flow was continuous throughout the study reach, and swift flow conditions were experienced during 3 of the 4 survey periods when river streamflow was measured in excess of 25.0 cfs. Station 1 was established at River Mile (RM) 155 directly downstream of Hoggys Crossing on private property. This is the uppermost river access selected for monitoring and is found approximately 3 miles downstream of the SH 6 crossing. Station 2 was established about 1.0 river mile downstream of Station 1 near RM 154 at the Flatlands Crossing located on private property. Station 3 is located at RM 143 approximately 11 river miles downstream of Station 2 and adjacent with the Hendrick Ranch Boys Home property. Station 4 is located at a remote river crossing near RM 129 approximately 4.7 river miles downstream of Station 3 and approximately 1.1 river miles downstream of the proposed dam location. The station 5 reach is located at RM 125 both upstream and downstream of the river

crossing near the Krooked River Ranch headquarters. The river habitat quality observed at every location was very similar and can generally be characterized as shallow, fast flowing areas and slower, deeper pool areas.

The resulting habitat quality metric score after summation of the habitat data taken for each site investigated indicated a predominately High aquatic habitat rating. No significant habitat changes were noted between each location other than slight differences in stream wetted width and depth measurements. High water marks, sediment-stained vegetation on the banks and the lack of in-stream woody debris accumulation indicate that the river carries a high volume of runoff during storm events.

Table 6-4 presents a checklist of the benthic macroinvertebrate assemblages collected by station during the four survey periods. A total of 4,188 individuals representing 64 taxa were collected and identified to the lowest practical taxonomic level, using standard taxonomic references (Appendix H). Based on the 12-parameter evaluation developed by TCEQ, 16 of the 18 samples collected reflected a predominately High overall aquatic life use rating (Table 6-5). The samples typically had high diversity, a balanced trophic structure, and a community suggestive of a complex and healthy ecosystem.

A standardized adjustment was made in the collection of fish from sample collection guidance found on Page 3-2 in Chapter 3 (Freshwater Fish) of the 2007 Surface Water Quality Monitoring (SWQM) Procedures Manual, Volume 2.[81] Previously recorded high water conductivities dictated the increased number of seine hauls to compensate for the fact that a backpack electroshock unit was deemed unrealistic in terms of overall efficiency and safety and access to a tow-barge system was unavailable. Substrate size, depth, and reduced visibility of the aquatic habitats observed at every sampling location were identified as contributory sources of sampling bias as these factors somewhat limited the effectiveness of the seine and presented valid safety concerns for backpack electroshocking. Although the rocky nature of the wade-able areas within the designated sample zone (usually 500 m in length) made seining difficult, the sampling procedures, level of effort expended, and the types of habitat samples were all consistent between sampling locations and survey periods for comparison of species abundance and composition.

[81] Texas Commission on Environmental Quality (TCEQ). 2007. *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data.* Document No. RG-416. Monitoring Operations Division, Texas Commission on Environmental Quality, Austin, Texas.

Table 6-4
Checklist of Benthic Macroinvertebrates Collected by Kick Net
2009 and 2010

TAXA				Clear Fork Station				
Phylum	**Class**	**Order**	**Genus**	**1**	**2**	**3**	**4**	**5**
Platyhelminthes	Turbellaria	Tricladida	*Dugesia*	✓	✓	✓	✓	✓
Mollusca	Bivalvia	Veneroida	*Corbicula fluminae*	✓	✓	✓	✓	
			Musculium	✓	✓	✓	✓	✓
			Eupera cubensis	✓	✓	✓		
	Gastropoda	Basommatophora	*Physa/Physella*	✓	✓	✓	✓	✓
		Limnophila	*Gyraulus*			✓		
Annelida	Oligochaeta		Oligochaeta	✓		✓	✓	✓
	Hirudinea		Hirudinea	✓	✓	✓	✓	✓
	Insecta	Diptera	Chironomidae	✓	✓	✓	✓	
			Sciomyzidae			✓		
			Bezzia		✓			
			Culicoides	✓				
			Simulium		✓		✓	✓
			Euparyphus			✓		
			Tabanus				✓	✓
		Coleoptera	*Stenelmis*	✓	✓	✓	✓	✓
			Dubiraphia	✓	✓	✓	✓	✓
			Hexacylloepus	✓	✓		✓	✓
			Coptotomus	✓				
			Hydroporus			✓		
			Helichus	✓	✓	✓	✓	✓
			Gyretes	✓	✓			✓
			Helophorus	✓		✓		
			Berosus	✓	✓	✓	✓	✓
			Hydrochus		✓		✓	
			Tropisternus	✓		✓	✓	
			Peltodytes	✓	✓	✓	✓	
			Scirtes	✓	✓	✓	✓	✓
			Laccophilus	✓	✓	✓	✓	✓
		Lepidoptera	*Petrophila*	✓	✓			✓
		Ephemeroptera	*Callibaetis*				✓	
			Camelobaetidius	✓				
			Fallceon quilleri	✓	✓	✓	✓	✓
			Stenonema	✓	✓	✓		✓
			Isonychia	✓	✓	✓		✓

Table 6-4
Checklist of Benthic Macroinvertebrates Collected by Kick Net
2009 and 2010 (Concluded)

TAXA				Clear Fork Station				
Phylum	**Class**	**Order**	**Genus**	**1**	**2**	**3**	**4**	**5**
Arthropoda (cont.)	Insecta (cont.)	Ephemeroptera (cont.)	*Tricorythodes*	✓	✓	✓	✓	✓
			Neochoroterpes	✓	✓	✓	✓	✓
			Caenis	✓	✓	✓	✓	✓
		Hemiptera	*Trichocorixa*	✓	✓	✓	✓	✓
			Metrobates				✓	
			Rheumatobates		✓			
			Trepobates		✓		✓	✓
			Belostoma	✓		✓	✓	
			Ranatra	✓	✓	✓		
			Rhagovelia	✓	✓	✓	✓	✓
			Pelocoris	✓				
		Odonata	*Erpetogomphus*	✓	✓	✓	✓	✓
			Dromogomphus	✓			✓	
			Phyllogomphoides	✓	✓		✓	
			Macromia	✓	✓		✓	
			Argia	✓	✓	✓	✓	✓
			Enallagma	✓	✓	✓	✓	
			Haeterina	✓	✓	✓	✓	✓
		Trichoptera	*Helicopsyche*	✓				
			Cheumatopsyche	✓	✓	✓	✓	✓
			Hydropsyche	✓	✓	✓	✓	✓
			Hydroptila			✓	✓	✓
			Nectopsyche	✓	✓	✓	✓	✓
			Oecetis	✓	✓	✓	✓	✓
			Chimarra			✓	✓	✓
	Malacostraca	Amphipoda	*Hyalella*	✓	✓	✓	✓	✓
		Decapoda	Cambaridae	✓	✓		✓	✓
			Palaemonetes	✓	✓	✓	✓	✓
	Hydracarina (acari)		*Hydracarina*				✓	

Table 6-5.
Metrics and Scoring Criteria for Benthic Macroinvertebrate Kick Net Samples
2009 and 2010 Index and Critical Periods[1]

Metric	Clear Fork Brazos River - 2009																			
	Station 1				Station 2				Station 3				Station 4				Station 5			
	Index		Critical		Index		Critical		Index		Critical		Index		Critical		Index		Critical	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
1. Taxa Richness	31	4	29	4	24	4	29	4	24	4	27	4	26	4	33	4	17	3	28	4
2. EPT Taxa Abundance	7	3	11	4	5	2	8	3	7	3	9	3	9	3	10	4	7	3	11	4
3. Hilsenhof Biotic Index	5.7	1	5.1	2	6.1	1	5.5	1	6.1	1	6.0	1	6.1	1	5.6	1	5.9	1	5.6	1
4. Percent Chironomidae	2.9	4	8.5	2	1.8	4	6.9	3	0.6	1	4.5	3	2.5	4	4.43	3	5.4	3	4.4	3
5. Percent Dominant Taxa	20.1	4	18.6	4	18.4	4	23.2	3	40.5	1	19.8	4	27.2	3	11.4	4	28.7	3	19.5	4
6. Percent Dominant Functional Feeding Group	46.5	2	39.5	3	49.2	2	48.4	2	36.6	3	37.9	3	43.2	3	30.1	4	45.7	2	37.3	3
7. Percent Predators	19.5	3	17.6	3	15.4	3	17.5	3	20.4	3	22.3	3	27.8	2	19.7	3	12.3	4	15.3	3
8. Percentage of individuals as piscivores	0.7	1	1.2	1	0.52	1	0.9	1	0.3	1	0.4	1	0.4	1	0.6	1	0.4	1	0.6	1
9. Ratio of Intolerant to Tolerant Species	25.0	4	80.7	1	58.3	2	60.9	2	42.3	3	88.2	1	58.8	2	45.9	3	89.8	1	78.1	1
10. Number of Non-Insect Taxa	7	4	4	3	6	4	5	3	6	4	7	4	5	3	9	4	4	3	4	3
11. Percent Collector-Gatherers	46.5	1	39.5	2	49.2	1	48.4	1	36.6	2	37.9	2	43.2	1	30.1	3	21.3	3	37.3	2
12. Percent of Total Number as Elmidae	15.8	3	8.1	4	18.4	3	10.7	3	40.5	1	13.6	3	27.2	2	11.8	3	28.7	2	21.7	2
Total Score	34		33		31		29		27		32		29		37		29		31	
*Aquatic Life Use**	High		High		High		High		Intermediate		High		High		Exceptional		High		High	

[1]Index Period (15-17 June 2009 and 5-7 May 2010); Critical Period (10-12 August 2009 and 19-21 July 2010)
*Exceptional >36; High (29-36) Intermediate (22-28); Limited (< 22)

Table 6-5.
Metrics and Scoring Criteria for Benthic Macroinvertebrate Kick Net Samples
2009 and 2010 Index and Critical Periods[1] (Concluded)

Metric	Clear Fork Brazos River - 2010																			
	Station 1				Station 2				Station 3				Station 4				Station 5			
	Index		Critical		Index		Critical		Index		Critical		Index		Critical		Index		Critical	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
1. Taxa Richness	37	4	--	--	33	4	--	--	23	4	29	4	27	4	22	4	19	3	24	4
2. EPT Taxa Abundance	9	3	--	--	9	3	--	--	6	2	8	3	6	2	7	3	4	2	8	3
3. Hilsenhof Biotic Index	5.6	1	--	--	5.6	1	--	--	6.2	1	6.1	1	6.2	1	5.9	1	6.3	1	5.6	1
4. Percent Chironomidae	8.5	3	--	--	11.7	2	--	--	7.7	3	8.9	3	7.7	3	0.0	1	7.8	3	1.2	4
5. Percent Dominant Taxa	13.7	4	--	--	11.7	4	--	--	15.7	4	17.1	4	19.2	4	22.0	4	27.9	3	31.4	2
6. Percent Dominant Functional Feeding Group	46.0	2	--	--	48.6	2	--	--	35.1	4	39.9	3	36.3	4	36.2	4	32.6	4	44.1	3
7. Percent Predators	19.6	3	--	--	18.7	3	--	--	17.4	3	39.9	1	16.7	3	31.6	2	12.4	4	18.1	3
8. Percentage of individuals as piscivores	0.7	1	--	--	0.9	1	--	--	0.2	1	0.3	1	0.3	1	0.3	1	0.6	1	0.3	1
9. Ratio of Intolerant to Tolerant Species	33.3	2	--	--	41.2	2	--	--	89.6	1	79.3	1	69.2	2	69.0	2	0.0	4	79.3	1
10. Number of Non-Insect Taxa	10	4	--	--	8	4	--	--	7	4	9	4	8	4	7	4	7	4	5	3
11. Percent Collector-Gatherers	46.0	1	--	--	48.6	1	--	--	35.1	2	21.9	3	36.3	2	22.5	3	29.3	3	23.1	3
12. Percent of Total Number as Elmidae	15.1	3	--	--	7.5	4	--	--	16.5	3	13.5	3	19.9	3	14.7	3	10.7	3	20.3	2
Total Score	31		NOT		31		NOT		32		31		33		32		35		30	
*Aquatic Life Use**	High		Assessed		High		Assessed		High		High		High		High		High		High	

[1]Index Period (15-17 June 2009 and 5-7 May 2010). Critical Period (10-12 August 2009 and 19-21 July 2010).
*Exceptional >36); High (29-36); Intermediate (22-28); Limited (< 22).

A total of 52,499 individuals of fish represented by 9 families and 21 species were collected during the four sampling events (Appendix H). Table 6-6 presents a checklist of fish species collected during this study. Approximately 57 percent of the 37 documented species in the Clear Fork watershed were captured.[82,83,84] The red shiner, ubiquitous in all habitats at every sampling location, comprised slightly over 79 percent of the fish caught, represented by 41,752 individuals. Application of the regionalized fish-based index of biotic integrity (IBI) scoring and evaluation criteria (Linam et al. 2002) is presented in Table 6-7. The aquatic life use scores calculated for the fish communities based on seine data only reflect the characteristics typical of Intermediate to High Intermediate quality stream habitat. These scores generally were 2 to 4 points lower than the designated High aquatic life use subcategory (41-48) assigned to Segment 1232. Since the results of the fish assemblages suggest non-support of the designated condition category, State biologists from TCEQ and TPWD were contacted for guidance in assessment of the ALU category by establishing an interval around the unadjusted IBI scores with the coefficient of variation (CV=standard deviation/mean) developed by TPWD for Ecoregions 27, 29, and 32.[85] The adjusted scoring was significant, resulting in elevated individual station IBI scores to the High Intermediate and High subcategory. The average coefficient of variation for the 18 sampling events represented by seine-only was slightly over 3 percent for the regionalized IBI. This value is less than the 6.4 percent ecoregion CV, thus indicating field collections were

[82] Wilcox, J. Undated. *Basic Survey and Inventory of Species as Well as Their Distribution in the Clear Fork of the Brazos River in Region 3-B, Texas,* April 16, 1958 – March 31, 1960. Dingell-Johnson Project F-5-R-7, Texas Parks and Wildlife Department, Austin, Texas.

[83] Moss, R. W., and K. B. Mayes. 1993. Current status of *Notropis buccula* and *Notropis oxyrhynchus* in Texas. River studies report 8. Texas Parks and Wildlife Department, Austin.

[84] Texas Parks and Wildlife Department (TPWD). 1985. Job A: Existing reservoir and stream management recommendations. Federal Aid Project F-30-R-10, Lake Stamford, 1984. Statewide fishery management recommendations, District 1-B. Texas Parks and Wildlife Department, Inland Fisheries Department, Abilene, Texas.

———. 1988. Existing reservoir and stream management recommendations. Federal Aid Project F-30-R-13, Fort Phantom Hill

Reservoir, 1987. Statewide fishery management recommendations, District 1-B. Texas Parks and Wildlife Department, Inland Fisheries Department, Abilene, Texas.

———. 1994a. Statewide freshwater fisheries monitoring and management program. Federal Aid Project F-30-R0. Survey report for Abilene Reservoir, 1993. Texas Parks and Wildlife Department, Inland Fisheries Division, District 1-B, Abilene, Texas.

———. 1994b. Statewide freshwater fisheries monitoring and management program. Federal Aid Project F-30-R0. Survey report for Hubbard Creek Reservoir, 1993. Texas Parks and Wildlife Department, Inland Fisheries Division, District 1-B, Abilene, Texas.

[85] TCEQ. DRAFT 2010 guidance for assessing and reporting surface water quality in Texas (June 6, 2009). In compliance with Section 305(b) and 303(d) of the Federal Clean Water Act. Texas Commission on Environmental Quality, Austin.

consistently conducted and the fish assemblage was very stable over this collection period (Appendix H, Section H.3.3.3.5).

Table 6-6.
A Checklist of Fish Species Collected by Seine at Five Stations
2009–2010

Scientific Name	*Common Name*
Lepisosteus oculatus	Spotted gar
Lepisosteus osseus	Longnose gar
Dorosoma cepedianum	Gizzard shad
Cyprinella lutrensis	Red shiner
Cyprinus carpio	Common carp
Notropis buchanani	Ghost shiner
Pimephales vigilax	Bullhead minnow
Carpiodes carpio	River carpsucker
Ictalurus punctatus	Channel catfish
Pylodictis olivaris	Flathead catfish
Gambusia affinis	Western mosquitofish
Menidia beryllina	Inland silverside
Lepomis cyanellus	Green sunfish
Lepomis gulosus	Warmouth
Lepomis humilis	Orangespotted sunfish
Lepomis macrochirus	Bluegill
Lepomis megalotis	Longear sunfish
Lepomis microlophus	Redear sunfish
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
Aplodinotus grunniens	Freshwater drum

Table 6-7.
Metrics and Scoring Criteria for Fish Samples Based On Ecoregions 27, 29, and 32 Criteria 2009-2010 Index and Critical Periods[1]

Metric	Clear Fork Brazos River - 2009																			
	Station 1				Station 2				Station 3				Station 4				Station 5			
	Index		Critical		Index		Critical		Index		Critical		Index		Critical		Index		Critical	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
1. Total number of fish species	13	3	13	3	11	3	13	3	13	3	11	3	11	3	12	3	12	3	9	3
2. Number of native cyprinid species	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3
3. Number of benthic invertivore species	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
4. Number of sunfish species	3	3	3	3	3	3	4	5	4	5	3	3	3	3	6	5	4	5	3	3
5. Percentage of individuals as tolerant species[2]	86.7	1	93.7	1	91.3	1	32.5	3	95.3	1	68.3	1	97.4	1	79.7	1	91.6	1	51.4	1
6. Percentage of individuals as omnivores	0.4	5	3.7	5	6.2	5	1.1	5	0.4	5	0.1	5	0.4	5	0.1	5	2.0	5	0.1	5
7. Percentage of individuals as invertivores	99.2	5	96.0	5	93.4	5	98.7	5	99.3	5	99.8	5	99.3	5	99.3	5	98.0	5	99.8	5
8. Percentage of individuals as piscivores	0.5	1	0.3	1	0.4	1	0.3	1	0.3	1	0.1	1	0.3	1	0.6	1	0.0	1	0.1	1
9. Number of individuals in sample	1686	--	2270	--	1767	--	3482	--	4658	--	3018	--	3562	--	2656	--	6264	--	5455	--
9a. Number of individuals/seine haul	112	5	151	5	118	5	232	5	311	5	201	5	238	5	177	5	418	5	364	5
9b. Number of individuals/min electrofishing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. Percentage of individuals as Non-native species	0.1	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5
11. Percentage of individuals with disease anomalies	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5
Total Score	37		37		37		41		39		37		37		39		39		37	
Aquatic Life Use*	Intermediate		Intermediate		Intermediate		High		Intermediate		Intermediate		Intermediate		Intermediate		Intermediate		Intermediate	

[1]Index Period (15-17 June 2009 and 5-7 May 2010), Critical Period (10-12 August 2009 and 19-21 July 2010). [2]Excluding western mosquitofish
*Exceptional (≥48), High (41-48), Intermediate (35-40), Limited (< 35)

Table 6-7.
Metrics and Scoring Criteria for Fish Samples Based On Ecoregions 27, 29, and 32 Criteria 2009-2010 Index and Critical Periods[1] (Concluded)

Metric	Clear Fork Brazos River - 2010																			
	Station 1				Station 2				Station 3				Station 4				Station 5			
	Index		Critical		Index		Critical		Index		Critical		Index		Critical		Index		Critical	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
1. Total number of fish species	12	3	--	--	11	3	--	--	10	3	12	3	10	3	11	3	10	3	12	3
2. Number of native cyprinid species	3	3	--	--	3	3	--	--	3	3	3	3	2	3	3	3	3	3	3	3
3. Number of benthic invertivore species	0	1	--	--	0	1	--	--	0	1	0	1	0	1	0	1	0	1	0	1
4. Number of sunfish species	3	3	--	--	4	5	--	--	3	3	3	3	3	3	3	3	4	5	4	5
5. Percentage of individuals as tolerant species[2]	87.2	1	--	--	80.3	1	--	--	96.4	1	61.9	1	96.4	1	98.9	1	94.0	1	88.4	1
6. Percentage of individuals as omnivores	0.4	5	--	--	0.1	5	--	--	0.1	5	0.5	5	0.1	5	3.3	5	0.1	5	1.1	5
7. Percentage of individuals as invertivores	99.2	5	--	--	99.6	5	--	--	99.7	5	99.2	5	98.6	5	95.9	5	99.3	5	98.8	5
8. Percentage of individuals as piscivores	0.3	1	--	--	0.3	1	--	--	0.2	1	0.4	1	1.2	1	0.8	1	0.6	1	0.2	1
9. Number of individuals in sample	1831	--	--	--	1347	--	--	--	3665	--	2149	--	2069	--	1384	--	2588	--	2648	--
9a. Number of individuals/seine haul	122	5	--	--	90.0	5	--	--	244	5	195	5	138	5	138	5	173	5	265	5
9b. Number of individuals/min electrofishing	N/A	N/A	--	--	N/A	N/A	--	--	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. Percentage of individuals as Non-native species	0.2	5	--	--	0.0	5	--	--	0.0	5	0.0	5	0.1	5	0.1	5	0.0	5	0.0	5
11. Percentage of individuals with disease anomalies	0.0	5	--	--	0.0	5	--	--	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5
Total Score	37		NOT		39		NOT		37		37		37		37		39		39	
Aquatic Life Use*	Intermediate		ASSESSED		Intermediate		ASSESSED		Intermediate		Intermediate		Intermediate		Intermediate		Intermediate		Intermediate	

[1]Index Period (15-17 June 2009 and 5-7 May 2010); Critical Period (10-12 August 2009 and 19-21 July 2010). [2]Excluding western mosquitofish
*Exceptional (≥48), High (41-48), Intermediate (35-40), Limited (< 35)

6.7.4.1.2 Freshwater Mussel Monitoring

Concern for the status of freshwater mussels in the U.S. originates from the belief that they may represent the most threatened and rapidly declining group of freshwater organisms in North America. Mussels are sensitive to environmental disturbance and consequently serve as an indicator of aquatic ecosystem health. Freshwater riverine mussels are generally found in relatively stable areas not significantly impacted by flood events. Preferred habitat areas include free-flowing rivers and streams with stable bed substrates of mud, sand, and gravel.

While knowledge of mussel populations is limited within the Clear Fork watershed system, this information is necessary for assessing the potential direct and indirect impacts of Cedar Ridge Reservoir on resident mussel communities, if present, in this region. To date, four mussel surveys have been conducted in various levels of examination to collect data on mussel distribution, abundance, and habitat utilization within the section of river that will be directly or indirectly impacted by the proposed project with emphasis on the smooth pimpleback and Texas fawnsfoot.

In March 2009, a preliminary qualitative presence/absence freshwater mussel survey was conducted during the initial project reconnaissance in anticipation of future regulatory protection. Mussel shell was collected from 37 shoreline areas starting at Round Valley and ending at the Perry Camp (Figure 6-8) and their locations were plotted.[86] Concurrent with the August 2009 ALM survey, a more thorough survey of the freshwater mussels within and downstream of the reservoir footprint was conducted by Robert Howells, a recognized expert on freshwater mussel species (Appendix I). Sites were examined by kayaking the river between the M1 and M4 crossings and by examination of the river up- and downstream from access points at Perry, Lodge, Picnic, and Boys Home crossings (Figure 6-8). No timed or area searches, quadrate samples, or transect surveys were deemed necessary during this survey due to a failure to locate living or very recently dead unionid mussels. While this segment of the Clear Fork was found to contain suitable habitat for freshwater mussels, no evidence was found to indicate that live specimens of either the Texas fawnsfoot or the smooth pimpleback currently inhabit the

[86] HDR Engineering, Inc. 2009. *Environmental Report for Cedar Ridge Reservoir for the City of Abilene.* Prepared for the City of Abilene and Enprotec / Hibbs and Todd. Prepared by HDR Engineering, Inc. September, 2009.

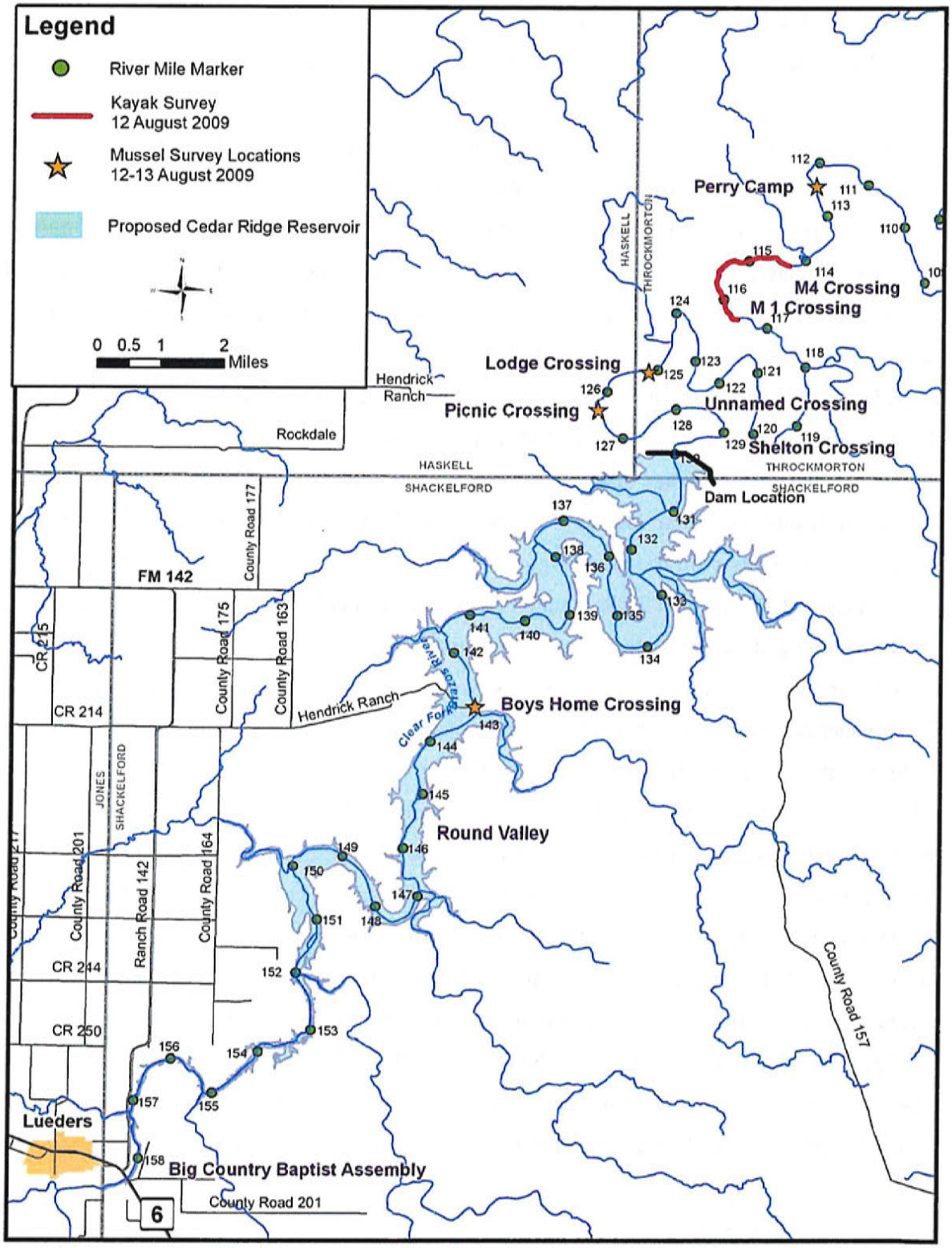


Figure 6-8. Freshwater Mussel Survey—August 2009

Clear Fork in the area to be affected by the reservoir.[87] Although acceptable mud, sand, and gravel mussel habitats were found, the presence of a black organic material in the substrate along with filamentous algal growth, and a general lack of living mussel species tolerant of stressful conditions (e.g. Asian clams) suggested challenges to freshwater mussel survival. The shell assemblages examined in 2009 were represented by species with neither federal nor state status.

In response to the TPWD state listings authorized in November 2009[88], two mussel surveys were conducted during 2010 to evaluate the abundance and distribution of unionid mussels in the Clear Fork in Haskell, Jones, Shackelford, Taylor, and Throckmorton counties (Appendix J). The July 2010 survey was conducted at numerous river crossings concurrent with the ALM survey with a concentration of effort in the main channel of the Clear Fork downstream of the proposed dam. After a reported TPWD discovery of a recently dead Texas fawnsfoot at Fort Griffin, the areal coverage of the second field effort conducted in October was expanded to include numerous collection locations in the Clear Fork watershed situated upstream and downstream of the reservoir footprint (Figure 6-9).

A total of 398 unionid shells, single valves, or identifiable fragments representative of 14 species including eleven live specimens were enumerated from 24 locations during the July and October surveys (Appendix J). Live mussels were found only at two locations. The one live fragile papershell (*Leptodea fragilis*) specimen found at the Baptist Assembly in July and ten living non-protected individuals collected at the Fort Griffin location in October 2010 were pulled from the water for identification and immediately returned carefully back (siphon end up) to the substrate alive. The shell assemblages collected during 2010 included the two threatened endemic species. A total of 16 (1 whole; 15 valves) Texas fawnsfoot were identified at four locations and 10 smooth pimpleback (10 valves) were recorded from five sites during 2010. However, the shell conditions for each species found in the vicinity of Cedar Ridge Reservoir ranged from relatively long dead to subfossil. A whole, relatively recently-dead Texas fawnsfoot was documented at Fort Griffin during the October 2010 survey. A single valve (or shell) of a long-dead Texas fawnsfoot was found in the spring of 2010 by HDR biologists approximately 48 river-miles downstream of the proposed project during a snake survey. Additionally, during the

[87] HDR Engineering, Inc. 2009. *Environmental Report for Cedar Ridge Reservoir for the City of Abilene.* Prepared for the City of Abilene and Enprotec / Hibbs and Todd. Prepared by HDR Engineering, Inc. September, 2009.
[88] TPWD. 2010. Commission Agenda Item No. 7 Action, Listing of Certain Mussel Species as State-Threatened, November 5, 2009. http://www.tpwd.state.tx.us/business/feedback/meetings/2010/1105/agenda/item_7/

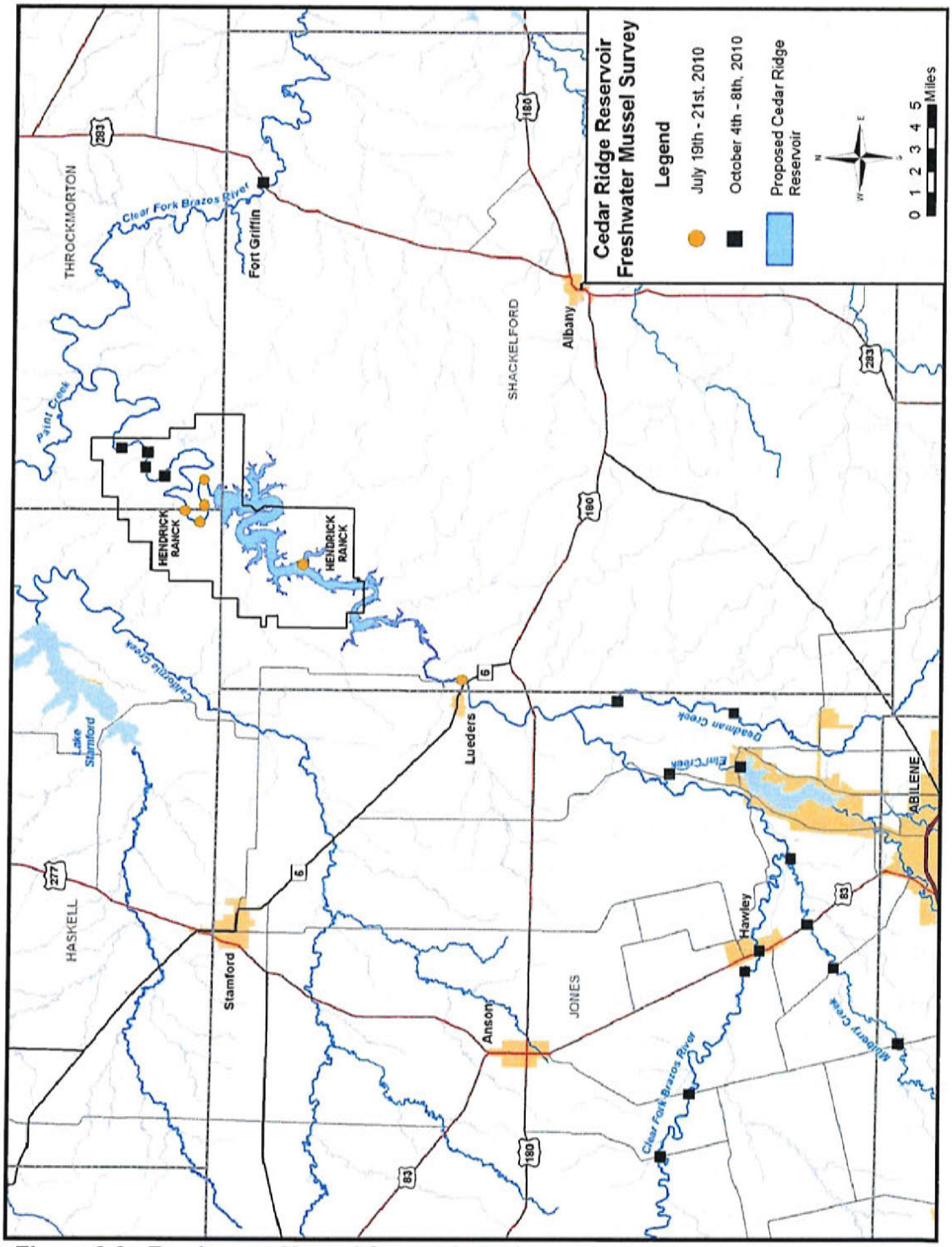


Figure 6-9. Freshwater Mussel Survey Locations, July and October 2010

spring 2011 survey, a live Texas fawnsfoot specimen was found near the Fort Griffin location. This record, in addition to other 2011 survey information is being compiled and will be provided as a supplemental report.

6.7.4.2 Potential Effects

Inundation will displace and eliminate about 307 acres of lotic habitat (280 acres of the Clear Fork and 27 acres of its tributaries) and create 6,635 acres of lentic habitat at a conservation pool level of 1,489 ft-msl.

6.7.4.2.1 Anticipated Impoundment Effects on Aquatic Biota

Impoundment of the Clear Fork following construction of the dam will cause both immediate and long-term changes in the benthic macroinvertebrate assemblage of this portion of the river. An immediate effect will be that most of the existing fauna will perish due to inundation of substrates and food sources. This would involve the direct loss of habitat and direct removal of benthic populations along the channel corridor. Aquatic insects have winged adult stages that allow for movement between stream sections and other water sources. Gradually, lentic-adapted invertebrates from nearby waters will colonize the reservoir.

Another effect of reservoir development would be to replace the existing stream fishery of the Clear Fork with a reservoir fishery. A number of important native sport fishes inhabit the Brazos River and the area lakes in the vicinity of the section of Clear Fork that is proposed for impoundment. These include three species of catfishes, several species of sunfishes, largemouth bass, black and white crappie, and white bass. Enhancement of the sport fishing of Lake Fort Phantom Hill, Hubbard Creek Reservoir, Lake Abilene, and Lake Stamford has been accomplished by TPWD through the stocking of fish, vegetation control, and fish harvest regulations based on lake survey results and recommendations. Predominant important sport fish found in the above reservoirs include the channel catfish, flathead catfish, largemouth bass, white crappie, several sunfish species (*Lepomis* spp.), white bass (*Morone chrysops*), and hybrid striped bass (*Morone saxatilis x chrysops*). Rough fish dominants include longnose gar (*Lepisosteus osseus*), spotted gar (*Lepisosteus oculatus*), gizzard shad (*Dorosoma cepedianum*), river carpsucker (*Carpiodes carpio*), and smallmouth buffalo (*Ictiobus bubalus*).[89]

[89] Texas Parks and Wildlife Department (TPWD). 1985. Job A: Existing reservoir and stream management recommendations. Federal Aid Project F-30-R-10, Lake Stamford, 1984. Statewide fishery management

Sampling of the river indicates that most fish species in the Clear Fork are tolerant or well adapted to reservoirs and are common to Lake Fort Phantom Hill, Hubbard Creek Reservoir, Lake Abilene, and Lake Stamford (Table 6-8). Fisheries surveys conducted by HDR in 2009 and 2010 found that 95 percent of the species residing in the creek were also inhabitants of nearby lake environments. Game fish production in the creek was found in relatively low numbers. While the proposed dam will restrict upstream migration by many species residing in the river, many of the 37 fish species documented in this watershed are generalists and can adapt to a wide range of habitat. Changes in the composition of the existing fish populations due to construction of Cedar Ridge Reservoir are predictable based on the long-term fisheries monitoring of Lake Fort Phantom Hill, Hubbard Creek Reservoir, Lake Abilene, and Lake Stamford. Initial reservoir development will favor game fish, including largemouth bass, but as the reservoir matures, the proportion of other fish (e.g., catfish and gar) will increase.

Exclusive of stocking programs, several fish species similar to those currently residing in the area lakes will eventually become dominant in the proposed Cedar Ridge Reservoir. The creation of new pool areas will provide new and more diverse habitats for species previously restricted to a few areas and expand territory for species such as the largemouth bass. Establishment of aquatic vegetation immediately after reservoir filling can encourage an increase in fish biomass. This vegetation will be colonized by a large, varied invertebrate assemblage, producing a source of food for fish and providing shelter from predators in addition to adequate reproductive habitats. The rise in the water level will inundate riffle areas and reduce the habitat for certain minnow species that inhabit these areas. Other factors such as increased competition, changes in predator-prey relationships, and stocking programs may play key roles in the success of the fish populations.

Two candidate species of fish petitioned for federal protection smalleye shiner and sharpnose shiner and two state-protected mussel species smooth pimpleback and Texas fawnsfoot-potentially occur in the Brazos River. Neither fish species was collected during the ALM surveys that have occurred to date. The likelihood of these cyprinid species inhabiting the Clear Fork is quite low due to the rocky nature of the riverine habitat that acts as natural barriers prohibiting major migration runs. Additionally, during both the 2010 and spring 2011 surveys, no living examples of smooth pimpleback or Texas fawnsfoot were found in the river from S.H. 6 to the northwest property boundary of the Hendrick Ranch (Appendix J). Only shells ranging from relatively long dead to subfossil conditions were gathered.

Table 6-8.
Comparison of Present Survey Fish Collection Results with Historical River Collections and Area Reservoir Assemblages

Scientific Name	Common Name	Present Study Area	Fort Phantom Hill	Hubbard Creek Reservoir	Lake Abilene	Lake Stamford
Lepisosteus oculatus	Spotted gar	✓	✓	✓		✓
Lepisosteus osseus	Longnose gar	✓	✓	✓		✓
Dorosoma cepedianum	Gizzard shad	✓	✓	✓	✓	✓
Dorosoma petenense	Threadfin shad		✓	✓	✓	✓
Cyprinella lutrensis	Red shiner	✓	✓			✓
Cyprinus carpio	Common carp	✓	✓	✓	✓	✓
Notemigonus crysoleucas	Golden shiner		✓			✓
Notropis buchanani	Ghost shiner	✓				
Notropis volucellus	Mimic shiner					
Pimephales promelas	Fathead minnow		✓			
Pimephales vigilax	Bullhead minnow	✓	✓			✓
Carpiodes carpio	River carpsucker	✓		✓	✓	✓
Ictiobus bubalus	Smallmouth buffalo		✓	✓		✓
Ameiurus melas	Black bullhead					
Ameiurus natalis	Yellow bullhead					
Ictalurus punctatus	Channel catfish	✓	✓	✓	✓	✓
Ictalurus furcatus	Blue catfish		✓	✓	✓	✓
Pylodictis olivaris	Flathead catfish	✓	✓	✓	✓	✓
Fundulus zebrinus	Plains killifish					
Fundulus notatus	Blackstripe topminnow					
Cyprinodon rubrofluviatilis	Red River pupfish					
Gambusia affinis	Western mosquitofish	✓	✓			
Menidia beryllina	Inland silverside	✓	✓	✓	✓	✓
Morone chrysops	White bass		✓	✓		
M. saxatilis x M. chrysops	Hybrid striped bass			✓	✓	✓
Lepomis cyanellus	Green sunfish	✓	✓	✓	✓	✓
Lepomis gulosus	Warmouth	✓	✓	✓	✓	✓
Lepomis humilis	Orangespotted sunfish	✓	✓	✓	✓	✓
Lepomis macrochirus	Bluegill	✓	✓	✓	✓	✓
Lepomis megalotis	Longear sunfish	✓	✓	✓	✓	✓
Lepomis microlophus	Redear sunfish	✓	✓	✓		✓
Micropterus salmoides	Largemouth bass	✓	✓	✓	✓	✓
Pomoxis annularis	White crappie	✓	✓	✓	✓	✓
Pomoxis nigromaculatus	Black crappie					
Percina caprodes	Logperch		✓			✓
Stizostedion vitreum	Walleye		✓			
Aplodinotus grunniens	Freshwater drum	✓	✓	✓	✓	✓

Source: Wilcox (undated)[90]; Moss and Mayes (1993)[91]; TPWD (1985; 1988; 1994a, 1994b)[92]

[90] Wilcox, J. Undated. *Basic Survey and Inventory of Species as Well as Their Distribution in the Clear Fork of the Brazos River in Region 3-B, Texas,* April 16, 1958 – March 31, 1960. Dingell-Johnson Project F-5-R-7, Texas Parks and Wildlife Department, Austin, Texas.

[91] Moss, R. W., and K. B. Mayes. 1993. Current status of *Notropis buccula* and *Notropis oxyrhynchus* in Texas. River studies report 8. Texas Parks and Wildlife Department, Austin.

[92] Texas Parks and Wildlife Department (TPWD). 1985. Job A: Existing reservoir and stream management recommendations. Federal Aid Project F-30-R-10, Lake Stamford, 1984. Statewide fishery management recommendations, District 1-B. Texas Parks and Wildlife Department, Inland Fisheries Department, Abilene, Texas.

———. 1988. Existing reservoir and stream management recommendations. Federal Aid Project F-30-R-13, Fort Phantom Hill Reservoir, 1987. Statewide fishery management recommendations, District 1-B. Texas Parks and Wildlife Department, Inland Fisheries Department, Abilene, Texas.

———. 1994a. Statewide freshwater fisheries monitoring and management program. Federal Aid Project F-30-R0. Survey report for Abilene Reservoir, 1993. Texas Parks and Wildlife Department, Inland Fisheries Division, District 1-B, Abilene, Texas.

———. 1994b. Statewide freshwater fisheries monitoring and management program. Federal Aid Project F-30-R0. Survey report for Hubbard Creek Reservoir, 1993. Texas Parks and Wildlife Department, Inland Fisheries Division, District 1-B, Abilene, Texas.

6.7.4.2.2 Downstream Effects on Aquatic Biota

Best management practices (BMPs) will be employed during and after construction in accordance with Sections 401 (Water Quality Certification) and 402 (Texas Pollutant Discharge Elimination System - Stormwater Permitting) of the Clean Water Act to minimize adverse effects from erosion and sedimentation during dam construction.[99] However, severe flood events during construction could present short-term sedimentation potential as the section of river immediately downstream of the principal spillway may receive fine sediment. Increased suspended sediment contributes to a decline in water quality by interfering with light transmission, reducing photosynthesis, decreasing plant growth, and carrying attached pollutants such as phosphorous. Such substrate conditions usually favor colonization by organisms having morphological adaptations such as a worm-type body as in the Chironomidae larvae (midges) and the Oligochaeta (aquatic worms) that are soft-bottom opportunistic animals adapted to the fine-grain size material.

If floods result in runoff conditions beyond the capacity of properly implemented construction BMPs, the temporary increase of suspended solids below Cedar Ridge could affect the fish populations downstream during construction activities. Currently, there is natural variation in turbidity within the Clear Fork, which is often very muddy due to the variability in stormwater runoff due to high flows.

The ecological benefits provided by the optimal volume and timing of environmental flow passes from the reservoir will be an important consideration in maintaining a healthy riverine environment in the Clear Fork downstream of the proposed dam. Stream flows affect the passage of migratory adults and juveniles, temperature, the amount of habitat available for fish and their prey, maintenance of riparian vegetation, maintenance of the river bank, and flushing flows. A preliminary in-stream flow requirement was developed using the HEFR methodology as initiated by the TPWD with input from other agencies and organizations. As described in Section 5, the HEFR-based methodology produces a multi-tiered set of seasonal flow recommendations consisting of subsistence, baseflows and high-flow pulses (HFP) using a statistical analysis of average daily flows for a long-term historical period. For this project, the HEFR recommendations served as the starting point for the development of seasonal in-stream

[99] TCEQ. 2010. Water Quality Permits and Registration. http://www.tceq.state.tx.us/nav/permits/water_qual.html (accessed December 13, 2010).

flow requirements and were only slightly modified (during wet conditions in August) by HDR biologists based on biological function associated with juvenile Brazos water snake activity.

The operation of the reservoir will temper periodic downstream flooding as flow regimes will be altered by the reduction in the total amount of water in the downstream reach by an amount equal to withdrawals from the reservoir and to the additional evaporation from the reservoir. To help mitigate for these anticipated reductions in flood flows, the HEFR-based methodology includes seasonal HFPs in an attempt to approximate pre-reservoir occurrences of flushing flows. HFPs for this project will vary as high as 421 cfs during wet-summer conditions and as low as 22 cfs during dry-fall conditions. The full range of HFPs, baseflows, and subsistence flows proposed for the Cedar Ridge Reservoir are more fully described in Section 5 and listed in Table 5-2.

To implement the HEFR-based environmental flow passes, the City has contracted with the USGS for the installation and operation of a continuous recording stream gage located near the SH 6 bridge near the town of Lueders. Daily stream flow is being recorded at this site to monitor the quantity of water inflow to the reservoir. This gage will provide average daily flow data which will be used on a daily basis to make decisions about daily flow passes from the reservoir as described in Section 5. Impacts to aquatic habitats downstream of the proposed dam will be mitigated, in part, by the periodic pass of HFPs which will serve to scour the river channel and help minimize the buildup of silt and stands of aquatic vegetation and will reduce impacts to the riffle fauna.

6.7.5 Water Quality

The Clean Water Act (CWA) was enacted to maintain and restore the chemical, physical, and biological integrity of waters of the U.S. Every 2 years, Texas must assess the quality of its water and submit a report to the EPA detailing the extent to which each water body in the state meets water quality standards. The TCEQ has combined the CWA 305(b) and 303(d) assessments into the Water Quality Inventory and 303(d) list. Water quality criteria have been designed to insure long-term protection of desired water uses. The Brazos River and large streams in Texas are required to meet Texas Surface Water Quality Standards. These standards include four general categories for water use including: contact recreation, aquatic life use, public water supply, and fish consumption. These standards require that water should be of sufficient quality to be used for their intended purposes.

6.7.5.1 Affected Environment

Water quality criteria include both numerical and narrative requirements necessary to protect designated uses such as swimming, drinking water, and the propagation and growth of aquatic life. The reach of the Clear Fork in the project area includes TCEQ-defined Segment 1232 of the Brazos River. Segment 1232 includes the Clear Fork from the confluence with the Brazos River in Young County to the most upstream crossing of U.S. 180 in Fisher County. Table 6-9 identifies the water uses and supporting numerical criteria for Segment 1232.

The primary water quality issue within the Brazos River Basin is the intrusion of natural salt in the main-stem occurring from brine springs in the northern portion of the basin and from the Gulf of Mexico in its most downstream reach. The primary sources of the natural salt pollution are principally in the watersheds of the Salt and Double Mountain Forks of the Brazos River. Elevated chlorides and total dissolved solids (TDS) periodically affect water usability along the entire main-stem. Natural salt pollution has been recognized as the most serious and widespread water quality problem in the Brazos River Basin.

Table 6-9.
Texas Surface Water Quality Standards

TCEQ Segment 1232 *Brazos River*	
Narrative Criteria	Contact Recreation
	High Aquatic Life
Numeric Standards	
Chloride (mg/L)	1,250
Sulfate (mg/L	2,200
Total Dissolved Solids (mg/L)	4,900
Dissolved Oxygen (mg/L)	5.0
pH Range (Standard Units)	6.5–9.0
Escherichia coli (#/100 ml)	126/100
Water Temperature	93° F (33.8° C)
Source: 30 TAC §307.10(1), Appendix A.	

The high salt content in the upper Brazos River is evident in the historical data. The downstream, middle, and upstream portions of Segment 1206 (Brazos River below Possum Kingdom Lake) is listed on TCEQ's 2008 Texas Water Quality Inventory and 303(d) List for chloride. However, public comments submitted during the TCEQ's draft 2008 Water Quality Inventory and 303(d) List comment period ending January 31, 2008, state that listing for

chlorides was inappropriate since natural salt conditions occur from the unique geologic features of the area that intensify during periods of drought. The TCEQ acknowledges that chloride inputs originate from natural sources and has recommended a review of the standard to address the natural concentrations of salt. Additionally, biological data assessed for the Brazos River segment indicated a concern for nonsupport of macroinvertebrate community habitat along the entire main-stem segment. Within the Brazos River Basin, a number of streams and stream segments are listed on TCEQ's 303(d) List due to various reasons, including low DO levels, high levels of bacteria, low and high pH, nutrients, total dissolved solids, chlorides, and sulfate.[100]

In Segment 1232, land use is predominantly agricultural and rangeland with only one major urban area (Abilene). This segment of the Clear Fork is not included on the 2008 List of Impaired Water Bodies for Texas (303(d) List) for any of the above parameters.[101]

The TCEQ 2008 305(b) assessment for Segment 1232 identifies concerns for nitrate, orthophosphorus, total phosphorus, chlorophyll a, and depressed dissolved oxygen (DO) levels in the unclassified tributaries to this river segment. A major tributary to the river is California Creek that flows through a dominantly rural area with no municipal discharges. California Creek (Segment 1232A) has been listed for nitrate and chlorophyll a concerns. Potential nonpoint contributors to nutrient enrichment in this stream include agricultural runoff and faulty on-site sewage facilities.[102]

Another water quality concern throughout the basin includes the potential lethal effects of golden algae (*Prymnesium parvum*) to the aquatic environment which have resulted in a number of significant fish kills. Conditions necessary for these algae-blooms are not yet clearly understood; however, research has indicated that this algal species is able to remain dormant in sediments until conditions are optimal for large increases in its population. The majority of golden algae fish kills have occurred during winter months when the water is cold, which is a period of the year not favorable for high production of the typical green algae. The TPWD is coordinating work efforts with university researchers, other state agencies, river authorities, and

[100] Brazos River Authority (BRA). 2009. *Brazos River basin highlights report 2009.* Brazos River Authority.
[101] Texas Commission on Environmental Quality (TCEQ). 2008. 2008 Texas water quality inventory and 303(d) list. http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/08twqi/twqi08.html
[102] Ibid.

interested parties to better understand and manage the potentially harmful golden algae in Texas.[103]

Moderate to abundant growth of filamentous algae (*Oedogonium* sp. and *Cladophora* sp.) was noted in all riffle areas during the 2009 site visits. Both are green algae (*Chlorophyceae*) genera that are common in streams and are relatively tolerant of hard water and nutrient enrichment. An algal die-off was observed in June 2009, but dense strands of new algal growth were encountered in the sample zone riffles during the August 2009 survey. Similarly, in 2010, riffle zones exhibited excessive filamentous algal growth during the May 2010 visit, but development was not as heavy on the substrate in July 2010. Algal grab samples taken in July 2010 from thick luxuriant filamentous mats observed in the flowing riffle areas of three ALM locations indicate a major source of organic material for consumers (e.g., insects and other invertebrates). The decomposition of abundant algal growths may temporarily deplete these shallow interstitial substrate areas of dissolved oxygen which could result in a temporary decline in habitat utilization by riffle-dwelling species. The algal community, which changes how light and nutrients are distributed in water, was dominated in 2010 by three green algae species (*Cosmarium* sp., *Oedogonium* sp., and *Protoderma* sp.), three blue-green algae species (*Oscillatoria* sp., *Schizothrix* sp., and *Spirulina* sp.), and several diatom species including *Nitzchia acicularis* (Table 6-10). The stream assemblages are consistent with moderate to high TDS water and characteristic of organic enrichment which suggests project impoundment of mesotrophic or eutrophic water.

[103] Texas Parks and Wildlife Department (TPWD). 2010f. Frequently asked questions about golden algae. Accessed from http://www.tpwd.state.tx.us/landwater/water/environconcerns/hab/ga/faq.phtml, September 3, 2010.

Table 6-10
A Checklist of Representative Algal Species
at Three River Locations
July 2010

Scientific Name
Cyanobacteria (blue-green)
Oscillatoria sp.
Schizothrix sp.
Spirulina sp.
Chlorophyta (green)
Cosmarium sp.
Oedogonium sp.
Protoderma sp.
Bacillariophyta (diatoms)
Cocconeis sp.
Encyonema sp.
Frustulia sp.
Gyrostigma sp.
Navicula sp.
Nitzchia sp.
Nitzchia acicularis

Ten historical water quality data sampling stations selected by TCEQ and the Brazos River Authority for monitoring purposes have been identified in the Clear Fork watershed in the general vicinity of the project area including four found on the main stem Clear Fork and one each positioned on three major tributaries in Jones, Haskell, and Stephens counties (Table 6-11; Figure 6-10).

Concurrent with the habitat/biological assessment efforts conducted in 2009 and 2010, instantaneous measurements of water temperature (°C), conductivity (µS/cm), DO (mg/L), pH, and Secchi depth (m) (i.e., a measure of water clarity) were recorded during the 2009 and 2010 surveys (Table 6-12). Cross-sectional flow measurements were also recorded to determine stream discharge in cfs.

Table 6-11.
TCEQ Designated Monitoring Stations in the Clear Fork Watershed

TCEQ Segment	*TCEQ Station ID*	*Monitoring Entity*	*TCEQ Site Description*
1232	11985	TCEQ Region 3	Clear Fork at Bridge on US 283 NE of Fort Griffin
1232	11992	BRA	Clear Fork at FM 600 near Nugent
1232	18765	TCEQ Region 3	Clear Fork at Hayford Crossing 2.07 km DS of Paint Creek Confluence
1232	18766	TCEQ Region 3	Clear Fork at Burkett Ben 1.41 km US of Paint Creek Confluence
1232A	11709	TCEQ Region 3	California Creek at FM 142 East of Stamford
1232B	11697	TCEQ Region 3	Deadman Creek at County Road 3 miles SE of Nugent
1233	12002	TCEQ Region 3	Hubbard Creek Reservoir near Dam
1233A	13640	TCEQ Region 3	Big Sandy Creek 600 ft. DS of Battle Creek, 1.6 miles US of FM 576, 9.8 miles SW of Breckenridge
1234	12005	TCEQ Region 3	Lake Cisco near FM 2807
1235	12006	TCEQ Region 3	Lake Stamford near Dam

Table 6-12.
Water Quality Parameters by Sampling Station
2009–2010

Station	*Date*	*Time*	*Water Temperature (°C)*	*Dissolved Oxygen (mg/L)*	*Percent Saturation (percent)*	*Conductivity (µS/cm)*	*pH (S.U.)*	*Secchi Depth (m)*
1 Hoggy Crossing	15 June	10:05	27.40	6.20	78.1	1488	8.30	0.15
	10 August	08:05	20.95	7.35	82.6	425	8.11	0.17
	6 May	10:08	22.60	9.60	112.8	2439	8.90	0.12
2 Flatland Crossing	15 June	15:55	29.20	8.00	105.4	1530	9.00	0.21
	10 August	12:43	29.70	17.80	234.5	1030	8.70	0.27
	6 May	14:06	23.60	14.30	169.6	2433	9.00	0.29
3 Boys Camp Crossing	16 June	10:35	28.40	7.90	102.3	1504	9.70	0.30
	11 August	10:33	29.70	6.90	91.5	709	8.80	0.41
	7 May	13:27	23.50	9.50	113.0	2170	9.00	0.29
	19 July	15:34	32.6	10.40	143.3	1283	9.10	0.20
	20 July	09:30	30.30	5.50	72.7	1286	8.50	0.29
4 Shelton Crossing	16 June	10:25	28.70	12.90	166.9	1408	10.50	0.39
	12 August	07:38	26.60	5.37	67.0	600	8.40	0.33
	7 May	08:08	22.20	7.90	91.6	1869	7.90	0.90
	20 July	15:10	32.3	8.50	117.6	1297	8.50	0.39
	21 July	08:43	29.6	6.00	79.4	1278	8.90	0.33
5 Krooked River Ranch Crossing	16 June	15:37	31.00	17.8	243.9	1358	10.80	0.20
	11 August	15:14	29.70	7.11	93.7	560	8.80	0.40
	5 May	18:44	23.70	14.00	166.7	1792	9.40	0.21
	19 July	14:40	32.60	10.70	147.7	1436	9.20	0.28
	20 July	17:55	32.80	10.90	151.7	1346	9.30	0.43
	21 July	10:50	30.63	6.90	--	1321	8.90	0.13

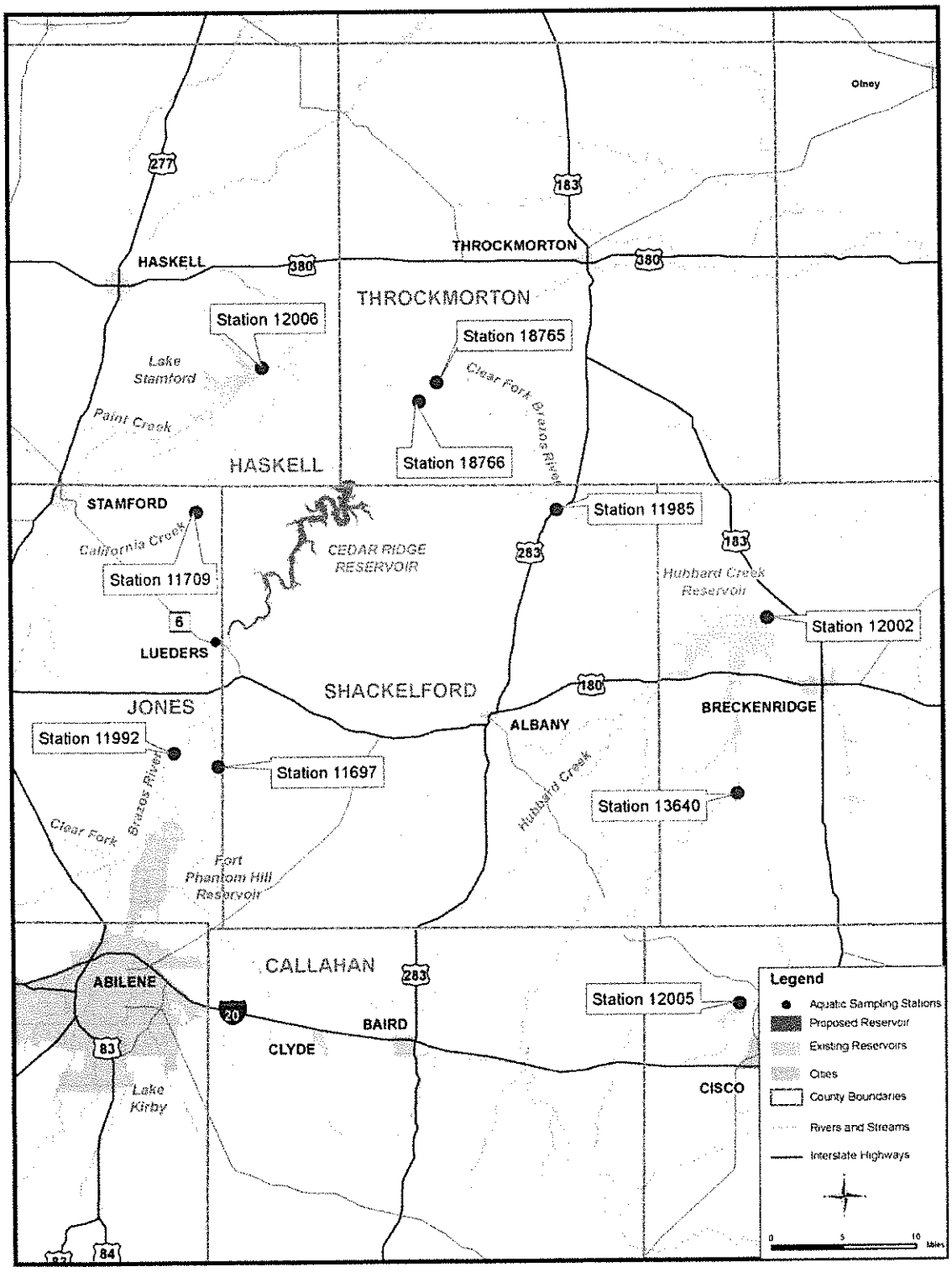


Figure 6-10. TCEQ Monitoring Stations Located in the Clear Fork Watershed

Temperatures recorded at the five biological monitoring stations during the index periods varied from a low of 27.4° C at Station 1 to 31.0° C at Station 5 in June 2009 and ranged from 22.2° C recorded at Station 4 to 23.7° C at Station 5 in May 2010. The critical period temperatures measured during 2009 and 2010 ranged from 20.9° C to 29.7° C in August 2009 and 29.6° C to 32.8° C in July 2010.

DO levels at the surface were above 5.0 mg/L at every location measured during the two year study period. DO levels were generally above saturation with most values in excess of 75 percent solubility. Recorded supersaturation levels (>100 percent) at all five locations suggest high levels of photosynthetic activity of algae suspended in the water column. Measurements of diurnal variations of temperature, DO concentrations, conductivity, and pH in the river were recorded at three locations during May and July 2010. Generally, DO concentrations were lowest from around 5 a.m. to 11 a.m., and highest from 1 p.m. to 7 p.m.

Conductivity measurement of a watershed is usually influenced by local geology or from anthropogenic activities (i.e., fertilizer runoff and wastewater discharges). The conductivity of water is directly linked to the concentration and mobility of dissolved ions and the ability to pass an electrical current. With the exception of the August 2009 survey, high water conductivities in excess 1250 µS/cm were recorded throughout the river. Conductivity measurements were much lower in August when values ranged from 425 µS/cm at Station 1 to 1030 µS/cm at Station 2. Although all surveys were preceded by thunderstorm activity, dilution by rainwater in the area was more pronounced during August 2009 that reduced the overall conductivity levels in the top 0.3 m of the water column in the river.

Seven values of pH were measured outside of the TCEQ standard pH range for Segment 1232 (6.5–9.0). Algal blooms have dramatic effects on pH values when sufficient light and nutrients are available. Photosynthesis can cause a depletion of DO in the water column during the night and a rise of pH during the daylight hours by removing carbon dioxide from the water. Secchi disc depth (transparency) averaged about 0.25 m (0.82 ft) during the June sampling period, 0.33 m (1.1 ft) in August, 0.36 m (1.2 ft) in May, and 0.29 m (0.95 ft) in July. The consistently low depth measurements recorded in the river are probably due to the high algal concentrations common at all locations and turbidity from suspended sediment. Because the spring of 2009 and the spring and summer of 2010 were unusually wet prior to sampling, streamflow in the river channel was swift and continuous. Total discharge (cfs) ranged from a low of 7.11 cfs in August 2009 at Station 3 to a high of 51.79 cfs at Station 5 in July 2010.

6.7.5.2 Potential Effects

6.7.5.2.1 *Anticipated Impoundment Effects on Water Quality*

A comparison of estimated chloride levels based on conditions with and without the reservoir was completed by HDR in 2008.[104] Figure 6-11 shows the frequency of occurrence of estimated chloride concentrations at the Nugent gage compared to the estimated chloride concentration in Cedar Ridge after impoundment. Because the reservoir will blend both baseflows and flood flows, the resulting chloride levels will be significantly less variable and will generally remain within the current secondary drinking water standard of 300 mg/L.

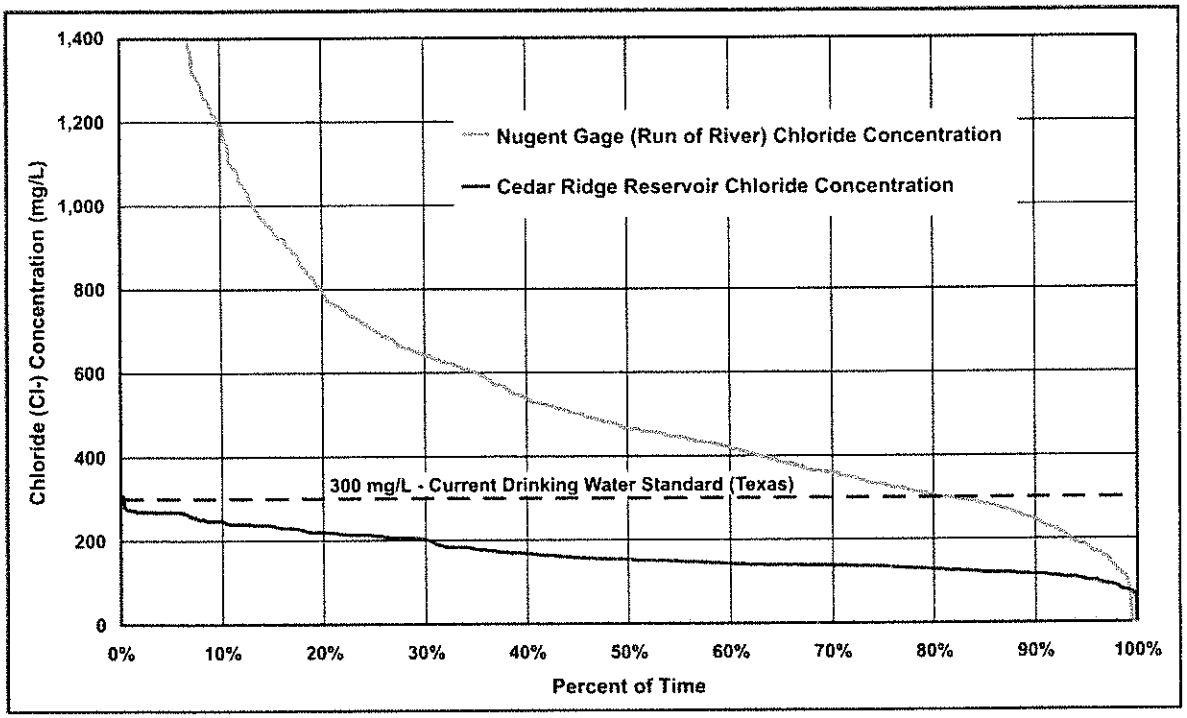


Figure 6-11. Comparison of Chloride Concentration at Nugent Gage and Cedar Ridge Reservoir

Stratification of lake water can decrease DO levels and affect aquatic biota through oxygen depletion in the hypolimnion. Oxygen depletion can also occur in the deeper parts of a reservoir through the decomposition of flooded vegetation during the initial inundation. A temporary increase may occur in turbidity and nutrient concentrations due to the leaching effects following initial inundation. Chemical contaminants such as the use of persistent agricultural

[104] HDR Engineering, Inc. 2008. Evaluation of Cedar Ridge Reservoir and Possum Kingdom Lake Water Supply Options for the City of Abilene.

pesticides can have a long-term effect on water quality. Excess dissolved nutrients introduced from wastewater discharges, agricultural fertilizer runoff, or manure leaching may impair water quality though increased nitrate and phosphorus concentrations producing eutrophication effects such as algal blooms. However, impoundment generally results in improved water quality conditions because particulate matter and bacteria tend to settle out in the quiet waters of the reservoir, and dissolved nutrient materials are removed by phytoplankton growth, which in turn is removed by sedimentation. Since the reservoir will be significantly deeper than the Clear Fork, it is anticipated that suspended sediment concentrations will be significantly lower than currently exist. This will result in reduced suspended sediment levels in the river reach downstream of the reservoir. There will also be an increased capacity with the reservoir to assimilate nutrients and contaminants due to the dilution effects of a larger water volume.

6.7.5.2.2 ***Downstream Effects on Water Quality***

Changes to the chemical and physical quality of the water of the Clear Fork after passing inflows from the Cedar Ridge Reservoir will be affected by ambient meteorological conditions, primary production and respiration from the aquatic environment, aeration from riffles, and inputs from other tributary sources. A concern of dam releases is the compliance of state water quality standards for water temperature and DO. Both parameters must be protective of downstream aquatic communities. Average water temperatures below the dam will potentially increase or decrease depending on the season and ambient air temperatures as water passed from the reservoir flows downstream. A change in water temperature can affect organisms that live or reproduce in the water. A decrease in water temperature may result in effects to the downstream warm-water fishery, impaired feeding, decreased growth rates, reduced resistance to disease and parasites, increased sensitivity to toxins, reduced ability to compete with more temperature-resistant species, and increased vulnerability to predation.

Water temperatures will also affect the concentrations of DO in water passed from the dam, and pH values will fluctuate daily as affected by photosynthesis. The most critical aspect of water quality is de-oxygenation. Oxygen depletion in the tailrace has the potential for fish mortality if not mitigated. A variation of 1.0 mg/L below the minimum DO standard of 3.0 mg/L for Segment 1232 is not allowed for more than 8 hours during any 24-hour period. DO levels are characteristic of a stratified reservoir where concentrations in the epilimnion are typically high, while little or no DO is present in the hypolimnion. Under well-mixed conditions, oxygen levels

are generally high throughout the water column. To help ensure that oxygen depleted water in the hypolimnion is not passed, a multi-level outlet tower will be installed at the dam so that water from the upper level of the reservoir's water column can be passed regardless of the reservoir level. Additionally, the outlet works' stilling basin will be constructed so that it will aerate the water as it is passed, further enhancing DO levels before entering the tailrace portion of the Clear Fork.

The runoff of nutrients including nitrogen and phosphorous, occur through point source and non-point source contributions that enrich the receiving water and can lead to undesirable consequences. The introduction of rich nutrient input stimulates growth of algae, diminishes light penetration, and results in lowered dissolved oxygen content. The Water Quality Management Plan for the Brazos River in 1978 attributed high pH measurements in Segment 1208 to influence from eutrophic conditions in the Clear Fork.[105] Over 30 years later, the abundance of mesotrophic and eutrophic algal taxa and high pH readings observed in 2010 still indicate influence from the availability of nutrients and the relative turbidity of the water. The reduced concentrations of these nutrients from those found in the inflows experienced by the proposed reservoir will indicate a positive effect by the impoundment on downstream water quality. The quality of the water downstream will probably be more influenced by the quality of water released from the reservoir and local sources than by the amounts released.

6.8 Cultural Resources

6.8.1 Affected Environment

Due to the potential impacts of the proposed Cedar Ridge Reservoir to cultural resources properties (i.e., archeological sites and historic area structures), initial Phase IA studies were planned and implemented to determine the appropriate inventory and evaluation strategies that would allow the proper assessment of potential impacts as required by state (Texas Antiquities Code) and federal laws and regulations (National Historic Preservation Act, Section 106). These investigations consisted of three tasks: (1) geoarchaeological reconnaissance work to characterize the nature of the landscape and to define the potential context of archeological deposits (surficial or buried) within different portions of the project area; (2) development of prehistoric and historic contexts to aid in the projection of the types of sites expected and their potential locations within the project area, as well as the identification of cultural resources as

[105] Brazos River Authority (BRA). 1978. Water Quality Management Plan for the Brazos River Basin.

potential historic properties (defined as resources eligible for inclusion in the National Register of Historic Places [NRHP]) or for designation as a State Archeological Landmark (SAL); and (3) creation of a predictive geographic information system (GIS) model to further aid in the location of potential prehistoric cultural resources within the project area. The initial field studies for the project were performed May 24–June 4, 2010.

6.8.1.1 Archeological (Pre-Historic) Resources

Previous studies of the alluvial stratigraphy of the upper Brazos[106,107,108] suggest that the first terrace of the Clear Fork may contain deep Holocene alluvium with buried archaeological sites. Field observations made during the initial field reconnaissance support this impression. Holocene alluvium beneath the first terrace of the Clear Fork of the Brazos is variable in thickness and approximately 9 meters thick in some areas, and buried archaeological sites were observed in the majority of examined exposures of this deposit.

The Texas Archeological Sites Atlas online database of the Texas Historical Commission (THC) was consulted, and background research was conducted to determine any previous cultural resources survey efforts as well as the locations of previously recorded historic and archaeological resources in the project area. Eight previously recorded prehistoric archaeological sites were located within a 1-mile (1.6-kilometer [km]) radius of the project area. No modern archaeological survey work has been carried out within the current project area, and the current status of the above-referenced sites is presently unknown.

Based on database information and field observation during the reconnaissance, the frequency of buried sites appears to be high, and it is anticipated that the project area could contain multiple buried sites. Archaeological sites are anticipated to be visible on the tread and scarps of Pleistocene age alluvial deposits, and trenching off the leading (stream side) of such terraces is one method by which buried prehistoric occupations may be discovered. The apparent high potential for buried sites suggests that systematic backhoe trenching will be necessary to evaluate a representative proportion of such sites in this area.

---

[106] Blum, M. D., J. T. Abbott, and S. Valastro, Jr. 1992. Evolution of Landscapes on the Double Mountain Fork of the Brazos River, West Texas: Implications of the Preservation and Visibility of the Archaeological Record. *Geoarchaeology* 7:339–370.

[107] Leighton, M. M., 1936. Geological Aspects of the Findings of Primitive Man near Abilene, Texas. Medallion Papers No. XXIV. Gila Pueblo, Globe Arizona.

[108] Mandel, R. D., 1992.Geomorphology. In *An Archeological Survey of the Proposed South Bend Reservoir Area: Young, Stephens and Throckmorton Counties, Texas*, edited by Joe W. Saunders, C. S. Mueller-Wille, and David L. Carlson, pp. 53–83.

In general, the predictive GIS model is intended to be used during preliminary Phase IA evaluations to determine the probability of an area to contain cultural deposits, and the appropriate survey methodologies to be used during Phase IB surveys. By identifying land features, it is possible to infer what areas will require subsurface testing for possible buried resources and which areas will only require surface inspection. The model does not identify the actual depths for possible resources, it only identifies areas where surface and subsurface testing is recommended.

The Phase IA reconnaissance and background investigations of the proposed Cedar Ridge Reservoir revealed data that support the survey strategies will be necessary to identify the archaeological cultural resources that may be affected by the proposed construction of the reservoir. The following paragraphs present additional recommendations concerning the inventory and evaluation processes needed to complete the investigations that will define the potential impacts of the proposed construction project on cultural resources.

A two-stage survey—geoarchaeological and archaeological—is proposed for the project area. The Phase IB survey and inventory of archaeological sites for Cedar Ridge Reservoir include the prehistoric context, in conjunction with the geoarchaeological reconnaissance, and indicates the landscape within the project area is variable, containing both Holocene and Pleistocene sediments having implications for the location and contextual integrity of archaeological sites. In order to recommend an appropriate cultural resources survey strategy, a more thorough understanding of the geology of the Clear Fork valley will be necessary.

During the geoarchaeological reconnaissance work within the project area, Pleistocene and Holocene alluvial deposits were encountered. Holocene alluvium beneath the first terrace of the Clear Fork is as much as 9 meters thick in some areas, and buried archaeological sites were observed at multiple of examined exposures of this deposit. It is anticipated that the project area will contain buried sites, some deep. Therefore, systematic deep trackhoe trenching will occur along the river in the project area within the deep Holocene sediments. Archaeological sites are also anticipated to be visible on the tread and scarps of Pleistocene age alluvial deposits, and trenching off the leading (stream side) of such terraces may be one method by which buried prehistoric occupations may be discovered. Once sites are detected in a given location, the immediately adjacent Holocene surfaces leading to the active stream channel will be trenched to assess whether multiple constructional surfaces were occupied at the same time. Trenches will

be excavated perpendicular to the stream channel to gain a better understanding of alluvial deposits and their associated geologic age.

The archaeological survey will be based on the geoarchaeological reconnaissance and GIS modeling. The project area has been subdivided into low-, medium-, and high-probability areas based on their likelihood of containing cultural materials. High-probability areas include the suspected upland Pleistocene alluvial and colluvial deposits as well as the deep Holocene deposits closer to the river channel. The upland Pleistocene surfaces are largely devoid of soil cover, and in those areas, a pedestrian survey is recommended along with shovel testing when soils are encountered. For the high-probability Holocene deposits of the valley floor, shovel testing at 30-meter intervals is recommended. Medium-probability areas are represented by surfaces with slopes ranging from 10 to 25 percent, and in these areas, shovel testing at 50-meter intervals is recommended. Highly sloped areas (exceeding 25 percent) are considered to be of low probability for containing archaeological materials, and as such, no work is recommended in these areas.

6.8.1.2 Historic-Age Resources

Resources evaluated for NRHP eligibility typically must be at least 50 years of age; however, to allow for a conservative evaluation of potential project impacts to historic structures and adequate time for the permitting and construction schedule, the condition of all structures constructed before 1980 was considered. Potential historic structures involved in the architectural evaluation of the project area are primarily located on the Hendrick property. However, a comparison of historic and modern aerials indicates a possibility for historic structures on the Swenson Ranch located in the southwest portion of the project area. Right-of-entry was not granted for the Swenson Ranch; therefore, this area was not evaluated for historic-age resources. However, this area should be surveyed in the future during the Phase IB survey efforts.

Potential historic-age resources found within the project area are located on five sites—three on the Hendrick property, one on the Dawson-Conway property and one to the south on SH 6. Land use of the sites on the Hendrick and Dawson-Conway properties is limited to ranching and recreational hunting. Structures include both domestic dwellings, agricultural outbuildings, and a low-head concrete dam. The fifth site is a bridge located on SH 6, which crosses the Clear

Fork. Review of the THC Atlas indicated no State Historical Markers (SHMs), Recorded Texas Historic Landmarks (RTHLs), or NRHP-listed properties occur within the project area.

In total, 29 resources located at five sites were recorded in the Cedar Ridge Reservoir project area. Twenty-seven (27) of the 29 resources are located on the Hendrick property. Twenty-four (24) of the resources on the Hendrick property evaluated during Phase IA are associated with the Hendrick River Ranch (formerly Boy's Home) and the nearby Foreman's House facilities. The Hendrick River Ranch, a satellite operation for the Hendrick Home for Children in Abilene is currently used for unrelated events and gatherings. The Hendrick River Ranch is important at the local level for its impact upon the social welfare of children in the area.

During preliminary coordination with the THC, the agency recommended these sites be considered for documentation as a historic district. Based on the evaluation conducted to date, 15 of the structures in the potential Hendrick River Ranch historic district are considered eligible for NRHP listing. While the other nine structures at the two sites are not considered individually eligible for NRHP listing, they are anticipated to be documented as contributing resources during mitigation activities.

Of the five remaining resources not associated with the Hendrick River Ranch and Foreman's House sites, the concrete dam and the SH 6 bridge structures are considered eligible for NRHP listing. The low-head concrete dam located on the Dawson-Conway property was constructed in the 1930s. Two resources (dwellings) located on the Hendrick property, but not associated with potential Hendrick River Ranch historic district, are not considered eligible for NRHP listing, while one historic-aged dwelling in a state of disrepair is currently undetermined in regard to potential NRHP eligibility and will require further research during Phase IB surveys.

In summary, of the 29 resource evaluated during Phase IA, 17 are considered potentially eligible for NRHP listing, 11 are not considered individually eligible for NRHP listing, and one is currently undetermined in regard to NRHP eligibility.

6.8.2 Potential Effects

6.8.2.1 Archeological (Pre-Historic) Resources

The inundation from the reservoir development may directly affect cultural resources at the dam location and indirectly affect sites below the conservation pool elevation. Although the extent and characteristics of the archeological sites are not yet known, it is anticipated that the Phase IB survey will be followed by further testing and data recovery activities. Appropriate

data recovery and curation recommendations will be made, in coordination with the state and federal agencies, to mitigate the potential adverse effects. For example, data recovery will be needed from sites located within or near the dam location and some portion of the shoreline that will be subject to damage of site integrity due to frequent wave action.

6.8.2.2 Historic-Age Resources

Of the 29 resources considered, one dwelling of historic age was found to have undetermined eligibility for listing in the NRHP; therefore, it is unknown if this resource would be adversely affected by the proposed project. Additional historic research and archaeological evaluation will be conducted in order to determine the NRHP eligibility of this resource. Eleven (11) resources were found not eligible for inclusion in the NRHP; therefore, the proposed project would have no effect on these sites. Seventeen (17) resources were found to be potentially eligible for NRHP inclusion. One of these resources, the SH 6 bridge, is located at the upstream end of the reservoir and will not be directly impacted by the proposed project; therefore, it will not be adversely affected. The remaining 16 resources are recommended as eligible for listing in the NRHP and will be impacted by the project because the structures would be inundated by the reservoir. The remaining 16 eligible resources include 15 structures associated with the potential Hendrick River Ranch historic district and the low-head concrete dam structure. Therefore, it is anticipated that Historic American Buildings Survey (HABS) Level III documentation will be required for these resources prior to reservoir construction.

Historic American Buildings Survey (HABS) documentation often serves as a means to mitigate historic properties that are to be altered or demolished. HABS documentation is administered by the National Park Service (NPS) and follows the Secretary of the Interior's Standards and Guidelines for Architectural and Engineering Documentation. Three basic levels of documentation exist, as listed below. If HABS documentation is not being submitted to the Library of Congress, 35mm or digital photographs (processed in accordance with NPS guidelines) frequently suffice for the photographic documentation.

- Documentation Level I:
  - Drawings: a full set of measured drawings depicting existing or historic conditions.
  - Photographs: photographs with large-format negatives of exterior and interior views; photocopies with large-format negatives of select existing drawings or historic views where available.
  - Written data: history and description.

- Documentation Level II:
  - Drawings: existing drawings, where available, will be photographed with large-format negatives or photographically reproduced on Mylar.
  - Photographs: photographs with large-format negatives of exterior and interior views, or historic views, where available.
  - Written data: history and description.

- Documentation Level III:
  - Drawings: sketch plan.
  - Photographs: photographs with large-format negatives of exterior and interior views.
  - Written data: architectural data form or history and description.

To mitigate anticipated adverse effects of the project on the 16 resources potentially eligible for NRHP listing, HABS Level III documentation for each eligible resource is recommended by the THC. HABS Level III documentation would include a narrative text and black-and-white, large format photography to be processed and printed in accordance with the archival standards set forth by the National Park Service for HABS documentation. If additional historic-aged resources are identified on properties not yet surveyed, the eligibility for NRHP listing will also be assessed.

Prior to initiating the steps for mitigating eligible properties that would be adversely affected by the proposed action, a formal memorandum of agreement (MOA) would be developed. The MOA would stipulate the terms for the mitigation measures as established through consultation with the Texas State Historic Preservation Officer (SHPO) and the party responsible for the action.

6.9 Economic Conditions

Cedar Ridge Reservoir will be located primarily in Shackelford County with small portions extending into Throckmorton and Haskell counties. Cedar Ridge Reservoir is being permitted by the City of Abilene to overcome a projected 2060 water supply deficit for the region of approximately 24,000 ac ft/year. The City will own and operate the reservoir. Socio-economic data for the region is included in Section 3.0 of this report.

The reservoir project will result in a short term beneficial economic effect in the region during the construction period. Additionally there will be long term beneficial effects to the population, businesses, and industry in the region through providing a sustainable source of water at a reasonable and predictable cost structure. The Cedar Ridge Reservoir project is not

anticipated to disproportionally impact any low income or minority populations. Existing landowners will be compensated for property or easements required for the project in accordance with state guidelines. No adverse economic impacts are anticipated from the project.

6.10 Land Use

6.10.1 Existing Conditions

The reservoir area is predominantly in a rural area with limited development. Residential use of the project vicinity is limited to scattered ranch houses. No cemeteries or parks are located within the project area. The 1997 National Resource Inventory (NRI) is the most recent inventory available through the Natural Resources Conservation Service (NRCS) for land use information in this region (NRCS 2000).[109] It shows how land uses in Shackelford, Throckmorton, and Haskell counties have changed from 1982 to 1997 (Table 6-13). In Shackelford County, the area in cultivation increased slightly from 1982 to 1997, while rangeland and urban land uses decreased slightly during the same time period. In Throckmorton County during this same period, land area in cultivation and pastureland decreased, while the acreage in rangeland increased. Cultivated areas and rangeland in Haskell County decreased, while pastureland and urban areas increased during the 1982 to 1997 time period.

Table 6-13.
Percentage of County Land Use in 1982 and 1997

County	Cultivation (%)		Pastureland (%)		Rangeland (%)		Urban (%)		Rural Transportation (%)	
	1982	1997	1982	1997	1982	1997	1982	1997	1982	1997
Shackelford County	4.8	5.4	1.7	1.7	91.6	90.8	0.5	0.2	0.9	0.9
Throckmorton County	16.6	15.0	3.6	0.2	78.3	83.2	0.2	0.2	0.8	0.8
Haskell County	59.7	51.9	0.8	2.5	35.2	34.7	1.0	1.5	1.4	1.4

1. Figures represent percentage of land used per total county acreage
2. Table includes only selected land use categories, therefore percentage totals do not equal 100

[109] Natural Resources Conservation Service (NRCS). 2000. Land Use Estimates by County for Texas. 1997 National Resources Inventory. U.S. Department of Agriculture. Washington D.C.

6.10.2 Potential Effects

The conservation pool includes an area of approximately 6,635 acres, and will be converted from agricultural, rangeland and hunting uses to a water supply reservoir with associated recreation and fishing uses. The anticipated effects to the land use and vegetated areas within the construction area and flood pool (2,268 acres), will be the removal of livestock from some areas which is anticipated to beneficially affect the native vegetation community. Due to the remote setting of the proposed reservoir and distance to major population centers, long-term effects to land use in the project vicinity are anticipated to be minor.

6.11 Hazardous Materials

The reservoir is located in rural areas of Shackelford, Throckmorton, and Haskell counties, and the potential to encounter hazardous materials is low. A review of Leaking Petroleum Storage Tanks (LPST) at TCEQ revealed no records of any LPSTs within the reservoir site. No federal or state-listed Superfund sites are present in Shackelford, Throckmorton, or Haskell counties. An All Appropriate Inquiry (AAI) conforming Initial Site Assessment would be conducted by the City prior to land acquisition. Small oil and gas wells and collector lines are common in the project vicinity, but a detailed inventory of those sites in relation to the project area has not been done. These facilities would be relocated or plugged in accordance with TCEQ and Railroad Commission of Texas guidelines prior to reservoir development. Based on currently available information, no adverse impacts to hazardous material sites or impacts to the project from hazardous material sites are anticipated.

6.12 Permitting and Regulatory Requirements

During the feasibility and alternatives analysis of the project, the Applicant hosted a field trip in August 2010 with state and federal Resource Agency staff to share project information, answer questions, gather information related to potential areas of concern, and discuss the anticipated permitting requirements. The construction of the Cedar Ridge Reservoir Project may require the following permits:

- TCEQ Water Right permit;
- Clean Water Act, Section 404 Permit from the U.S. Army Corps of Engineers (USACE) for discharge of dredge or fill material into wetlands and waters of the U.S. for dam construction and the permanent inundation of those waters;

- Clean Water Act, Section 401 Water Quality Certification administered by the TCEQ and coordinated concurrently with the Section 404 permit review process;
- Texas Antiquities Permit from the THC for the investigation, testing, and curation of cultural resources found within the project area;
- TCEQ-administered Texas Pollutant Discharge Elimination System (TPDES) Storm Water Pollution Prevention Plan for construction activities;
- General Land Office (GLO) Easement if state-owned land or water (streambed of the Clear Fork) is involved; and,
- TPWD Sand and Gravel permit for excavation of materials from state-owned streambed.

6.13 Summary of Potential Mitigation Actions

The following is a list of potential mitigation actions the Applicant is considering as discussed with Resource Agency staff during the August 2010 field trip. These actions would be further defined in the Applicant's mitigation plan as a part of the USACE's permitting process:

- A provision for environmental flows is included as part of the application. This provision includes pass-throughs of baseflow and periodic high flow pulses for environmental preservation/protection generally in accordance with the HEFR-based flow method (as previously discussed).
- To help manage temperature and DO levels of water passed from the reservoir (which has a maximum conservation pool water depth of about 124 feet near the dam), a multi-level outlet tower may be constructed so that water can be passed from the upper level of the reservoir with the most suitable water quality considering seasonal aquatic life needs.
- Additional rock habitat may be constructed in the Clear Fork channel downstream of the dam location to provide additional habitat for the Brazos water snake and increase benthic macroinvertebrate production and food availability to fish.
- BMPs will be included in the construction plans to minimize the suspended solids loading into the Clear Fork during construction activities.The City will comply with requirements of the Clean Water Act, Section 404 permit regarding mitigation for the project. Mitigation actions may include: (1) obtaining conservation easements from landowners along the Clear Fork downstream of the dam to protect the riparian corridor; (2) measures for shoreline protection in the reservoir; (3) restoration and/or enhancement of stream corridor(s) in the project vicinity which are degraded, or at risk of degradation, due to existing or adjacent land uses; (4) preservation and protection of riparian buffer habitat of selected tributaries to the Clear Fork and/or the reservoir; and (5) enhancement of riparian vegetation communities, including wetlands in the floodplain of the Clear Fork and/or its tributaries.
- The City will comply with the requirements of USACE (NHPA, Section 106) and THC (Texas Antiquities Code) for Cultural Resource investigations, recovery, curation of artifacts, and historical documentation of historic sites determined to be eligible for listing on the National Register of Historic Places.

6.14 Schedule of Environmental Studies and Resource Agency Coordination

A schedule of on-going and planned environmental studies through 2011 is shown in Figure 6-12. The initial Resource Agency site visit occurred on August 23 to 25, 2010, as noted on Figure 6-12.. Future resource agency site visits will be scheduled as needed.

Environmental Studies and Resource Agency Site Visit	*2009*				*2010*				*2011*			
	Qtr 1	*Qtr 2*	*Qtr 3*	*Qtr 4*	*Qtr 1*	*Qtr 2*	*Qtr 3*	*Qtr 4*	*Qtr 1*	*Qtr 2*	*Qtr 3*	*Qtr 4*
Initial Site Reconnaissance												
Aquatic Life Monitoring (ALM) and Mussel Surveys												
Brazos Water Snake Surveys												
Vegetation Mapping												
Delineation of Waters of the U.S.												
Phase I Cultural Resources Survey (Preliminary Site Identification)												
Phase II Cultural Resources Survey (Site Investigations)												
Resource Agency Site Visit												

Figure 6-12. Schedule for Environmental Studies and Resource Agency Site Visit

Section 7
No Harmful Impacts to Groundwater Resources

A review of maps of aquifer outcrops in the study area indicates that the Cedar Ridge Reservoir site is not located on an outcrop of any major or minor aquifer as defined by the TWDB. Consequently, groundwater will not be adversely affected by the project. Allowing the City to develop a significant surface water supply will reduce the need to utilize other sources of water, particularly groundwater, and may actually have a positive effect on groundwater resources by reducing groundwater consumption.

This page is intentionally left blank.

Appendices for the Supplemental Application, Engineering and Environmental Information Document for Cedar Ridge Reservoir

Prepared for:

City of Abilene, Texas

Prepared by:

HDR | ONE COMPANY *Many Solutions*℠

Texas Registered Engineering Firm F-754

and:

eHT Enprotec / Hibbs & Todd

Texas Registered Engineering Firm F-1151

July 2011

List of Appendices

A	Interlocal Agreement with the Brazos River Authority
B	Rainfall/Runoff Model
C	Brazos Water Availability Model Data (Provided on Compact Disc)
D	Photographs of the Project Area Channel and Bank Conditions Throughout the Study Reach
E	Vegetation Species Observed within the Proposed Cedar Ridge Reservoir Site along the Clear Fork of the Brazos River, 23-26 March 2009
F	Wildlife Habitat Appraisal Procedure (WHAP)
G	Brazos Water Snake
H	Aquatic Life Monitoring Data Report (Includes Attachments H1, H2, and H3) Attachment H1 – Stream Physical Characteristics Worksheets, Physical Characteristics of Water Body Worksheets, and Habitat Quality Index (HQI) Worksheets, 2009 and 2010. (Provided on Compact Disc) Attachment H2 – Photographs, Aquatic Life Monitoring Locations, 2009 and 2010 (Provided on Compact Disc) Attachment H3 – 24-Hour Monitoring at Three Locations May and July 2010
I	Freshwater Mussels of the Clear Fork Brazos River; Cedar Ridge Reservoir Project (2009 Report)
J	Cedar Ridge Reservoir Project, Freshwater Mussel Surveys (2010 Report)

This page is intentionally left blank.

Appendix A
Interlocal Agreement

Appendix A

INTERLOCAL AGREEMENT

This Interlocal Agreement ("Agreement") is made and entered into as of the date last executed below ("Effective Date") by and between: the BRAZOS RIVER AUTHORITY of Texas ("BRA"), a conservation and reclamation district created by the Texas Legislature pursuant to the provisions of Art. XVI, Section 59 of the Texas Constitution, acting by and through its Board of Directors and pursuant to a resolution duly passed and adopted by said Board of Directors; the CITY OF ABILENE, TEXAS (the "City"), a municipality of the State of Texas, organized and operating pursuant to its home rule charter, and the Constitution and laws of the State of Texas, acting herein by and through its City Council and pursuant to formal approval by said City Council; and, the WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT (the "District"), a conservation and reclamation district created by the Texas Legislature pursuant to the provisions of Art. XVI, Section 59 of the Texas Constitution, acting by and through its Board of Directors and pursuant to a resolution duly passed and adopted by said Board of Directors.

RECITALS

WHEREAS, the BRA owns certain water rights for reservoirs in the Brazos River Basin, including water rights for Possum Kingdom Reservoir (CA 12-5155) ("Possum Kingdom"); and

WHEREAS, on June 25, 2004 the BRA filed an application with the Texas Commission on Environmental Quality ("TCEQ") for a System Operation Permit (Application No. 5851) ("System Operation Permit"); and

WHEREAS, the City and the District own certain water rights in the upper Brazos River Basin, including District water rights for Hubbard Creek Reservoir (CA 12-4213) ("Hubbard Creek Reservoir"); City water rights for the diversion and reuse of a portion of City municipal wastewater effluent return flows (Permit No. 4266C) ("Existing Reuse Authorization") which was issued by a predecessor agency of TCEQ with a provision that conditioned its effectiveness on the continued validity of a "Water Supply Agreement By and Between Brazos River Authority and City of Abilene," (the "Upstream Water Supply Contract"), which contract expires on December 31, 2011; and City water rights for the scalping of water from the Clear Fork of the Brazos River into Lake Fort Phantom Hill (CA 12-4139) (the "City's Clear Fork Scalping"); and

WHEREAS, the City's Clear Fork Scalping authorization, the City's Existing Reuse Authorization, and the District's Hubbard Creek Reservoir authorization are all "junior" in time priority to the BRA's existing Possum Kingdom authorization; and

WHEREAS, the City and the District have filed applications with TCEQ for additional water rights, including the City's application to reuse its wastewater treatment plant discharges (Application No. 12-4161C) (the "City's Pending Reuse Project") and the District's application to scalp excess flows from the Clear Fork of the Brazos River into Hubbard Creek Reservoir (Application No. 5870) (the "District's Clear Fork

Scalping Project"), both of which, if granted, will be "junior" in time priority to the BRA's Possum Kingdom authorization; and

WHEREAS, the City and the District are pursuing a water rights application for the permitting and development of the Cedar Ridge Reservoir Project ("Cedar Ridge Project"), to be located on the Clear Fork of the Brazos River and which, if permitted, will be "junior" in time priority to the BRA's Possum Kingdom authorization; and

WHEREAS, BRA's System Operation Permit, if granted, will be "senior" in time priority to the District's Clear Fork Scalping Project, if issued, and to the City and/or the District's proposed Cedar Ridge Project, if permitted; and

WHEREAS, the City, the District, and BRA (jointly referred to as the "Parties") agree that it is in their respective interests and in the public interest, to resolve existing and potential conflicts between their respective water rights and their pending and proposed applications; and

WHEREAS, the Parties desire to enter into this Agreement so they can each pursue, in a coordinated manner, their pending and proposed water supply projects in the Brazos River Basin; and

WHEREAS, pursuant to Chapter 791, Texas Government Code, and the general and special laws of the State of Texas, the Parties are authorized to enter into this Agreement providing for the undertaking, administration and implementation of the Agreement;

NOW, THEREFORE, be it resolved that for and in consideration of the mutual covenants, benefits and agreements hereinafter set forth, the adequacy and sufficiency of which is evidenced by the Parties' respective execution of this Agreement, the Parties agree as follows:

AGREEMENT

ARTICLE I

1. Agreement Regarding Existing Water Rights

a. BRA agrees to waive, without cost, its right to make priority calls under its Possum Kingdom authorization on the District's Hubbard Creek Reservoir authorization and on the City's Clear Fork Scalping authorization.

b. The District agrees that it will sell to BRA, without cost, from the District's Hubbard Creek Reservoir authorization, by means of a water supply contract meeting TCEQ's regulatory requirements in 30 Texas Administrative Code Chapters 295 and 297, 14,000 acre-feet of the District's authorized use of water per annum. This water shall be authorized for municipal use with a 1957 priority.

BRA agrees that no call will be made for the diversion or releases of water from Hubbard Creek Reservoir of this 14,000 acre-feet of water. Additionally, BRA agrees that it will not require the District to provide such water in any manner that will reduce the supply available to the District from the remaining 42,000 acre-feet of authorized diversions from Hubbard Creek Reservoir. BRA further agrees to timely supply to the District BRA's end of year water use information for utilization in complying with TCEQ water use reporting requirements.

c. In the event TCEQ fails to accept or allow the water supply contract anticipated under Article 1.b. of this Agreement, the Parties agree to negotiate a mutually acceptable subordination agreement that preserves the intent of the Parties reflected in Article 1.a. and 1.b. of this Agreement.

d. Upon the expiration of the Upstream Water Supply Contract in Year 2011, BRA agrees to enter into an extension of that contract, if requested by the City, for a period or term commensurate with the provisions of Article 5.q. of this Agreement. BRA agrees that in such contract extension it shall waive, without cost, its right to make priority calls under its Possum Kingdom authorization on the City's use of its Existing Reuse Authorization rights.

ARTICLE II

2. Agreement Regarding Specified Future Water Rights

a. BRA agrees to waive, without cost, its right to make priority calls by any water right it obtains pursuant to its pending System Operation Permit application on both the District's pending Clear Fork Scalping Project and the District's and/or the City's proposed Cedar Ridge Project. The provisions of this Article 2.a. are contingent upon the District and/or the City having one or both of these permit application(s) deemed administratively complete and public notice issued within 10 years following the Effective Date of this Agreement, and upon such applications being granted, in whole or in part, within thirteen (13) years of the Effective Date of this Agreement. BRA will be under no obligation to waive priority calls on either of the above-referenced projects for which a permit has not been issued within thirteen (13) years of the Effective Date of this Agreement.

b. BRA agrees to grant the City and/or the District, without cost, for a period of 10 years following the Effective Date of this Agreement, a preferential right and option to purchase up to 20,000 acre-feet per annum of BRA System Water by water supply contract in a form consistent with those in common use by BRA at that point in time. "BRA System Water" shall be water that is available for diversion from Possum Kingdom Reservoir on a firm, non-interruptible basis. Such purchase shall be in the form of a water supply contract acceptable to the Parties and consistent with TCEQ regulations. At the expiration of the 10-year period, the City and/or the District, at their exclusive option, may exercise the option or may preserve the option to purchase up to 20,000 acre-feet per annum

supply of BRA System Water at a "Reservation Rate" (i.e., a rate established by BRA to reserve water supply for a purchaser of water from the BRA and prior to the actual diversion and use of the water supply). If no "Reservation Rate" has been developed at the expiration of the 10-year option period, then the preferential right and option to purchase the 20,000 acre-feet per annum supply may be extended for another 10-year period, at the exclusive option of the City and/or the District, at a default rate of 50% of the then-existing BRA System Rate until a "Reservation Rate" is established. Any extensions thereafter shall be by mutual agreement. Such an option, if exercised, shall be exercised, in writing, prior to the expiration of the 10-year period that follows the Effective Date of this Agreement.

c. BRA agrees to waive its right to make priority calls by its Possum Kingdom authorization on the proposed Cedar Ridge Project and the District's Clear Fork Scalping Project, if those projects are permitted by TCEQ. The District and/or the City agree to compensate BRA for the impact to Possum Kingdom's stand-alone firm yield that will result from permitting and operating the Cedar Ridge Project and the District's Clear Fork Scalping Project in the amount of 10,000 acre-feet of water per annum. In the event that only one of these projects is permitted and operated, compensation shall be as follows: compensation for the District's Clear Fork Scalping Project shall be for 5,000 acre-feet per annum; compensation for the Cedar Ridge Project shall be for 5,000 acre-feet per annum. Compensation will be payable at 50% of the then-existing BRA System Rate, after permitting of each project but prior to completion of construction of each project. Upon completion of construction of each project, compensation will be payable at the then-existing BRA System Rate. Such compensation shall be due and payable in accordance with the terms and conditions of written agreement(s) entered into by the Parties. Such obligation to pay and the other terms and conditions of such agreement(s) shall be dependent upon the continued validity and effectiveness of the water rights specified in this Article 2.c.

d. Future performance of the provisions reflected in Article 2 of this Agreement is subject to BRA's System Operation Permit being i) identified as a "recommended water management strategy" in the 2006 Region G and Region H Regional Water Plans, pursuant to Texas Water Development Board guidelines, and ii) granted by TCEQ in amounts substantially sufficient to meet needs identified as being supplied by BRA in the 2001 and 2006 Region G and Region H Regional Water Plans. Upon final approval of the System Operation Permit by TCEQ, BRA agrees to provide written notification to the City and the District of whether such permit is substantially sufficient to address such identified needs. In the event that such permit is not issued so as to be substantially sufficient to meet such identified needs, the Parties agree to work together, in good faith, to address the possible impacts of the Cedar Ridge Project and the District's Clear Fork Scalping Project on the Possum Kingdom authorization.

ARTICLE III

3. Agreement Regarding Reuse

a. BRA agrees not to protest or seek payment from the City for: i) any direct reuse authorization it pursues, or ii) any indirect reuse authorization that may be issued as a result of the City's Pending Reuse Project water right application, for municipal, industrial and irrigation purposes, consistent with the area of use limitations on its indirect reuse supplies as referenced in Article 3.b.

b. The City agrees to limit the actual end-use of its indirect reuse supplies to locations within the City's corporate boundaries, its extra-territorial jurisdiction boundaries, its water Certificate of Convenience and Necessity service area, and within such boundaries and service areas as may be changed or amended in the future. This Agreement does not limit the location of use of any water available to the City under its other water rights and its other water supplies.

ARTICLE IV

4. Agreement Regarding Cooperation

a. BRA agrees not to protest the City's Pending Reuse Project, an application filed by the City and/or the District on the Cedar Ridge Project, an application filed by the City to transfer all or part of its Clear Fork Scalping permit to the Cedar Ridge Project location, or the District's pending Clear Fork Scalping Project. BRA further agrees not to fund or support the protest of these applications by any third party.

b. The City and the District agree not to oppose BRA's System Operation Permit application, and further agree not to fund or support the protest of that application by any third party.

c. The Parties agree to provide each party to this Agreement with copies of permit applications, documents, amendments, modifications, and proposed permit language related to any pending or proposed water right referenced in this Agreement so as to allow the Parties reasonable opportunity to review and comment on such applications and proposed permits.

d. The Parties agree to support and work towards inclusion of the City's Pending Reuse Project, the City's and/or the District's Cedar Ridge Project, the District's pending Clear Fork Scalping Project, and BRA's System Operation Permit in the Region G and State Water Plans as "recommended water management strategies." This Agreement extends to both the 2006 Region G Regional Water Plan and the 2007 State Water Plan and amendments of the 2001 Region G Regional Water Plan and the 2002 State Water Plan, if requested by any party.

e. The Parties agree to work together in developing a new Water Availability Model for the Brazos River Basin ("WAM") that will implement the subordination concepts identified in this Agreement in a manner that is acceptable to TCEQ.

f. BRA agrees to support, if sought, a unique reservoir designation pursuant to Water Code Section 16.051, for the Cedar Ridge Project.

ARTICLE V

5. Miscellaneous Provisions

a. ENTIRE AGREEMENT: Except for the provisions of Article 1.d,, above, the terms and provisions of this Agreement contain the entire Agreement between BRA and the City and between BRA and the District with respect to water supply issues within the Brazos River Basin.

b. SEVERABILITY: Except for the provisions of Article 2.d., above, the provisions of this Agreement are severable, and if for any reason any one or more of the provisions contained in this Agreement shall be deemed to be invalid, illegal, or unenforceable in any respect, the invalidity, illegality, or unenforceability shall not affect any other provisions of this Agreement and this Agreement shall remain in effect and be construed as if the invalid, illegal, or unenforceable provision had never been contained in the Agreement.

c. ADDRESSES AND NOTICE: Unless otherwise provided in this Agreement, any notice, communication, request, reply, or advice (herein severally and collectively called "Notice") herein provided or permitted to be given, made, or accepted by any Party to the other must be in writing and may be given or be served by depositing the same in the United States mail postpaid and registered or certified and addressed to the party to be notified, with return receipt requested, or by delivering the same to an officer of such party, or by facsimile or other documentary form. Notice by facsimile or hand delivery shall be deemed to have been received by the close of the business day on which it was transmitted or hand delivered (unless transmitted or hand delivered after close, in which case it shall be deemed received at the close of the next business day). Notice by overnight mail or courier shall be deemed to have been received two (2) business days after it was sent. Notice deposited in the mail in the manner hereinabove described shall be conclusively deemed to be effective upon deposit in the United States mail. Notice given in any other manner shall be effective only in and when received by the party to be notified. For the purpose of Notice, the addresses of the Parties shall, until changed as hereinafter provided, be as follows:

If to the City, to:
Mayor
City of Abilene
555 Walnut Street

P. O. Box 60
Abilene, Texas 79604-0060
Telephone: (325) 676-6386
Fax: (325) 676-6229

If to the District, to:
President, Board of Directors
West Central Texas Municipal Water District
P. O. Box 2362
410 Hickory Street
Abilene, Texas 79601
Telephone: (325) 673-8254
Fax: (325) 673-8272

If to BRA, to:
General Manager
Brazos River Authority
P.O. Box 7555
Waco, Texas 76714-7555
Telephone: (254) 761-3100
Fax: (254) 761-3207

The Parties shall have the right from time to time and at any time to change their respective addresses and each shall have the right to specify as its address any other address by at least five (5) days written notice to the Parties.

d. MODIFICATION: This Agreement shall be subject to change or modification only by the mutual written consent of the Parties.

e. ASSIGNABILITY: This Agreement shall bind the Parties and their legal successors, but shall otherwise not be assignable by the Parties without prior written consent of the other Parties, which consent shall not be unreasonably withheld. All of the respective obligations of each of the Parties shall bind that Party and shall apply to and bind any successors or assigns of that Party.

f. COSTS AND EXPENSES: Each party to this Agreement shall be responsible for all costs and expenses incurred by such Party in connection with this Agreement.

g. GOVERNING LAW: This Agreement shall be governed by the Constitution and law of the State of Texas, except as to matters exclusively controlled by the Constitution and Statutes of the United States of America.

h. AMENDMENTS: This Agreement may be amended or modified only by written agreement duly authorized by the respective governing bodies of the Parties and executed by the duly authorized representative of each.

i. COOPERATION: The Parties agree to perform all obligations and undertake such actions as are or may become necessary or convenient to effectuate the purposes and intent of this Agreement.

j. VENUE: Venue for any action arising hereunder shall be in McLennan County, Texas.

k. THIRD PARTY BENEFICIARIES: Except as expressly provided herein, nothing in this Agreement, express or implied, is intended to confer upon any person, other than the Parties, any rights, benefits, or remedies under or by reason of this Agreement.

l. DAMAGES: None of the Parties shall be liable or have any responsibility to the other for any indirect, special, consequential, punitive or delay-related or performance-related damages including, without limitation, lost earnings or profits. Such limitation on liability shall apply to any claim or action, whether it is based on whole or in part on contract, negligence, strict liability, tort, statute or any other theory of liability.

m. FURTHER ASSURANCES: The Parties agree to do all acts and things and to execute and deliver such further written instruments, as may be from time to time reasonably required to carry out the terms and provisions of this Agreement.

n. INTERPRETATION AND RELIANCE: No presumption will apply in favor of any Party in the interpretation of this Agreement or in the resolution of any ambiguity of any provisions thereof.

o. RELATIONSHIP OF PARTIES: This Agreement and the transactions contemplated hereunder are based upon the active participation of the Parties. Neither the execution nor delivery of this Agreement, nor the consummation of the transactions contemplated hereunder, shall create or constitute a partnership, joint venture, or any other form of business organization or arrangement between the Parties, except for the contractual arrangements specifically set forth in this Agreement. Except as is expressly agreed to in writing in this Agreement, no Party (or any of its agents, officers or employees) have any power to assume or create any obligation on behalf of the other Party.

p. FUTURE AMENDMENT OF WATER RIGHTS: Nothing in this Agreement shall be construed to prohibit or restrict the Parties from seeking to amend or to secure an amendment of any term of the water right authorizations of either Party, or from pursuing additional authorizations, that are not contemplated herein. A Party may amend its water rights, pursue additional water supply authorizations, or object to any action by any other Party hereto in any manner it may deem appropriate, in its complete discretion, except that no Party will take any such action that will prevent performance of its duties or obligations under this

Agreement. Notwithstanding the foregoing, nothing herein shall restrict either Party's ability to lawfully seek to preserve and protect its own water rights interests.

q. TERM: This Agreement shall commence on the Effective Date and shall continue in effect for so long as any of the Parties' water rights referenced in this Agreement remain in effect.

r. TERMINATION: This Agreement may be terminated by mutual written agreement of the Parties.

ARTICLE VI

6. Remedies

a. The Parties acknowledge and agree that the rights contemplated herein are unique and in the nature of a real property right. Accordingly, without limiting any other remedies that may be available to the Parties at law or in equity, the Parties shall have the remedy of specific performance to enforce performance of this Agreement.

b. A breaching party shall be liable to the other Parties for all costs actually incurred in pursuing such remedies, including reasonable attorney's fees.

EXECUTED this 10 day of March, 2005.

THE CITY OF ABILENE, TEXAS

Mayor

ATTEST/SEAL:

City Secretary

WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT

President, Board of Directors

ATTEST/SEAL:

Secretary, Board of Directors

BRAZOS RIVER AUTHORITY

President, Board of Directors

ATTEST/SEAL:

Secretary, Board of Directors

Appendix B
Rainfall/Runoff Model

Appendix B
Rainfall/Runoff Model

B.1 Development of Rainfall/Runoff Model

The US Army Corps of Engineers (USACE) Hydrologic Engineering Center's hydrologic model HEC-HMS (version 3.3) was used to model the hydrology for the proposed reservoir's watershed. The primary input components of the HEC-HMS model include rainfall, soil loss parameters, runoff transformation parameters and reach routing parameters. A schematic of the HEC-HMS model showing the 11 watershed areas modeled is shown in Figure B-1.

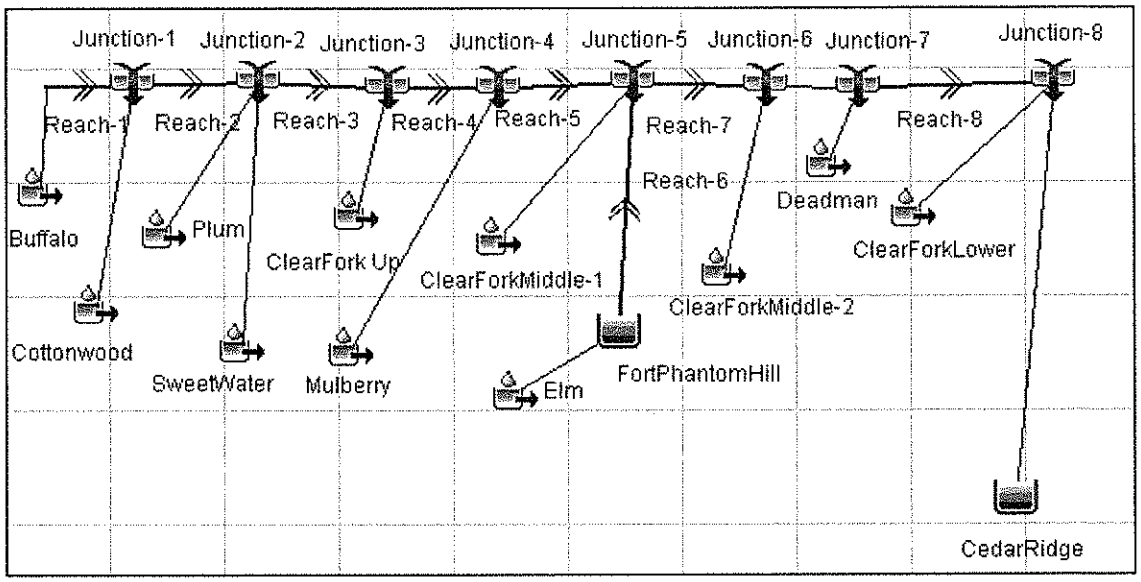


Figure B-1. HEC-HMS Model Configuration for Cedar Ridge Reservoir Watershed

B.2 Design Storm Precipitation

The design storm events modeled in the study included the 50-year, 100-year, 500-year and the PMF rainfall events. The 100-year storm event was utilized to size the principal and emergency spillways for the dam. The PMF was the design flood used to establish the top of dam elevation considering design wave height and long-term embankment settlement.

B.2.1 Probable Maximum Precipitation (PMP)

The PMF was derived by determining the amount of excess runoff resulting from the PMP. The PMP is defined as the greatest depth of precipitation physically possible for a given

set of meteorological and hydrologic conditions.[1] These include storm duration and area, and season. PMP estimates were obtained from the National Oceanic and Atmospheric Administration's (NOAA) Hydrometeorological Report No. 51 (HMR No. 51).[2] This publication provides PMP estimates for various combinations of storm areas and durations applicable to all seasons. National Weather Service criteria for developing a probable maximum storm from PMP estimates in HMR No. 51 are specified in Hydrometeorological Report No. 52 (HMR52).[3] The criteria require consideration of these four conditions: (1) the location of the storm center, (2) the size of the storm area, (3) the storm orientation, and (4) the temporal arrangement of precipitation amounts. These four conditions are considered using a standard procedure incorporated into the computer program HMR52.

The TCEQ guidelines[4] require that multiple duration PMP storm events be evaluated to determine the duration of the PMP storm that produces the highest peak stage in the reservoir. Since the drainage area for the proposed reservoir is between 1,000 and 10,000 square miles, the 24-, 48-, and 72-hour duration PMP events were modeled. The average rainfall depths for the watershed computed with HMR52 for the three events were 16.46, 20.28, and 22.58 inches, respectively. The corresponding average rainfall depths calculated for the 11 sub-basins are shown in Table B-1.

TCEQ guidelines provide a temporal distribution for use in generating the PMP hyetographs with the HMR52 precipitation depths and were used in the analysis. These distributions were input in HEC-HMS using the Specified Hyetograph option.

[1] Hoggan, Daniel H., Computer-Assisted Floodplain Hydrology & Hydraulics, McGraw-Hill Book Co., 1989.
[2] National Oceanic and Atmospheric Administration, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian," Hydrometeorological Report No. 51, June 1978.
[3] Hydrologic Engineering Center, "HMR52 Probable Maximum Storm (Eastern United States) Users Manual," U.S. Army Corps of Engineers, Davis, CA, 1984.
[4] Hydrologic and Hydraulic Guidelines for Dams in Texas, TCEQ Dam Safety Program, January 2007.

Table B-1.
Average Rainfall Depths for PMP

Sub-Basin Name	Average Rainfall (in)		
	24-Hr	48-Hr	72-Hr
Buffalo	8.41	10.92	12.43
Clear Fork Lower	13.89	17.47	19.63
Clear Fork Middle-1	20.50	24.94	27.61
Clear Fork Middle-2	19.44	23.87	26.55
Clear Fork Up	23.79	28.23	30.90
Cottonwood	15.10	18.92	21.23
Deadman	16.51	20.57	23.01
Elm	12.17	15.39	17.34
Mulberry	20.02	24.37	26.99
Plum	17.94	22.07	24.57
Sweetwater	20.01	24.32	26.92

B.2.2 Rainfall for Various Frequency Storms

The HEC-HMS frequency storm option was used to define the rainfall hyetographs for the 50-, 100-, and 500-year storm events. Point rainfall depths for 15-minute through 48-hour durations were obtained from the USGS Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas[5] and input to HEC-HMS for use in the frequency storm method. HEC-HMS applies a reduction factor to the point rainfall depths based on the watershed area to determine the basin average precipitation depth for the watershed. Table B-2 summarizes the point rainfall depths for the various frequencies storm events.

B.3 Soil Loss

Soils data for the 11 sub-basins were obtained from the U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS) and used to establish the hydrologic soil group distribution within each sub-basin. A summary of the hydrologic soil group resulting from this process with the dominant group highlighted is presented in Table B-3.

[5] Asquith, William H.; Roussel, Meghan C., "Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas," United States Geological Survey Report No. 2004-5041, 2004.

Table B-2.
Point Rainfall Depths for Frequency Storms

Time	Point Rainfall Depth (in)		
	50-Year	100-Year	500-Year
15 Min	1.50	1.63	2.10
1 Hr	3.00	3.36	4.40
2 Hr	4.00	4.60	6.50
3 Hr	4.30	5.00	6.90
6 Hr	5.10	6.00	8.60
12 Hr	5.70	6.50	8.90
24 Hr	7.00	8.00	11.00
48 Hr	8.00	9.20	12.00

Table B-3.
Hydrologic Soil Groups Classification

Sub-Basin Name	Hydrologic Soil Group (%)			
	A	B	C	D
Buffalo	1.93	57.65	31.47	8.95
Clear Fork Lower	3.06	27.86	51.1	17.97
Clear Fork Middle-1	43.28	17.32	30.08	9.32
Clear Fork Middle-2	18.56	22.51	44.85	14.11
Clear Fork Up	11.03	29.99	51.81	7.17
Cottonwood	0.14	59.07	33.26	7.52
Deadman	1.19	7.61	49.05	42.15
Elm	0.14	15.3	51.29	33.27
Mulberry	6.66	24.42	42.18	26.74
Plum	12.57	55.24	18.5	13.69
Sweetwater	0.03	27.46	23.07	49.44
The predominant Hydrologic Soil Group for each sub-basin is highlighted.				

Soil infiltration was modeled using the Initial Loss and Constant Rate method available within HEC-HMS. This method assumes that the maximum potential rate of precipitation loss resulting from infiltration is constant throughout an event. The initial loss component represents the interception and depression storage. Pursuant to the TCEQ guidelines for design flood analyses, the PMP initial loss was set to zero to represent saturated antecedent soil moisture

conditions. The assumption is that these losses occur prior to the onset of runoff. Table B-4 shows the NRCS recommended range of soil infiltration rates for each hydrologic soil group.[6]

Table B-4.
Range of Soil Infiltration Rates

Hydrologic Soil Group	*Range of Uniform Loss Rates (in/hr)*
A	0.30-0.40
B	0.15-0.30
C	0.05-0.15
D	0.00-0.05

An initial set of area-weighted infiltration rates were calculated for each sub-basin using the minimum infiltration rates from Table 4.5 and the hydrologic soil group distribution within each sub-basin. These values were later adjusted during the model verification analysis as discussed in Section 4.2.5.

B.4 Runoff Transformation

The runoff transformation process consists of simulating the direct runoff resulting from excess precipitation on a sub-basin. The Snyder Unit Hydrograph method available within the HEC-HMS model was used for this process. The two input parameters for this option are the lag time and the shape factor.

B.4.1 Lag Time:

The lag time is calculated using the following equation:

$$T_L = C_T (L \times L_{CA})^{0.3}$$

T_L = Lag time (hr).
C_T = Coefficient whose values range from 0.7-3.0 with lower values for higher slopes.
L = Hydraulic length of watershed along the longest flow path (mi).
L_{CA} = Hydraulic length along the longest water course from the point under consideration to a point opposite the centroid of the drainage basin (mi).

The C_T values for each subarea were determined during the model verification analysis.

[6] Hydrologic and Hydraulic Guidelines for Dams in Texas, TCEQ Dam Safety Program, January 2007.

B.4.2 Snyder Peaking Coefficient:

The peaking coefficient, also known as the shape factor, reflects the sharpness of the hydrograph with higher values reflecting a rapidly responding basin and lower values reflecting a flatter, slow responding basin. The value typically ranges from 0.4-0.8. Peaking coefficients for each subarea were adjusted to calibrate the model during the model verification analysis.

B.5 Hydrograph Routing

Hydrograph routing through the stream system and ultimately through the Cedar Ridge reservoir was modeled in accordance with the current TCEQ H&H guidelines.

B.5.1 Streamflow Reach Routing

The Muskingum-Cunge method (with the 8-point cross-section option), available within the HEC-HMS model, was used to simulate reach routing. A total of eight reaches were used in the model that route the runoff from the most upstream sub-basin to the reservoir. Figure B-2 shows a plot of the cross-sections used for all eight reaches. The cross-section geometry is based on the USGS 30-meter Digital Elevation Model (DEM) obtained through the NHDPlus portal.

B.5.2 Reservoir Storage Outflow Routing

Fort Phantom Hill Reservoir was included in the HEC-HMS model as a reservoir object using the Outflow Curve method with a specified elevation-storage-discharge relationship. This combined relationship was obtained from the Phase I inspection report[7] and TWDB Volumetric Survey Report[8]. The elevation-storage-discharge curves are provided in Table B-5.

[7] Fort Phantom Hill Dam, Phase I Inspection Report, National Dam Safety Program, Texas Department of Water Resources, October 1979.
[8] Volumetric Survey of Fort Phantom Hill Reservoir, Texas Water Development Board, February 1994.

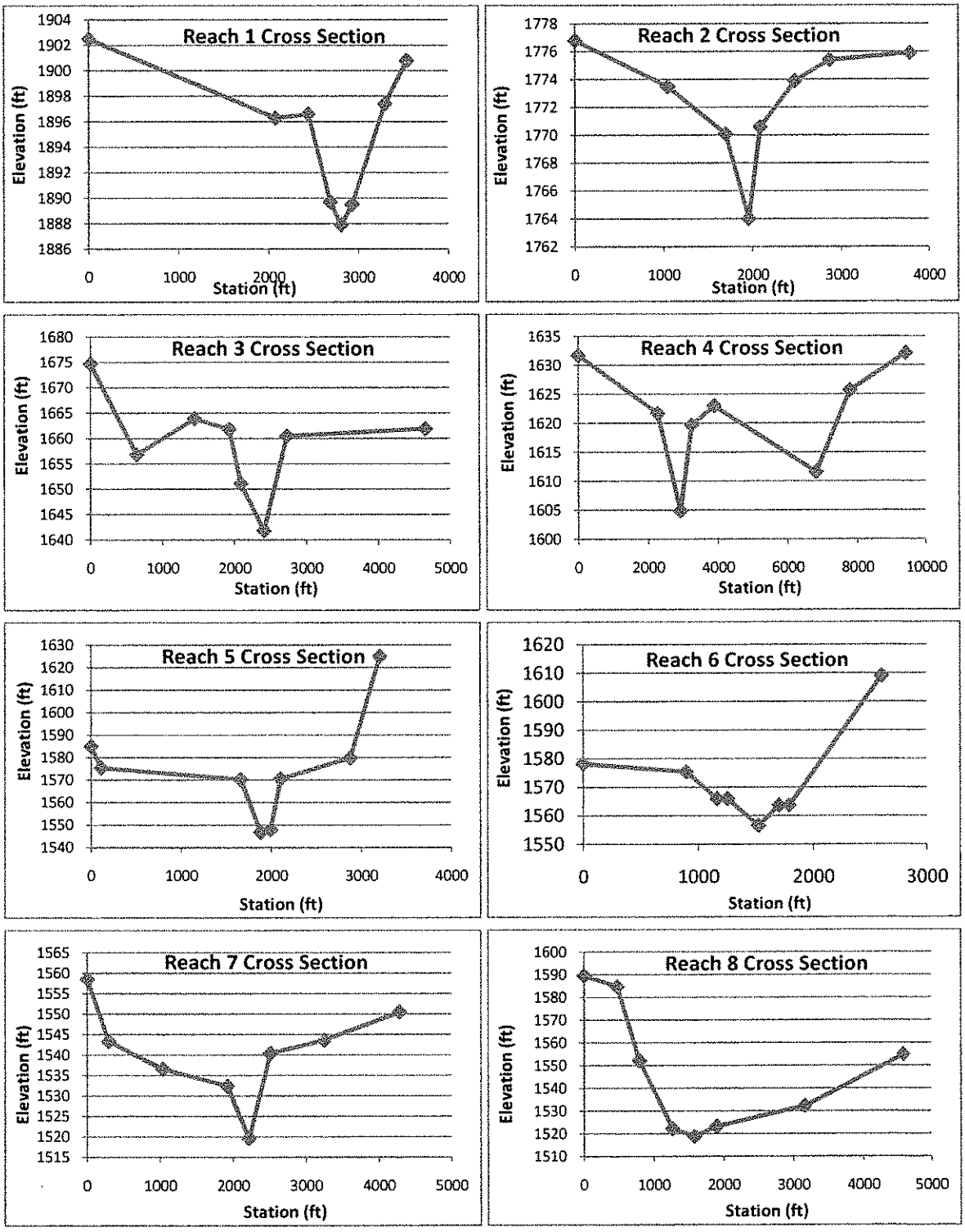


Figure B-2. Cross-Sections for Muskingum-Cunge Reach Routing

Table B-5.
Elevation-Storage-Discharge Curves for
Fort Phantom Hill Reservoir

Elevation (ft-msl)	*Storage (acft)*	*Discharge (cfs)*
1565	0	0
1635.9	76,800	1
1636	77,167	84
1637	80,833	3,058
1638	84,500	8,086
1639	88,250	14,536
1640	92,000	22,161
1641	96,000	30,816
1642	100,000	40,404
1643	102,500	68,533
1644	105,000	112,116
1645	110,000	165,998
1646	115,000	228,319
1647	119,000	297,995
1648	123,000	374,289
1649	127,000	456,658
1650	131,000	544,678
1651	133,722	638,007

Cedar Ridge Reservoir is modeled as a reservoir object located at the downstream end of the HEC-HMS model. The elevation-storage relationship included in Table 5-1 of the main report was used for this analysis. Discharge from the proposed reservoir was calculated by the model using a 500-ft wide ogee-shaped principal spillway with a crest elevation of 1,489 ft-msl and a 1,400-ft wide broad crested emergency spillway with a crest elevation of 1500 ft-msl.

B.6 Model Verification

B.6.1 Process

Rainfall and stream flow data for three historical storm events, occurring in May 1957 (1957 Event), September/October 1980 (1980 Event), and October 1986 (1986 Event), were evaluated to calibrate and verify watershed infiltration and Snyder unit hydrograph parameters in the HEC-HMS model. These events were selected based on the availability of recorded rainfall and streamflow data. The HEC-HMS model was calibrated and verified using these three steps:

- Matching the runoff volumes of the 3 historical events by adjusting infiltration parameters;
- Adjusting the C_T coefficient to match the time of peak flow; and
- Matching the hydrograph shape and magnitude by adjusting the peaking coefficient.

B.6.2 Flow Gages

The USGS Nugent gage is the nearest stream gage to the dam location and measures runoff from about 81 percent of the reservoir's watershed. This gage was used for model verification. Additional USGS streamflow gages (08083100 - Clear Fk Brazos Rv nr Roby TX; 08083240 - Clear Fk Brazos Rv at Hawley TX; and 08083245 - Mulberry Creek near Hawley TX) were also included in the model verification but their use was secondary due to limited availability of historical data for the events studied.

B.6.3 Rain Gages

Hourly rainfall data for the three storm events for rain gages in and around the Cedar Ridge Reservoir watershed were obtained from NOAA National Climatic Data Center (NCDC) database using EPA BASINS[9] data management tool. The available rain gages for each historical event are summarized in Table B-6.

The recorded or estimated hourly precipitation depths for each gage were used to compute spatially averaged hourly rainfall depths for each subarea by the Thiessen polygon method. Thiessen polygons identify the area that is closer to a given rainfall gage than to other gages, and the rainfall depth for the gage is assumed to apply over the entire polygon when computing the spatially averaged rainfall for the watershed. Thiessen polygons created for each of the three events are shown in Figures B-3 through B-5. The rain gages used for each of the three storm events studied are given in the Table B-6..

B.6.4 Fort Phantom Hill Reservoir Storage

The Fort Phantom Hill Reservoir storage volume at the beginning of the 1980 and 1986 events was available from USGS gage 08083500 (Fort Phantom Hill Reservoir near Nugent, Texas). For the 1957 event, the initial storage of Fort Phantom Hill Reservoir was estimated using the Brazos Water Availability Model (BWAM).

[9] Better Assessment Science Integrating Point and Nonpoint Sources (BASINS), Version 4.0, US Environmental Protection Agency.

Table B-6.
NCDC Rain Gages Used in Model Verification

1957 Event		*1980 Event*		*1986 Event*	
Station No.	***Station Name***	***Station No.***	***Station Name***	***Station No.***	***Station Name***
TX410016	Abilene Regional Ap	TX410016	Abilene Regional Ap	TX410016	Abilene Regional Ap
TX410120	Albany	TX410120	Albany	TX410120	Albany
TX410478	Baird	TX413890	Hamlin 1 SW	TX413890	Hamlin 1 SW
TX413890	Hamlin 1 SW	TX414026	Hawley 3 NE	TX414026	Hawley 3 Ne
TX415097	Lawn	TX414960	Lake Abilene 6WNW	TX414960	Lake Abilene 6WNW
TX415358	Loraine	TX415097	Lawn	TX415097	Lawn
TX416494	Nugent 1 ESE	TX415358	Loraine	TX416495	Oak Creek Lake
TX417678	Roby	TX416495	Oak Creek Lake	TX417743	Roscoe
TX417743	Roscoe	TX417743	Roscoe	TX417782	Rotan
TX417782	Rotan	TX417782	Rotan	TX418433	Snyder
TX418433	Snyder	TX418433	Snyder	TX418583	Stamford 1
TX418583	Stamford 1	TX418583	Stamford 1	TX419122	Trent
TX418584	Stamford 2	TX419122	Trent		
TX418939	Tesco				
TX419122	Trent				
TX419154	Truby 3 ESE				

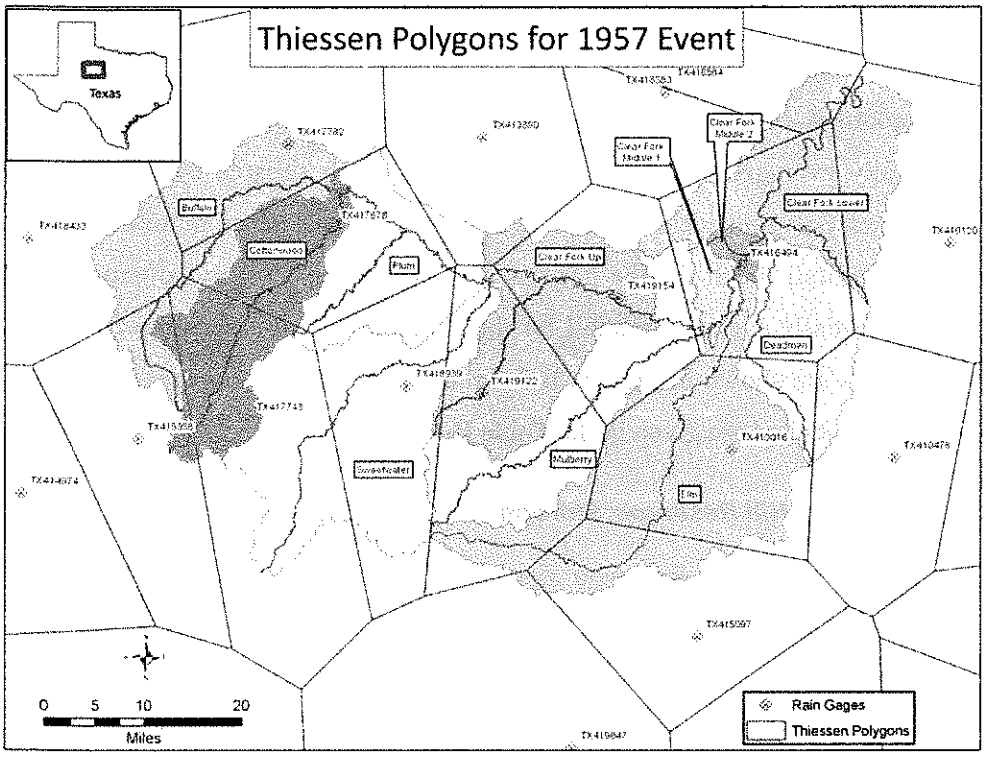


Figure B-3. Thiessen Polygons for 1957 Storm Event

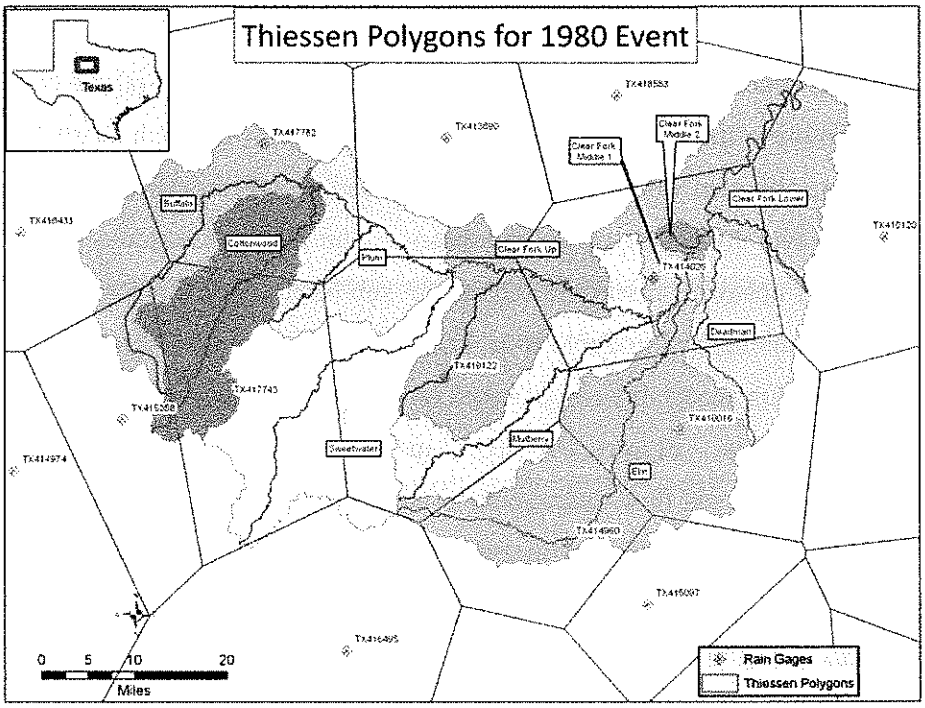


Figure B-4. Thiessen Polygons for 1980 Storm Event

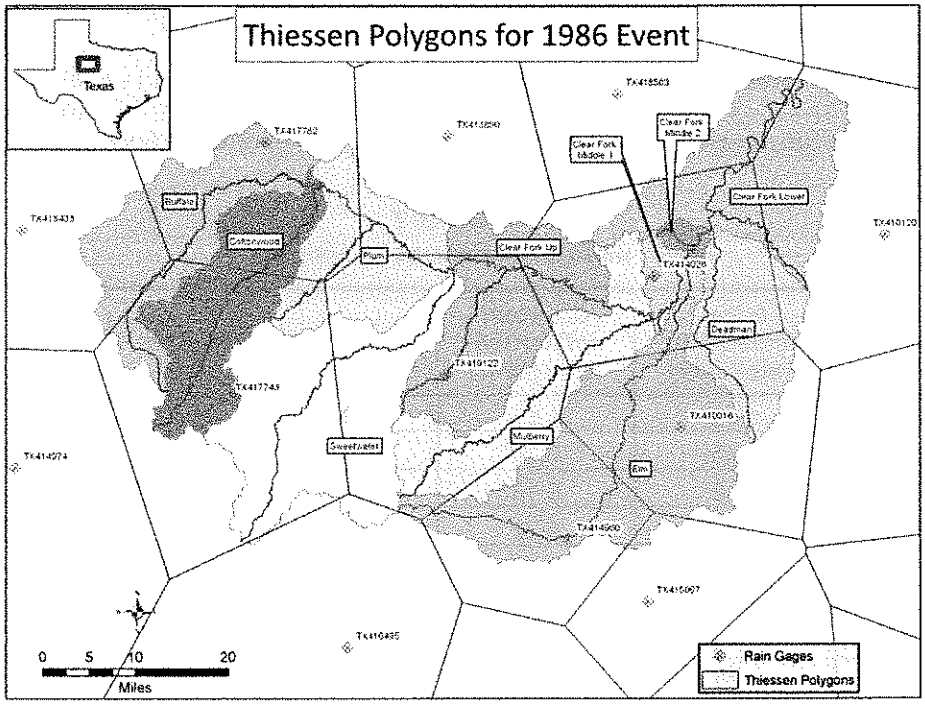


Figure B-5. Thiessen Polygons for 1986 Storm Event

B.6.5 Model Verification Results

The initial values for soil infiltration rates, coefficient C_T, and peaking coefficient were adjusted to approximate the observed volume, peak flow, and hydrograph shape for each of the three events. The calibrated values for coefficient C_T and peaking coefficient for Elm sub-basin were slightly different from rest of the sub-basin. The adjusted difference was due to the presence of several upstream reservoirs within the sub-basin. The final calibrated values for each sub-basin are summarized in Table B-7. The calibrated constant loss rates, C_T, and peaking coefficients were within acceptable ranges based on the TCEQ guidelines and published regional values in similar studies. Figures B-6, B-7, and B-8 illustrate the model-calculated flow hydrograph and the observed flow hydrograph at the Nugent gage for the 1957, 1980, and 1986 events, respectively. The observed hydrograph is based on daily mean flows observed at the Nugent gage and includes the instantaneous peak flow for that particular storm event. The model-calculated hydrograph consists of hourly flow values. The difference in modeled versus observed peak and volume of the hydrograph at the Nugent gage is summarized in Table B-8. Peak flows estimated by the model were between -13 and 18 percent of the observed flows. Flood volumes estimated by the model were between -12 and 10 percent of the observed volume.

B.7 Rainfall/Runoff Model Results

Results of the modeling effort are described in Section 4 of the report.

Table B-7.
Calibrated Parameter Values

Sub-basin Name	Initial Infiltration Rate (in/hr)	Constant Infiltration Rate (in/hr)	Coefficient C_T	Lag Time (hrs)	Peaking Coefficient C_p
Buffalo	1.45	0.13	2.3	19.6	0.55
Clear Fork	1.45	0.18	2.3	12.1	0.55
Clear Fork	1.45	0.16	2.3	7.4	0.55
Clear Fork	1.45	0.22	2.3	7.7	0.55
Clear Fork Up	1.45	0.15	2.3	21.2	0.55
Cottonwood	1.45	0.20	2.3	19.6	0.55
Deadman	1.45	0.12	2.3	14.3	0.55
Elm	1.45	0.15	3.0	30.1	0.40
Mulberry	1.45	0.16	2.3	19.6	0.55
Plum	1.45	0.21	2.3	18.1	0.55
Sweetwater	1.45	0.19	2.3	22.9	0.55

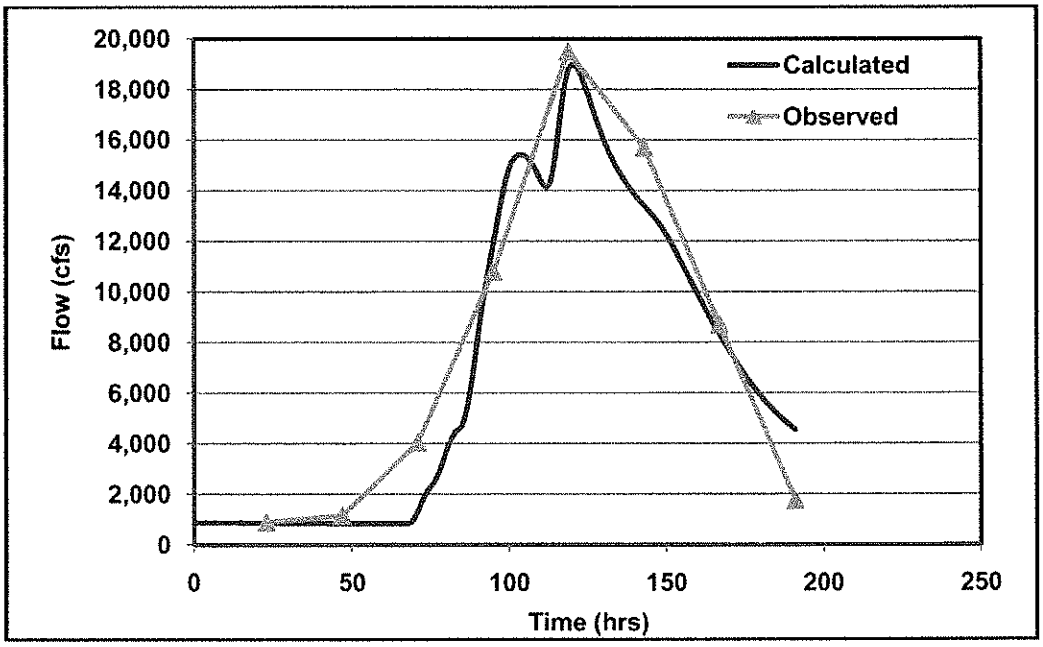


Figure B-6. Hydrograph Comparison for 1957 Event

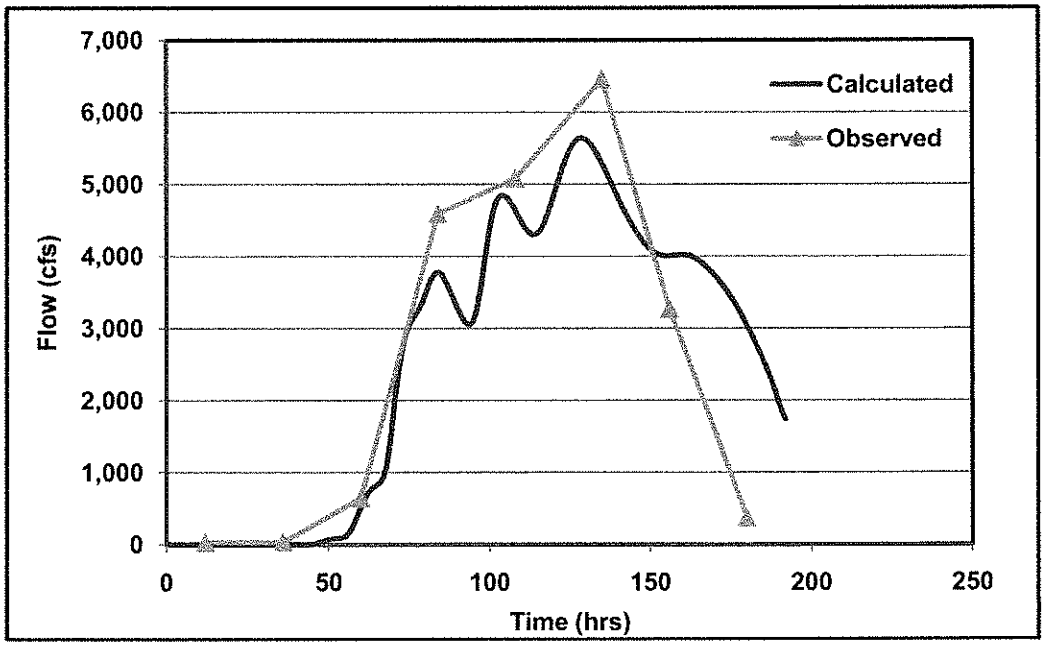


Figure B-7. Hydrograph Comparison for 1980 Event

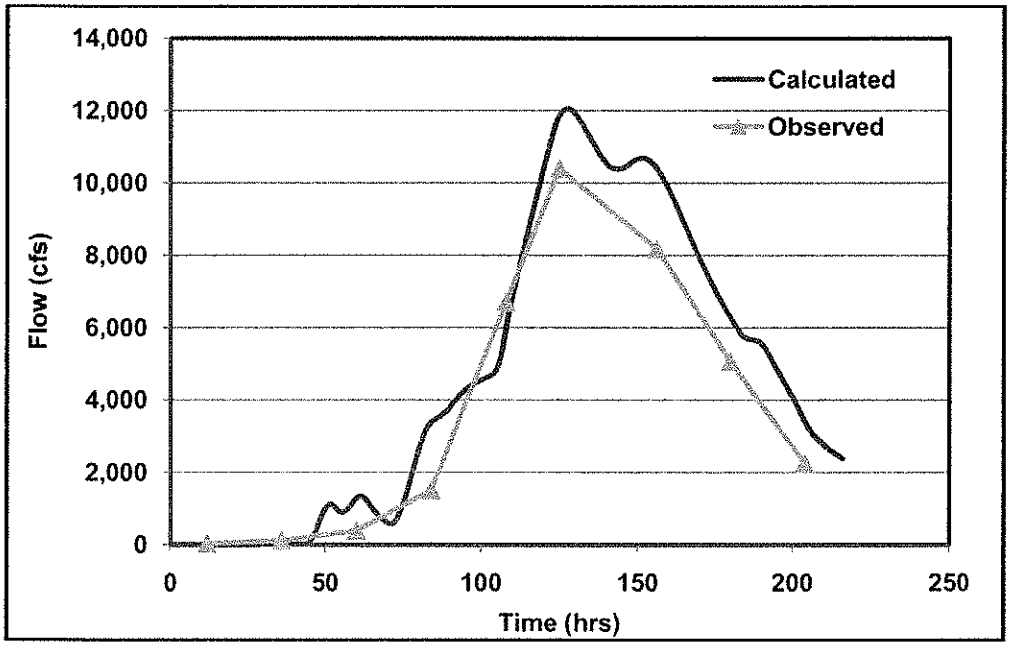


Figure B-8. Hydrograph Comparison for 1986 Event

Table B-8.
Observed and Model-Calculated Values at Nugent Gage

Event	Parameter	Observed	Calculated	Difference
1957	Volume (acft)	126,702	111,757	-12%
	Peak Flow (cfs)	19,500	18,989	-3%
1980	Volume (acft)	41,030	41,130	0%
	Peak Flow (cfs)	6,460	5,644	-13%
1986	Volume (acft)	71,057	78,467	+10%
	Peak Flow (cfs)	10,400	12,272	+18%

Appendix C
Brazos Water Availability Model Data

(Provided on Compact Disc)

City of Abilene

July 2011

Brazos Water Availability Model (WAM) Data

Available Upon Request

Contact

Mr. Chris Kozlowski

(512) 239-1801

Appendix D
Photographs of the Project Area Channel and Bank Conditions Throughout the Study Reach

Appendix D
Photographs of the Project Area Channel and Bank Conditions Throughout the Study Reach

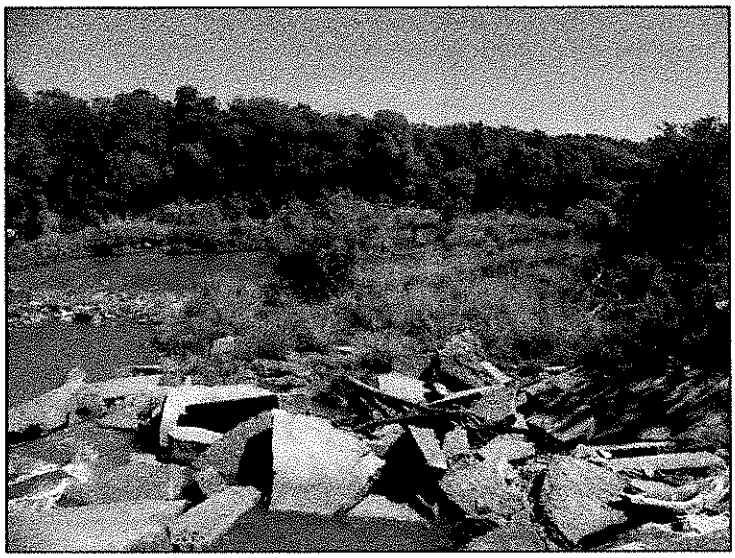
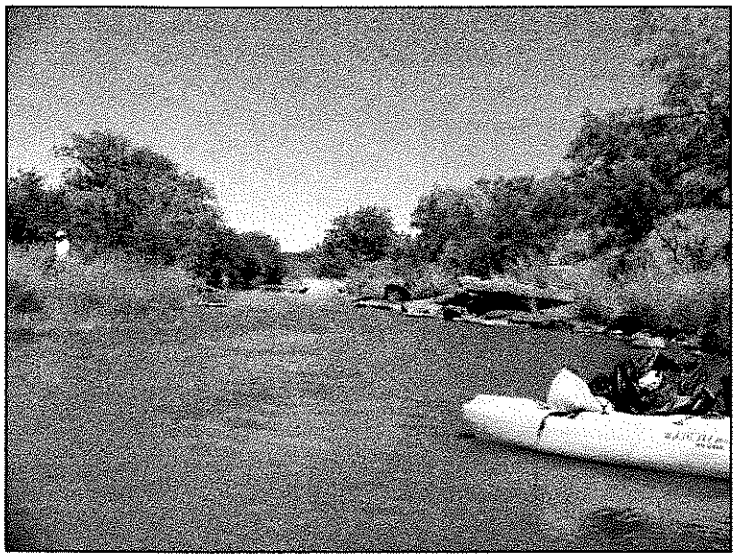
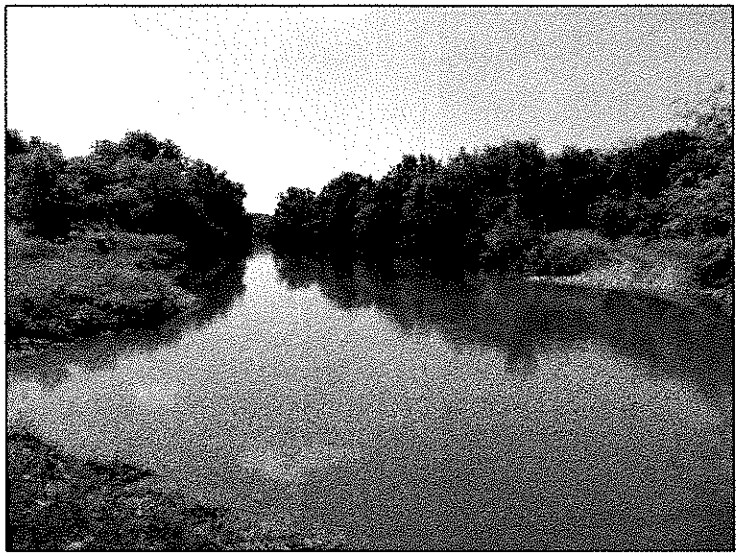


Photo 1: Clear Fork below the Lueders dam.



Photo 2: Clear Fork facing upstream from beneath the SH 6 bridge.

	**Photo 3: Clear Fork facing downstream toward eroded bank below Post Oak Creek confluence.**
	**Photo 4: Riffle on Clear Fork facing downstream, about 1.5 miles below Hog Creek confluence.**

	**Photo 5: Pool on Clear Fork facing upstream from above Bluff Creek confluence.**
	**Photo 6: Riffle facing downstream at confluence of Clear Fork and Bluff Creek.**

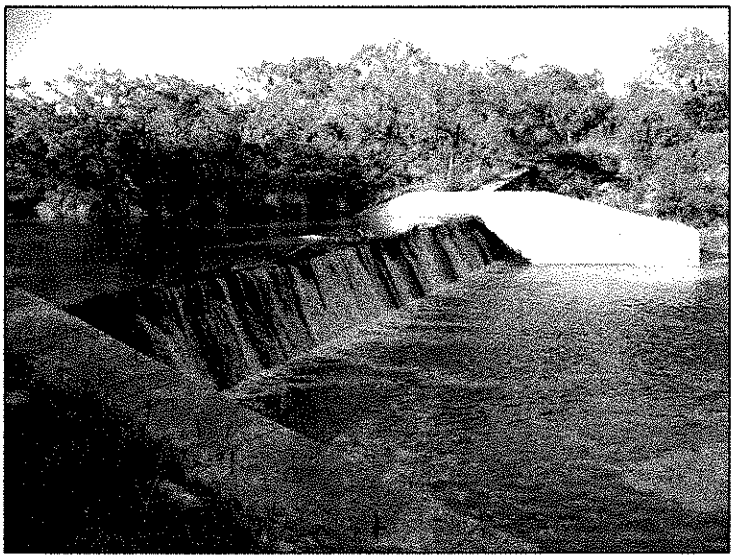


Photo 7: Low-head dam on the Clear Fork about 11 miles downstream of the Lueders dam.

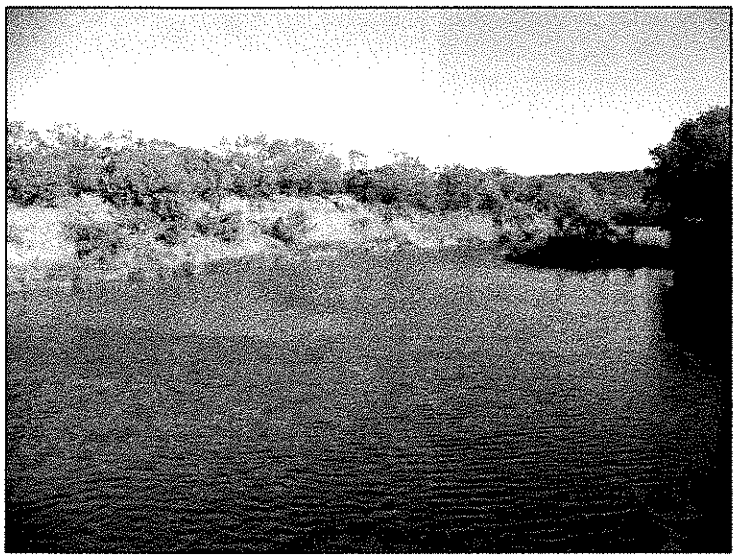


Photo 8: Clear Fork facing downstream below the low-head dam.

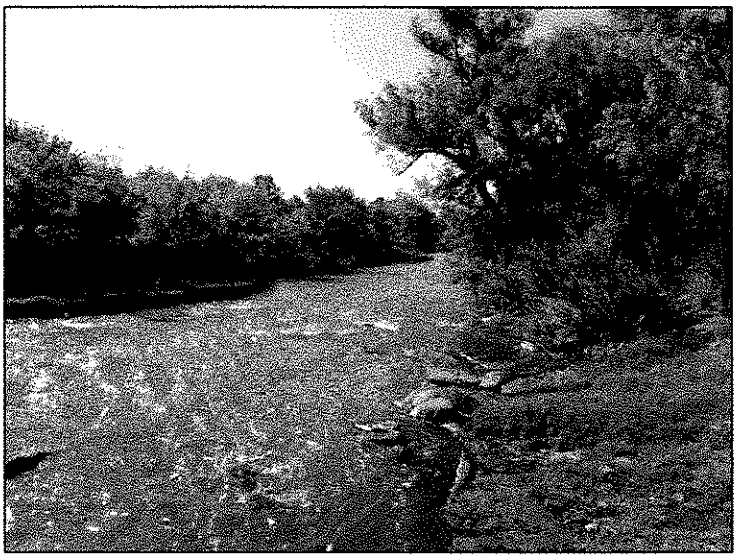


Photo 9: Riffle on Clear Fork facing downstream below the confluence with Swager Creek.

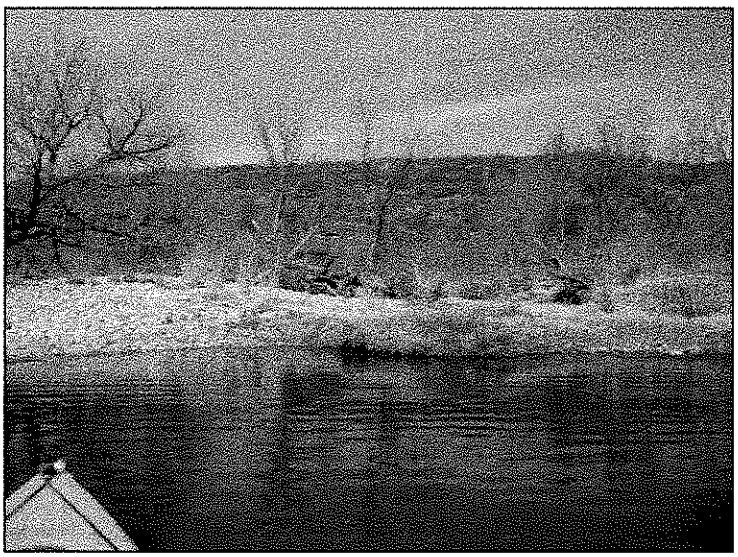


Photo 10: Frequently flooded gravel bar in the Clear Fork upstream of the Fish Creek confluence.

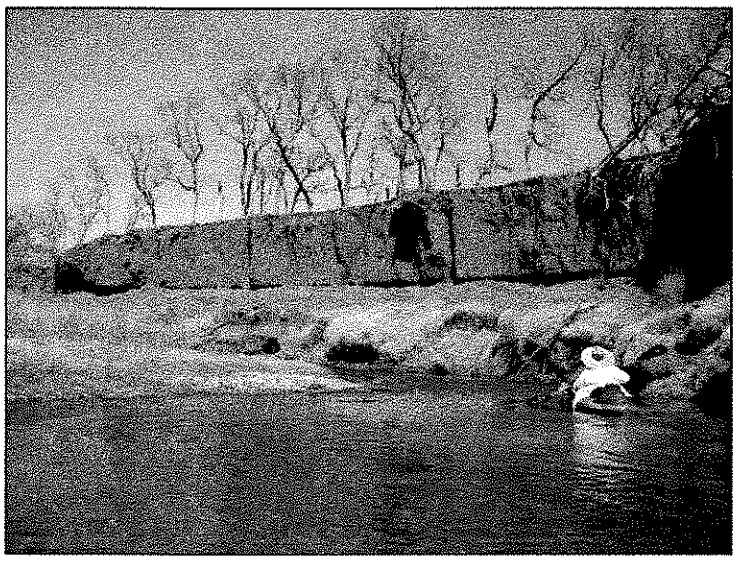
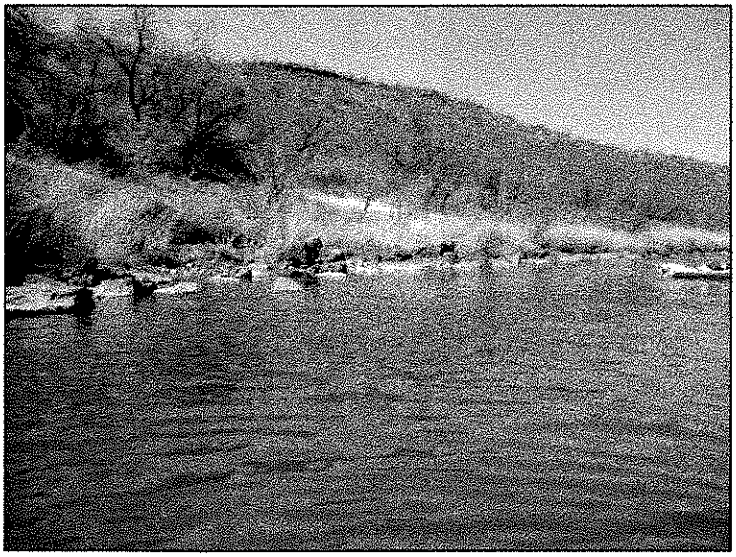
	**Photo 11: Eroded bank at a meander in the Clear Fork downstream of the Fish Creek confluence.**
	**Photo 12: Stable bank at a large bend in the Clear Fork downstream of the confluence with an unnamed tributary.**



Photo 13: Wide pool in the Clear Fork with moderately steep and heavily vegetated banks, upstream of the Antelope Creek confluence.



Photo 14: Clear Fork downstream of the proposed dam and service spillway showing vegetated, stable banks.

(This page intentionally left blank.)

Appendix E
Vegetation Species Observed within the Proposed Cedar Ridge Reservoir Site along the Clear Fork of the Brazos River, 23-26 March 2009

Appendix E
Vegetation Species Observed within the Proposed Cedar Ridge Reservoir Site along the Clear Fork of the Brazos River, 23-26 March 2009

Common Name	Scientific Name
Trees	
American elm	*Ulmus americana*
Ashe juniper	*Juniperus ashei*
Black willow	*Salix nigra*
Bumelia	*Sideroxylon lanuginosum* subsp. *oblongifolium*
Buttonbush	*Cephalanthus occidentalis*
Common hackberry	*Celtis laevigata*
Mesquite	*Prosopis glandulosa*
Mexican buckeye	*Ungnadia speciosa*
Oklahoma plum	*Prunus gracilis*
Pecan	*Carya Illinoinensis*
Tamarix	*Tamarix gallica*
Shrubs	
Aromatic sumac	*Rhus aromatica*
Christmas cactus	*Cylindropuntia leptocaulis*
Ephedra	*Ephedra antisyphilitica*
Forestiera	*Forestiera pubescens*
Lotebush	*Ziziphus obtusifolia*
Grasses/Forbs	
Bermudagrass	*Cynadon dactylon*
Buckley's yucca	*Yucca constricta*
Buttercup	*Ranunculus sceleratus*
Cocklebur	*Xanthium strumarium*
Common broomweed	*Amphiachyris dracunculoides*
Common goldenrod	*Solidago canadensis*
Curly dock	*Rumex crispus*
Deer pea vetch	*Vicia ludoviciana*
Eleocharis	*Eleocharis parvula*
Fragrant flat sedge	*Cyperus odoratus*
Giant ragweed	*Ambrosia trifida*
Greenbriar	*Smilax bona-nox*
Hooded windmill grass	*Chloris cutullata*
Japanese brome	*Bromus japonicus*

Appendix E
Vegetation Species Observed within the Proposed Cedar Ridge Reservoir Site along the Clear Fork of the Brazos River, 23-26 March 2009 (Concluded)

Common Name	Scientific Name
Johnson grass	*Sorghum halepense*
King Ranch bluestem	*Bothriochloa ischaemum* var. *songarica*
Leather-flower	*Clematis pitcheri*
Narrow-leaf sumpweed	*Iva angustifolia*
Pink evening primrose	*Oenothera speciosa*
Popweed	*Lesquerella gordonii*
Povertyweed	*Baccharis neglecta*
Prairie tea	*Croton monanthogynus*
Purple threeawn	*Aristida purpurea var. purpurea*
Sawtooth sunflower	*Grindelia papposa*
Scrambled-eggs	*Corydalis curvisiliqua*
Silver bluestem	*Bothriochloa laguroides* var. *torreyana*
Silverleaf nightshade	*Solanum elaeanifolium*
Slender vervain	*Verbena halei*
Switchgrass	*Panicum virgatum*
Tall dropseed	*Sporobolus compositus* var. *compositus*
Texas pricklypear	*Opuntia engelmannii var. lindheimeri*
Texas wintergrass	*Nassella leucotricha*
Virginia wild rye	*Elymus virginicus*
Western ragweed	*Ambrosia psilostachya*
William Emory's caric sedge	*Carex emoryi*
White sagebrush	*Artemisia ludoviciana*

Appendix F
Wildlife Habitat Appraisal Procedure (WHAP)

Appendix F
Wildlife Habitat Appraisal Procedure (WHAP)

The TPWD developed the WHAP to allow for the evaluation of wildlife habitat for specific tracts of land within the state without requiring large amounts of time for field work or compilation of the resulting data.

The WHAP was designed to be used to evaluate impacts upon wildlife populations from specific development projects, to establish baseline data prior to changes in habitat conditions within specific areas, to compare tracts of land proposed for land acquisition or mitigation, and to evaluate the general habitat quality and wildlife management potential of tracts of land within large geographical areas. However, this procedure was not designed to evaluate habitat quality in relation to specific wildlife species. The WHAP data assembled for the Cedar Ridge Reservoir site was collected during a second vegetation field survey performed within the proposed normal pool area from May 24-28, 2010.

Prior to initiating the vegetation cover data collection, a review of 2008 aerial photographs was conducted to determine the preliminary vegetation cover types found within the study area. Several potential sampling points within each cover type were then identified based on the aerial mapping and accessibility to the site. Sudden variations in soils, elevation, or vegetation disturbances were avoided when selecting sampling sites. Because the majority of the project area occurs within the Hendrick Ranch, surveys were limited to that area to simplify obtaining landowner permission.

The WHAP procedure includes three primary sections. Section 1 is designed to measure key components contributing to the ecological condition of the evaluated tract and the resulting overall suitability for wildlife. This section includes the assigning of value scores for each vegetation cover type present within the study area. Biological components incorporated in this evaluation section include (1) site potential, (2) temporal development of the existing successional stage, (3) uniqueness and relative abundance, (4) vegetation species diversity, (5) vertical vegetation stratification, (6) additional structural diversity components, and (7) condition of existing vegetation. These seven components are scored during the field survey for all sites selected for a specific vegetation cover type. It is assumed with this appraisal procedure that vegetation alone is sufficient to define habitat suitability for wildlife, that a positive relationship exists between vegetation diversity and wildlife species diversity, and that

vegetation composition and primary productivity directly influence the population density of wildlife species.

The survey effort at each site included an area large enough to provide an adequate representation of the dominantly occurring woody and herbaceous plants. All tree and shrub species found within an 80-foot radius of the selected sample site point were identified, along with all herbaceous species present in a one square meter subsample area.

A minimum number of sites representing each delineated cover type were inspected to ensure an acceptable appraisal. The number of sites surveyed reflects the percentage of each cover type found within the normal pool area of the proposed reservoir. A map illustrating the location of all the vegetation cover type sampling sites is included as Figure 1, and photos of representative vegetation areas are included following this discussion. All data collected in the field were recorded on standardized WHAP data sheets which are also included in this document. Habitat quality scores produced from the use of this form facilitate the comparison of cover types within or between tracts. These scores may also be used to determine strategies and needs associated with resource management planning.

The resulting Average Habitat Quality Score for all sites found within each cover type were then multiplied by their corresponding acreage values to generate available Habitat Units (HU). HU values are used to determine the extent of projected impacts upon a tract and establish the amount of habitat required to adequately compensate for unavoidable adverse impacts.

Section 2 of the WHAP, the Significance of Protected Flora and Fauna, does not require field data collection but rather an evaluation of protected fauna and flora, their distributional range and potential for occurrence in the study area. Section 2 data is included within this document. Section 3 concentrates on factors which might affect acquisition priority or management strategies. Because the land in the study area is privately owned and therefore not subject to management decisions by the TPWD, the Management Components Evaluation, or Section 3, is not applicable to this project.

The final product of this procedure is the Wildlife Habitat Appraisal Summary for the evaluated tract, which utilizes the values developed in the WHAP (Table 1). For the Cedar Ridge Reservoir site, this procedure estimates that 3241.01 Habitat Units within the normal pool area are affected by the construction of the reservoir.

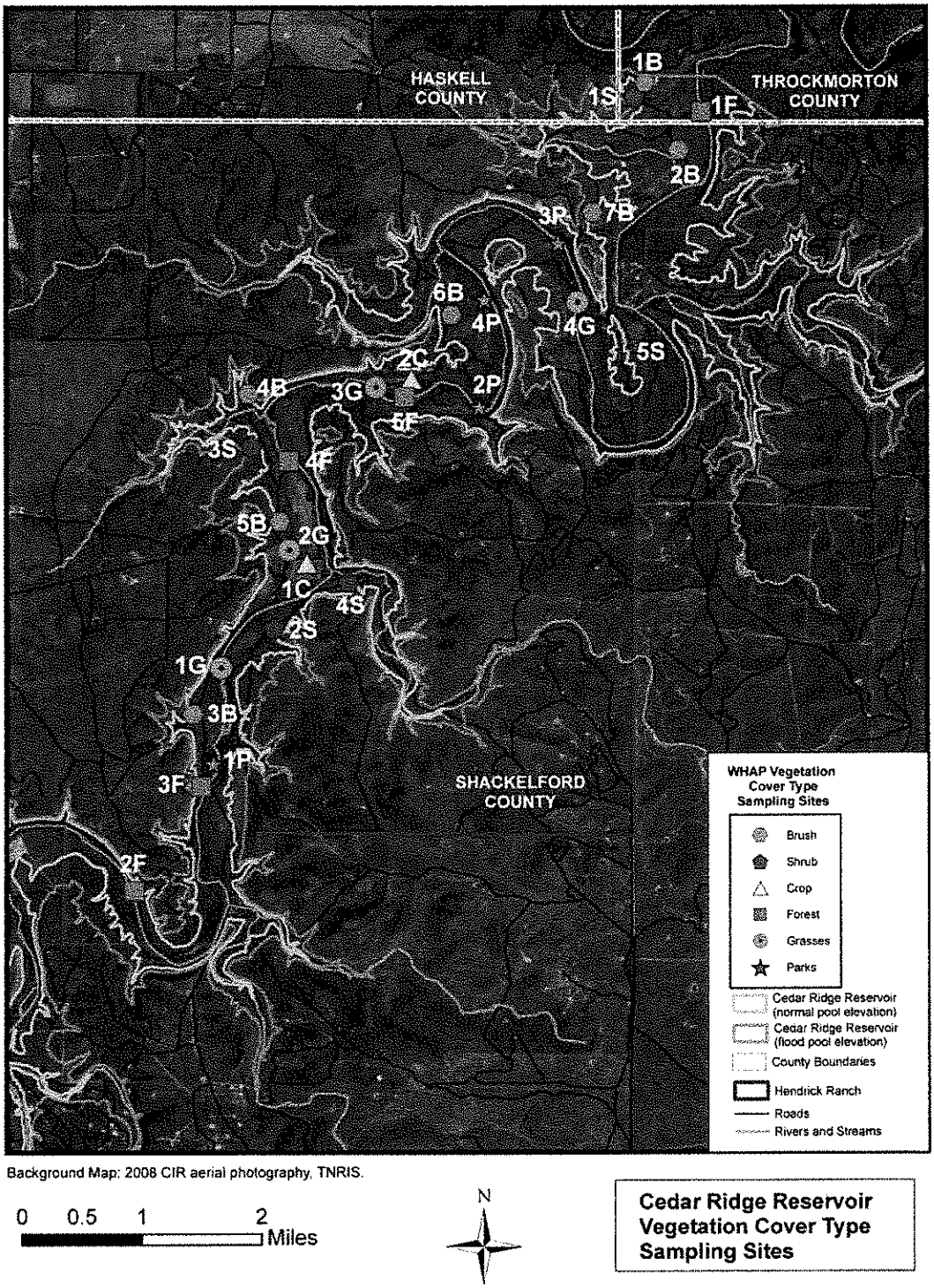


Figure 1. Cedar Ridge Reservoir Vegetation Cover Type Sampling Sites

The WHAP survey in 2010 occurred during a spring season which had an unusually heavy amount of rainfall. The project area received an additional 5 inches of rain over its normal rainfall quantity, resulting in vegetation abundance and diversity which could be considered uncharacteristically robust. Higher river levels also resulted in impassable conditions which result in the use of only those sample sites which were accessable west of the river.

A total of 106 different plant species were documented within the 27 sites surveyed. A table listing all the vegetation species found during the WHAP survey is included as Table 2. No federal or state threatened or endangered plants are listed for any of the counties in the study area. However, a secondary list of rare or uncommon, but not imperiled plant species compiled by the TPWD and The Nature Conservancy (TNC) was also reviewed. The Osage plains false-foxglove (*Agalinis densiflora*) is a rare species historically known to occur in Shackelford County. Cory's evening primrose (*Oenothera coryi*), another uncommon plant species was listed as occurring in Throckmorton County.[1] Texas endemic species potentially occurring in the study area include the denseflower bladderpod (*Lesquerella densiflora*), and a subspecies of the curvepod corydalis (*Corydalis curvisiliqua* ssp *curvisiliqua*).[2] No individuals of these four species were observed during this survey.

1 The Texas Nature Conservancy (TNC). 2009. Abstracts for G3/T3 and rare plant taxa of Texas: species information for select quasi-rare plants of Texas. http://www.nature.org/wherewework/northamerica/states/texas/science/art6069.html. Accessed March 4, 2009.

2 Carr, W. R. 2002. No Place But Texas: An Annotated List of Plant Taxa Endemic to the Lone Star State. Incomplete Working Draft, February 2002.

Table 1.
Wildlife Habitat Appraisal Summary

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Summary

1 Cover Type Category	2 Type or Plant Association	3 Average Habitat Quality Score	4 Total Acres	5 Habitat Units (Col. 3 X Col. 4)
Brush 1.		0.499	4763	2376.74
Shrub 1.		0.442	625	276.25
Park 1.		0.583	28	16.32
Forest 1.		0.660	514	339.24
Grass/Forbs 1.		0.438	76	33.29
Crop 1.		0.320	261	83.52
Marsh 1.		0.550	6	3.3
Inert Materials 1.		0.130	1	0.13

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Summary

1 Cover Type Category	2 Type or Plant Association	3 Average Habitat Quality Score	4 Total Acres	5 Habitat Units (Col. 3 X Col. 4)
Water				
1.		0.310	362	112.22

Total: 3241.01

1. Total Habitat Units = Total Column 5 (From Section I) = 3241.01

2. Protected Species (PS) or Endangered Species (ES) (From Section II) = 340

3. Acquisition and Administration Components Score (AC) (From Section III) = N/A

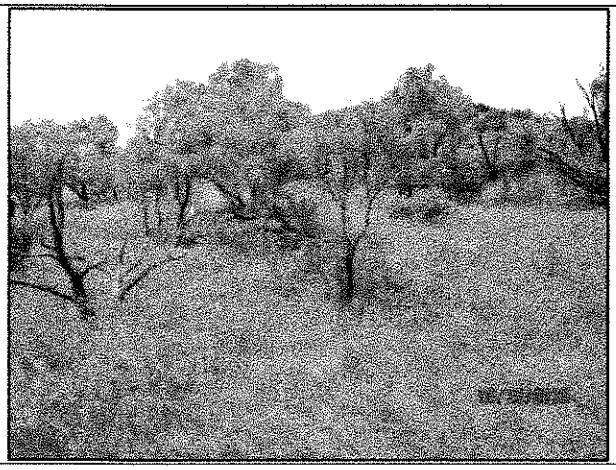
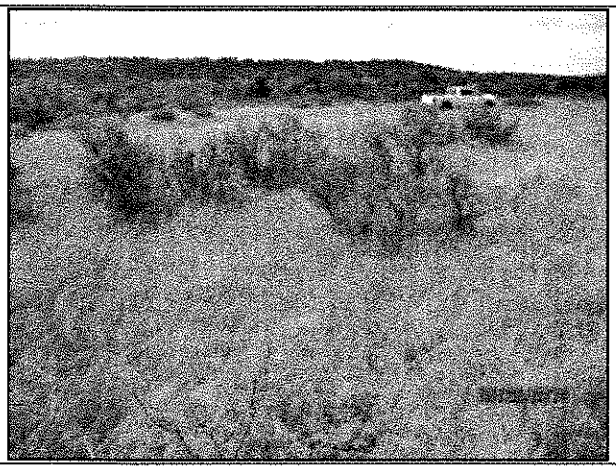
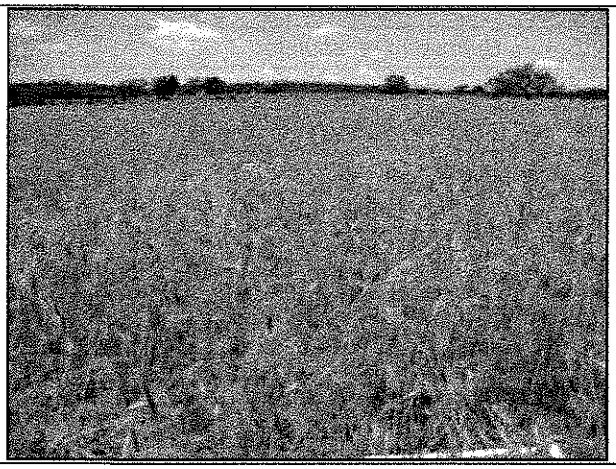
Total=3581.01

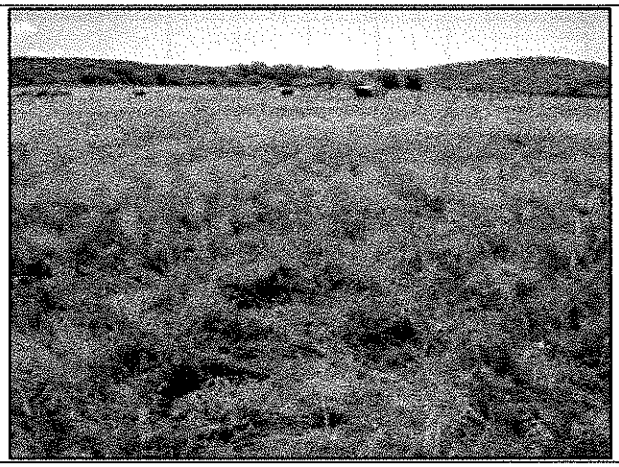
Table 2.
Vegetation Species Observed During the WHAP Survey
May 24-28, 2101 Cedar Ridge Reservoir

Common Name	*Scientific Name*
Trees	
American elm	*Ulmus americana*
Bumelia	*Sideroxylon lanuginosum* subsp. *oblongifolium*
Buttonbush	*Cephalanthus occidentalis*
Catclaw acacia	*Acacia greggii var. greggii*
Cedar Elm	*Ulmus crassifolia*
Dwarf hackberry	*Celtis tenuifolia*
Mesquite	*Prosopis glandulosa*
Mexican buckeye	*Ungnadia speciosa*
Net-leaf hackberry	*Celtis laevigata var. reticulata*
Pecan	*Carya Illinoinensis*
Redberry juniper	*Juniperus pinchotii*
Siberian elm	*Ulmus pumila*
Sugar hackberry	*Celtis laevigata* var. *laevigata*
Texas prickly ash	*Zanthoxylum hirsutum*
Western soapberry	*Sapindus saponaria* var. *drummondii*
Shrubs	
Aromatic sumac	*Rhus aromatica*
Beebush	*Aloysia gratissima*
Buckley's yucca	*Yucca constricta*
Catclaw sensitivebriar	*Mimosa microphylla*
Christmas cactus	*Cylindropuntia leptocaulis*
Desert sumac	*Rhus microphylla*
Ephedra	*Ephedra antisyphilitica*
Forestiera	*Forestiera pubescens var. glabrifolia*
Forestiera	*Forestiera pubescens var. pubescens*
Lotebush	*Ziziphus obtusifolia*
Grasses/Forbs	
Baby white aster	*Chaetopappa ericoides*
Basketflower	*Centaurea americana*
Bermudagrass	*Cynadon dactylon*
Blackfoot daisy	*Melanpodium leucanthum*
Common broomweed	*Amphiachyris dracunculoides*
Browntop signalgrass	*Urochloa fusca*
Buffalograss	*Buchloe dactyloides*
Bur clover	*Medicago minima*

Common Name	Scientific Name
Catchweed bedstraw	*Galium aparine*
Catnip noseburn	*Tragia ramosa*
Grasses/Forbs	
Common flax	*Linum usitatissimum*
Creeping ladies sorrel	*Oxalis corniculata*
False nightshade	*Chamaesaracha sordida*
Fendler threeawn	*Aristida purpurea var. longiseta*
Field brome	*Bromus arvensis*
Firewheel	*Gaillardia pulchella*
Golden tickseed	*Coreopsis tinctoria*
Greenthread	*Thelesperma filifolium*
Hairy tridens	*Erioneuron pilosum*
Halfshrub sundrops	*Calylophus berlandieri ssp. pinifolius*
Halls panicgrass	*Panicum hallii* var. *hallii*
Hare barley	*Hordeum murinum* subsp. *leporinum*
Hillside vervain	*Verbena neomexicana*
Hooded windmill grass	*Chloris cutullata*
Jointed goatgrass	*Aegilops cylindrica*
Lacy germander	*Teucrium laciniatum*
Lemon beebalm	*Monarda citriodora*
Little barley	*Hordeum pusillum*
Low silverbush	*Argythamnia humilis var. humilis*
Narrow-leaf liatris	*Liatris mucronata*
Peppergrass	*Lepidum virginicum*
Perennial broomweed	*Gutierrezia sarothrae*
Pin clover	*Erodium cicutarium*
Pink mock vervain	*Glandularia pumila*
Plains bluegrass	*Poa arida*
Popweed	*Lesquerella gordonii*
Prairie bluets	*Stenaria nigricans var. nigricans*
Prairie cordgrass	*Spartina pectinata*
Prairie pepperweed	*Lepidium densiflorum*
Prairie verbena	*Glandularia bipinnatifida*
Purple threeawn	*Aristida purpurea var. purpurea*
Queen Anne's Lace	*Daucus carota*
Redstem stork's bill	*Erodium cicutarium*
Rescuegrass	*Bromus catharticus*
Riddell's dozedaisy	*Aphanostephus riddellii*
Rio Grande bristlegrass	*Setaria reverchonii ssp. ramiseta*

Common Name	Scientific Name
Reverchon's bristlegrass	*Setaria reverchonii ssp. reverchonii*
Roemer's acacia	*Acacia roemeriana*
Sand muhly	*Muhlenbergia arenicola*
Saw greenbriar	*Smilax bona-nox*
Sideoats grama	*Bouteloua curtipendula*
Silver bluestem	*Bothriochloa laguroides* var. *torreyana*
Grasses/Forbs	
Silverleaf nightshade	*Solanum elaeagnifolium*
Slender vervain	*Verbena halei*
Small Venus' looking glass	*Triodanis biflora*
Southern caric sedge	*Carex austrina*
Spiderwort	*Tradescantia occidentalis*
Spotted spurge	*Chamaesyce maculata*
Sweet gaura	*Gaura drummondii*
Texas bluegrass	*Poa arachifera*
Texas blueweed	*Helianthus ciliaris*
Texas grama	*Bouteloua rigidiseta*
Texas pricklypear	*Opuntia engelmannii var. lindheimeri*
Texas sage	*Salvia texana*
Texas skeleton plant	*Lygodesmia texana*
Texas sleepy daisy	*Xanthisma texanum susbsp. drummondii*
Texas star	*Lindheimera texana*
Texas wintergrass	*Nassella leucotricha*
Trailing ratany	*Krameria lanceolata*
Twoleaf senna	*Senna roemeriana*
Vine mesquite	*Panicum obtusum*
Warty spurge	*Euphorbia spathulata*
Wedge-leaf spurge	*Euphorbia longicruis*
Western ragweed	*Ambrosia psilostachya*
Western wheatgrass	*Agropyron smithii*
Wheat	*Triticum aestivum*
Whitemouth dayflower	*Commelina erecta*
Windmillgrass	*Chloris verticillata*
Wooly plantain	*Plantago patagonica*

Photos of Representative Vegetation Types found within the Project Area	
	**Representative brush area.**
	**Representative shrub area.**
	**Representative crop area**

	**Representative forest area.**
	**Representative grass/forbs area.**
	**Representative park area.**

Wildlife Habitat Appraisal Procedure
Biological Components Field Evaluation

Project: Cedar Ridge Reservoir Date: May 25-28, 2010

Cover Type or Plant Association: Brush

Habitat Components	Component Points (from Key)							
Site No.	1	2	3	4	5	6	7	Total
1. Site Potential	7	7	7	7	7	7	7	49
2. Temporal Development								
Criteria A	6	6	6	6	6	12	12	54
Criteria B (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
3. Uniqueness and Relative Abundance	10	10	10	10	10	10	10	70
4. Vegetation Species Diversity								
Criteria A	3	3	3	3	3	4	3	22
Criteria B	3	3	3	5	3	5	3	25
Criteria C (Swamps Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
5. Vertical Stratification	4	4	3	4	4	4	5	28
6. Additional Structural Diversity Components	5	3	3	5	5	5	5	31
7. Condition of Existing Vegetation								
Criteria A (Woody Vegetation)	5	5	5	5	5	5	5	35
Criteria B (Herbaceous Vegetation)	5	5	5	5	5	5	5	35
Criteria C (Croplands Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0

Average Habitat Quality Score for all Sites within this cover type = $\frac{\text{Total Points}}{\text{Total number of sites}} \times \frac{1}{100} = 0.4986$

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Procedure
Species Diversity Worksheet

Project: Cedar Ridge Reservoir
Cover Type: Brush

Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
Berry/Drupe						
Netleaf hackberry	Netleaf hackberry	*Forestiera pubescens*	Netleaf hackberry	Netleaf hackberry	Netleaf hackberry	Bumelia
Desert Sumac	Lotebush	Lotebush	Bumelia	Lotebush	*Celtis tenuifolia*	Forestiera pubescens
Forestiera pubescens			*Forestiera pubescens*		*Forestiera pubescens*	Lotebush
Lotebush			Lotebush		Bumelia	Soapberry
			Aromatic sumac			Desert Sumac
Legume/Pod						
Mesquite	Mesquite	Mesquite	Mesquite	Mesquite	Mesquite	Mesquite
Catclaw acacia	Catclaw acacia	Catclaw acacia	Catclaw acacia		Catclaw acacia	Catclaw acacia
Acacia roemeriana			*Acacia roemeriana*			
Acorn						
Nut/Nutlike						
					Ephedra sp.	*Ephedra* sp.
Samara						
Cone						
Achene						
All Others						
Yucca constricta	Christmas cactus	Christmas cactus	*Ugadia speciosa*	*Ugadia speciosa*	Texas prickly ash	
		Texas prickly ash	Christmas cactus	Christmas cactus	Christmas cactus	

Wildlife Habitat Appraisal Procedure
Biological Components Field Evaluation

Project: Cedar Ridge Reservoir Date: May 24-28, 2010

Cover Type or Plant Association: Shrub

Habitat Components	**Component Points (from Key)**							
Site No.	1	2	3	4	5	6	7	**Total**
1. Site Potential	7	7	7	7	7			35
2. Temporal Development								
Criteria A	6	6	6	6	6			30
Criteria B (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
3. Uniqueness and Relative Abundance	10	10	10	10	10			50
4. Vegetation Species Diversity								
Criteria A	3	3	2	3	2			13
Criteria B	1	1	3	1	3			9
Criteria C (Swamps Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
5. Vertical Stratification	3	3	3	3	3			15
6. Additional Structural Diversity Components	5	5	5	3	3			21
7. Condition of Existing Vegetation								
Criteria A (Woody Vegetation)	5	5	5	3	5			23
Criteria B (Herbaceous Vegetation)	5	5	5	5	5			25
Criteria C (Croplands Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0

Average Habitat Quality Score for all Sites within this cover type = $\frac{\text{Total Points}}{\text{Total number of sites}} \times \frac{1}{100} = 0.442$

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Procedure
Species Diversity Worksheet

Project: Cedar Ridge Reservoir
Cover Type: Shrub

Site 1	Site 2	Site 3	Site 4	Site 5
Berry/Drupe				
Netleaf hackberry	Netleaf hackberry	Bumelia	Netleaf hackberry	Netleaf hackberry
Bumelia	Lotebush	Lotebush	Aromatic sumac	Lotebush
Forestiera pubescens		Netleaf hackberry		Redberry juniper
Lotebush		Aromatic sumac		Lotebush
Celtis tenuifolia				Bumelia
Legume/Pod				
Mesquite	Mesquite	Mesquite	Mesquite	Mesquite
	Catclaw acacia			Catclaw acacia
Acorn				
Nut/Nutlike				
Samara				
Cone				
Achene				
All Others				
Yucca constricta	Christmas cactus		*Yucca constricta*	*Ungadia speciosa*
			Texas prickly ash	Christmas cactus

Wildlife Habitat Appraisal Procedure
Biological Components Field Evaluation

Project: Cedar Ridge Reservoir Date: May 24-28, 2010

Cover Type or Plant Association: Park

Habitat Components	Component Points (from Key)							
Site No.	1	2	3	4	5	6	7	Total
1. Site Potential	12	12	12	12				48
2. Temporal Development								
Criteria A	12	12	12	12				48
Criteria B (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
3. Uniqueness and Relative Abundance	10	10	10	10				40
4. Vegetation Species Diversity								
Criteria A	4	3	4	4				15
Criteria B	1	3	3	3				10
Criteria C (Swamps Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
5. Vertical Stratification	4	4	4	4				16
6. Additional Structural Diversity Components	5	5	5	5				20
7. Condition of Existing Vegetation								
Criteria A (Woody Vegetation)	3	5	3	5				16
Criteria B (Herbaceous Vegetation)	5	5	5	5				20
Criteria C (Croplands Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0

Average Habitat Quality Score for all Sites within this cover type = $\frac{\text{Total Points}}{\text{Total number of sites}} \times \frac{1}{100} = 0.5825$

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Procedure
Species Diversity Worksheet

Project: Cedar Ridge Reservoir
Cover Type: Park

Site 1	Site 2	Site 3	Site 4
Berry/Drupe			
Lotebush	Netleaf hackberry	*Forestiera pubescens*	Netleaf hackberry
	Lotebush	Bumelia	Soapberry
	Bumelia	Soapberry	*Forestiera pubescens*
		Netleaf hackberry	Whitewood
Legume/Pod			
Mesquite	Mesquite	Mesquite	Mesquite
	Catclaw acacia		
Acorn			
Nut/Nutlike			
Pecan		Pecan	*Ephedra* sp.
Samara			
American elm			American elm
Cone			
Achene			
All Others			
	Christmas cactus	Buttonbush	

Wildlife Habitat Appraisal Procedure
Biological Components Field Evaluation

Project: Cedar Ridge Reservoir Date: May 24-28, 2010

Cover Type or Plant Association: Forest

Habitat Components	Component Points (from Key)							
Site No.	1	2	3	4	5	6	7	Total
1. Site Potential	12	12	12	12	12			60
2. Temporal Development								
Criteria A	12	12	12	12	12			60
Criteria B (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
3. Uniqueness and Relative Abundance	15	15	15	15	15			75
4. Vegetation Species Diversity								
Criteria A	5	5	5	4	5			24
Criteria B	3	3	3	3	3			15
Criteria C (Swamps Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
5. Vertical Stratification	5	5	5	5	5			25
6. Additional Structural Diversity Components	3	3	5	5	5			21
7. Condition of Existing Vegetation								
Criteria A (Woody Vegetation)	5	5	5	5	5			25
Criteria B (Herbaceous Vegetation)	5	5	5	5	5			25
Criteria C (Croplands Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0

Average Habitat Quality Score for all Sites within this cover type = $\frac{\text{Total Points}}{\text{Total number of sites}} \times \frac{1}{100} = 0.66$

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Procedure
Species Diversity Worksheet

Project: Cedar Ridge Reservoir
Cover Type: Forest

Site 1	Site 2	Site 3	Site 4	Site 5
Berry/Drupe				
Sugar hackberry	Sugar hackberry	*Forestiera pubescens*	Sugar hackberry	Desert hackberry
Desert hackberry	Soapberry	Lotebush	Soapberry	Lotebush
Forestiera pubescens	Bumelia	Bumelia	*Forestiera pubescens*	Desert hackberry
Bumelia	Lotebush	Soapberry	Lotebush	Sugar hackberry
Beebush		Sugar hackberry	Bumelia	Soapberry
Lotebush		Netleaf hackberry		*Forestiera pubescens*
				Cedar elm
Legume/Pod				
Mesquite	Mesquite	Mesquite	Mesquite	Mesquite
Acorn				
Nut/Nutlike				
Pecan	Pecan	Pecan	Pecan	Pecan
Ephedra				
Samara				
American elm	American elm	Chinese elm	American elm	American elm
			Chinese elm	
Cone				
Achene				
All Others				
Texas prickly pear	Christmas cactus	Christmas cactus		Christmas cactus
Christmas cactus				

Wildlife Habitat Appraisal Procedure
Biological Components Field Evaluation

Project: Cedar Ridge Reservoir Date: May 24-28, 2010

Cover Type or Plant Association: Grass/Forbes

Habitat Components	Component Points (from Key)							
Site No.	1	2	3	4	5			Total
1. Site Potential	12	12	20	20				64
2. Temporal Development								
Criteria A	5	5	6	6				22
Criteria B (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
3. Uniqueness and Relative Abundance	5	5	5	5				20
4. Vegetation Species Diversity								
Criteria A	1	1	2	1				5
Criteria B	1	1	1	1				4
Criteria C (Swamps Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
5. Vertical Stratification	1	1	3	3				8
6. Additional Structural Diversity Components	3	3	5	3				14
7. Condition of Existing Vegetation								
Criteria A (Woody Vegetation)	5	5	5	3				18
Criteria B (Herbaceous Vegetation)	5	5	5	5				20
Criteria C (Croplands Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0

Average Habitat Quality Score for all Sites within this cover type = $\frac{\text{Total Points}}{\text{Total number of sites}} \times \frac{1}{100} = 0.4375$

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Procedure
Species Diversity Worksheet

Project: Cedar Ridge Reservoir
Cover Type: Grass/forbes

Site 1	Site 2	Site 3	Site 4			
Berry/Drupe						
	Desert hackberry					
	Lotebush					
Legume/Pod						
Mesquite	Mesquite	Mesquite	Mesquite			
Acorn						
Nut/Nutlike						
Samara						
Cone						
Achene						
All Others						
		Buttonbush				

Wildlife Habitat Appraisal Procedure
Biological Components Field Evaluation

Project: Cedar Ridge Reservoir Date: May 24-28, 2010

Cover Type or Plant Association: Crop

Habitat Components	Component Points (from Key)							
Site No.	1	2	3	4	5	6	7	Total
1. Site Potential	12	12						24
2. Temporal Development								
Criteria A	1	1						2
Criteria B (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
3. Uniqueness and Relative Abundance	5	5						10
4. Vegetation Species Diversity								
Criteria A	--	--	--	--	--	--	--	0
Criteria B	--	--	--	--	--	--	--	0
Criteria C (Swamps Only)	--	--	--	--	--	--	--	0
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0
5. Vertical Stratification	3	3						6
6. Additional Structural Diversity Components	--	--	--	--	--	--	--	0
7. Condition of Existing Vegetation								
Criteria A (Woody Vegetation)	5	5						10
Criteria B (Herbaceous Vegetation)	1	5						6
Criteria C (Croplands Only)	1	5						6
Criteria D (Marsh Wetlands Only)	--	--	--	--	--	--	--	0

Average Habitat Quality Score for all Sites within this cover type = $\frac{\text{Total Points}}{\text{Total number of sites}} \times \frac{1}{100} = 0.320$

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Procedure
Species Diversity Worksheet

Project: Cedar Ridge Reservoir
Cover Type: Crop

Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
Berry/Drupe						
No woody species	No woody species					
Legume/Pod						
Acorn						
Nut/Nutlike						
Samara						
Cone						
Achene						
All Others						

Wildlife Habitat Appraisal Procedure
Biological Components Field Evaluation

Project: Cedar Ridge Reservoir Date: May 24-28, 2010

Cover Type or Plant Association: Marsh

Habitat Components	Component Points (from Key)							
Site No.	All							Total
1. Site Potential	25							25
2. Temporal Development								
Criteria A	0							0
Criteria B (Marsh Wetlands Only)	5							5
3. Uniqueness and Relative Abundance	0							0
4. Vegetation Species Diversity								
Criteria A	0							0
Criteria B	0							0
Criteria C (Swamps Only)	0							0
Criteria D (Marsh Wetlands Only)	15							15
5. Vertical Stratification	3							3
6. Additional Structural Diversity Components	1							1
7. Condition of Existing Vegetation								
Criteria A (Woody Vegetation)	0							0
Criteria B (Herbaceous Vegetation)	1							1
Criteria C (Croplands Only)	0							0
Criteria D (Marsh Wetlands Only)	5							5

Average Habitat Quality Score for all Sites within this cover type = $\frac{\text{Total Points}}{\text{Total number of sites}} \times \frac{1}{100} = 0.550$

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Procedure
Species Diversity Worksheet

Project: Cedar Ridge Reservoir

Cover Type: Marsh—No woody species present

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Berry/Drupe						
Legume/Pod						
Acorn						
Nut/Nutlike						
Samara						
Cone						
Achene						
All Others						

Wildlife Habitat Appraisal Procedure
Biological Components Field Evaluation

Project: Cedar Ridge Reservoir Date: May 24-28, 2010

Cover Type or Plant Association: Water

Habitat Components	Component Points (from Key)							
Site No.	All							Total
1. Site Potential	25							25
2. Temporal Development								
Criteria A	0							0
Criteria B (Marsh Wetlands Only)	0							0
3. Uniqueness and Relative Abundance	5							5
4. Vegetation Species Diversity								
Criteria A	0							0
Criteria B	0							0
Criteria C (Swamps Only)	0							0
Criteria D (Marsh Wetlands Only)	0							0
5. Vertical Stratification	0							0
6. Additional Structural Diversity Components	1							1
7. Condition of Existing Vegetation								
Criteria A (Woody Vegetation)	0							0
Criteria B (Herbaceous Vegetation)	0							0
Criteria C (Croplands Only)	0							0
Criteria D (Marsh Wetlands Only)	0							0

Average Habitat Quality Score for all Sites within this cover type = $\frac{\text{Total Points}}{\text{Total number of sites}} \times \frac{1}{100} = 0.310$

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Procedure
Species Diversity Worksheet

Project: Cedar Ridge Reservoir
Cover Type: Water—No woody species present

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Berry/Drupe						
Legume/Pod						
Acorn						
Nut/Nutlike						
Samara						
Cone						
Achene						
All Others						

Wildlife Habitat Appraisal Procedure
Biological Components Field Evaluation

Project: Cedar Ridge Reservoir Date: May 24-28, 2010

Cover Type or Plant Association: Inert Materials (roads)

Habitat Components	Component Points (from Key)							
Site No.	All							Total
1. Site Potential	7							7
2. Temporal Development								
Criteria A	1							1
Criteria B (Marsh Wetlands Only)	0							0
3. Uniqueness and Relative Abundance	0							0
4. Vegetation Species Diversity								
Criteria A	0							0
Criteria B	0							0
Criteria C (Swamps Only)	0							0
Criteria D (Marsh Wetlands Only)	0							0
5. Vertical Stratification	1							1
6. Additional Structural Diversity Components	3							3
7. Condition of Existing Vegetation								
Criteria A (Woody Vegetation)	0							0
Criteria B (Herbaceous Vegetation)	1							1
Criteria C (Croplands Only)	0							0
Criteria D (Marsh Wetlands Only)	0							0

Average Habitat Quality Score for all Sites within this cover type = $\frac{\text{Total Points}}{\text{Total number of sites}} \times \frac{1}{100} = 0.13$

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Procedure
Species Diversity Worksheet

Project: Cedar Ridge Reservoir

Cover Type: Inert Materials—No woody species present

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Berry/Drupe						
Legume/Pod						
Acorn						
Nut/Nutlike						
Samara						
Cone						
Achene						
All Others						

TEXAS PARKS & WILDLIFE

Wildlife Habitat Appraisal Procedure
Protected and Endangered Species Evaluation Summary
Section 2

Endangered Species	**Points**
Whooping crane	20
Gray wolf--extirpated	0
Red wolf--extirpated	0
Interior least tern	50
No listed species	
Total	70
Endangered Species Score (ES) = Total Points =	70

Protected Species	**Points**
Brazos water snake	80
Texas horned lizard	80
American peregrine falcon	10
Bald eagle	10
Peregrine falcon	10
Smooth pimpleback mussel	40
Texas fawnsfoot mussel	40
No listed species	0
Total	270
Protected Species Score (PS) = Total Points =	340

Enter the sum of the Protected Species (PS) and Endangered Species (ES) scores on the Wildlife Habitat Appraisal Summary Sheet.

Appendix G
Brazos Water Snake

Appendix G
Brazos Water Snake

The Brazos water snake (*Nerodia harteri harteri*) is a relatively small, highly aquatic snake endemic to the upper Brazos River drainage in north-central Texas. The known range of this snake is limited to approximately 440 miles of the upper Brazos River and some of its tributaries[1] (Figure G-1), giving it one of the most restricted geographic distributions of any North American snake species.[2] From upstream to downstream the Brazos water snake is known to occur along the following river segments: the last 10 miles of Deadman Creek, a tributary to the Clear Fork in Jones and Shackelford counties; Paint Creek below Lake Stamford, a tributary to the Clear Fork in Haskell and Throckmorton counties; the Clear Fork from the city of Lueders, on the Jones-Shackelford County line, downstream to approximately Fort Griffin, Shackelford County; and generally the Brazos River from Morris Sheppard Dam (Possum Kingdom Lake), Palo Pinto County, downstream to the headwaters of Lake Whitney, near where Bosque, Johnson, and Somervell Counties meet.[3,4] In addition to these river segments, the Brazos water snake is also known to inhabit two reservoirs along the main stem of the Brazos River, Possum Kingdom Lake and Lake Granbury. [5,6]

Even within this restricted range, the population distribution of the Brazos water snake is not contiguous, but rather patchy, and is linked to the availability of suitable habitat. Preferred habitat, particularly for juvenile snakes, consists of rocky shallow areas for foraging adjacent to gently sloping rocky shorelines with sparse vegetation for shelter and thermoregulation (i.e., internal core temperature regulation).[7] Along the river corridor these habitat features are commonly associated with riffle areas. Within reservoir environments the Brazos water snake

[1] Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.
[2] Werler, J. E., and J. R. Dixon. 2000. Texas Snakes: Identification, Distribution, and Natural History. University of Texas Press, Austin.
[3] Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.
[4] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.
[5] Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.
[6] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.
[7] Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.

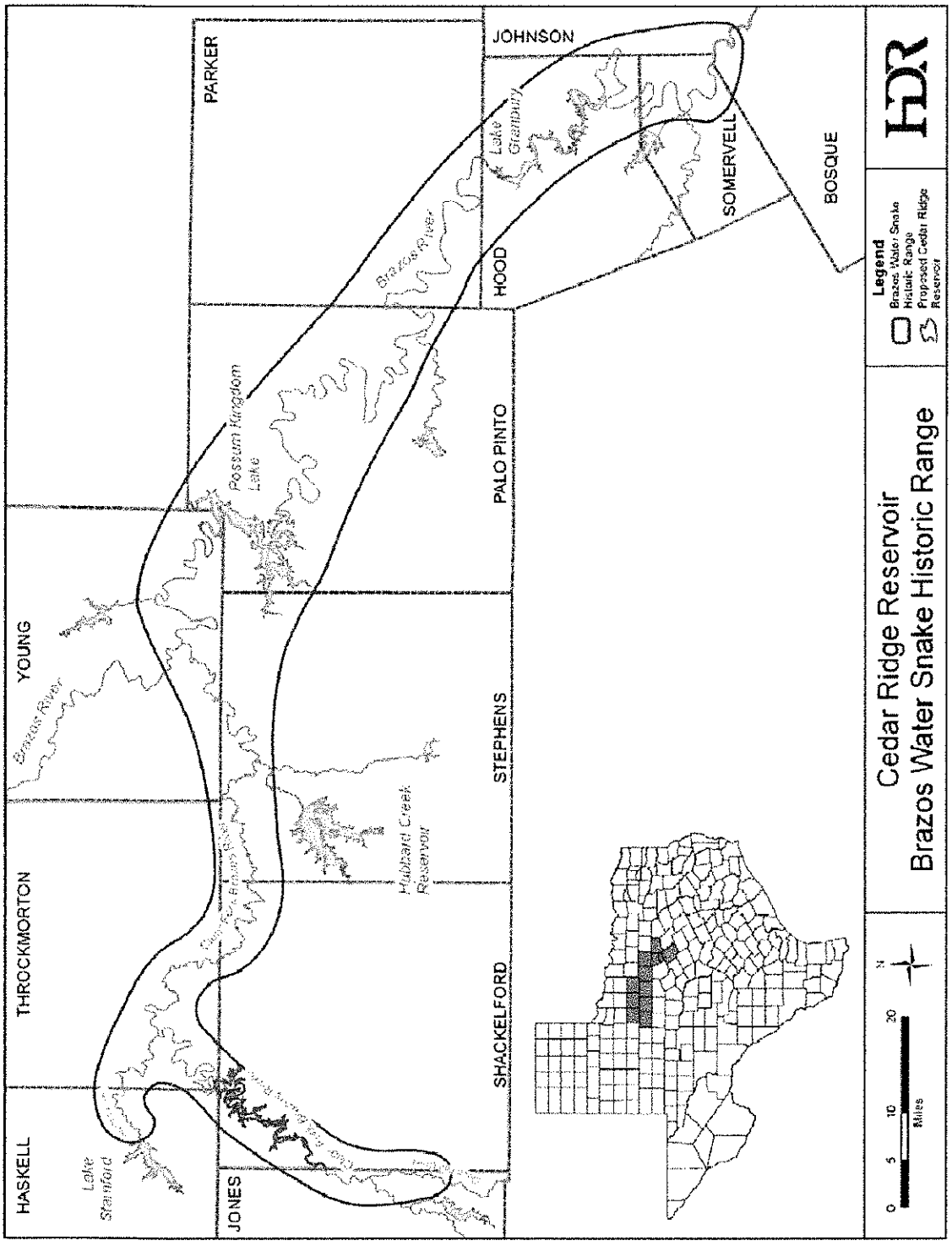


Figure G-1. Historic Range of the Brazos Water Snake. Reproduced From McBride [8].

[8] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.

is also known to occupy those portions of shoreline which include similar features.[9] While adult Brazos water snakes can utilize a wider range of habitats than the juveniles, including deeper waters, their distribution is limited by their need for secure rocky cover and the distance that they can travel from suitable rocky areas for giving birth.[10]

Formal concern for the conservation of the Brazos water snake was expressed in 1977, when the State of Texas placed both it and the closely related Concho water snake (*Nerodia harteri paucimaculata*; a subspecies from the Concho and Colorado River drainages in central Texas), on the state list of endangered species.[11] This listing was apparently prompted due to the local endemism of both snakes to their respective river drainages and the overall lack of information concerning their distribution, population, and ecology. Following several studies funded by the U.S. Fish & Wildlife Service (USFWS)[12,13,14] to fill these information gaps and a petition to list both snakes as federally threatened in 1984[15], it was determined that federal listing was warranted only for the Concho water snake.[16] Consequently the Concho water snake was listed as federally threatened in 1986.[17] It should be noted that the USFWS has recently proposed to remove this snake from the federal list of endangered and threatened wildlife.[18]

Given the location of the proposed Cedar Ridge Reservoir within the known range of the Brazos water snake and the potential impacts that a reservoir may have on this state threatened species, an investigation of the Brazos water snake population and habitat within and surrounding the reservoir footprint was initiated as part of an evaluation of the proposed reservoir as a new water supply source for the city of Abilene and the surrounding region. Data

[9]Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.
[10] Ibid.
[11] Ibid.
[12] Maxwell, T. C. 1982. Status and distribution of *Nerodia harteri harteri*. Unpublished Report, Endangered Species, U.S. Fish and Wildlife Service, Albuquerque, NM.
[13] Scott, N. J., Jr., and L. A. Fitzgerald. 1985. Status survey of *Nerodia harteri*, Brazos and Concho-Colorado Rivers, Texas. Unpublished Report, Endangered Species, U. S. Fish and Wildlife Service, Albuquerque, NM.
[14] Flury, J. W., and T. C. Maxwell. 1981. Status and distribution of *Nerodia harteri paucimaculata*. Unpublished Report, Endangered Species, U.S. Fish and Wildlife Service, Albuquerque, New Mexico.
[15] Dodd, K., Jr. 1984. Endangered and threatened wildlife and plants; findings on petitions involving the yacare caiman and Harter's water snake. Federal Register 49:21089–21090.
[16] Drewry, G. 1985. 50 CFR Part 17. Endangered and threatened wildlife and plants; findings on petitions and initiation of status review. Federal Register 50:29238-29239.
[17]Stefferud, S. 1986. 50 CFR Part 17. Endangered and threatened wildlife and plants; determination of *Nerodia harteri paucimaculata* (Concho Water Snake) to be a threatened species; final rule. Federal Register 51:31412-31422.
[18] U.S. Fish and Wildlife Service (USFWS). 2008. Endangered and threatened wildlife and plants; proposed removal of the Concho water snake (*Nerodia paucimaculata*) from the federal list of endangered and threatened wildlife; removal of federally designated critical habitat. Federal Register 73:38956–38967.

collected during this investigation will facilitate a better understanding of current Brazos water snake populations and habitat preferences within the proposed reservoir site, surrounding stream reaches, and existing reservoirs. Furthermore, these data will provide essential information considered necessary for future mitigation and planning efforts for the Cedar Ridge project. Objectives of this investigation are to (1) document the occurrence of Brazos water snakes within and surrounding the Cedar Ridge Reservoir site, and (2) investigate the habitat characteristics of locations where Brazos water snakes occur within existing reservoir environments.

In-depth surveys by HDR Engineering, Inc. (HDR) biologists led by Dustin McBride, an experienced Brazos water snake researcher, were initiated in the spring of 2009 to assess the presence and habitat of the Brazos water snake within and surrounding the proposed Cedar Ridge Reservoir site. These surveys are currently on-going; however, preliminary results indicate that Brazos water snake populations and suitable habitat exist along the Clear Fork, both within and downstream of the proposed Cedar Ridge Reservoir footprint, in addition to three (3) tributaries to the Clear Fork that will remain unaffected by the proposed reservoir project. Because survey efforts are currently continuing, any data collected during surveys subsequent to this report will be analyzed and presented in future amendments. A detailed discussion of the surveys completed to-date and their results are presented in the following sections.

G.1 Study Area and Methods

Surveys for the Brazos water snake have been conducted by HDR from March 2009–October 2010 (Table G-1). Along the Clear Fork, surveys have been conducted along an 82-mile stretch in Haskell, Throckmorton, and Shackelford counties beginning at an old dam and spillway (32°47.576'N, 99°36.696'W) near the Town of Lueders, Texas, and continuing downstream to approximately where the Clear Fork crosses the Shackelford-Throckmorton county line (32°57.433'N, 99°14.118'W), northwest of Fort Griffin (Figure G-2).

In addition to the surveys along the Clear Fork, surveys for Brazos water snakes have also been conducted within Possum Kingdom Lake (Palo Pinto County), Lake Stamford (Haskell County), along 21 miles of Paint Creek below Lake Stamford, 13 miles of California Creek, and 13 miles of Deadman Creek (Figures G-2 and G-3). Paint Creek is a tributary to the Clear Fork, located downstream of the proposed reservoir project, in Haskell and Throckmorton counties. Surveys along Paint Creek began at a road crossing and dam (33°04.709'N, 99°32.613'W) approximately one mile downstream from the Lake Stamford dam, and continued downstream to

its confluence with the Clear Fork (33°03.105'N, 99°22.337'W). California Creek is a tributary to Paint Creek found in Haskell County. Surveys along California Creek began at a road crossing approximately 13 miles upstream from the creek's confluence (32°59.799'N, 99°35.459'W), and continued downstream to a point approximately 0.5 miles upstream from the confluence with Paint Creek (33°04.334'N, 99°32.369'W). Deadman Creek is a small tributary to the Clear Fork upstream of the proposed reservoir project in Jones and Shackelford counties. Surveys along Deadman Creek began at a point approximately 14 miles upstream from the creek's confluence with the Clear Fork (32°34.992'N, 99°38.563'W), and continued downstream to a point approximately 0.25 miles upstream from this confluence (32°43.441'N, 99°37.491'W).

Table G-1
Brazos Water Snake Surveys Conducted
and Areas Surveyed, March 2009–October 2010

Dates	*Survey Area*	*Linear Distance (mi)*
March–May 2009	Clear Fork: Hendrick Ranch	33
	Clear Fork: Lueders–Hendrick Ranch	46
September–October 2009	Clear Fork: Lueders–Hendrick Ranch	46
	Possum Kingdom Lake	--
	Lake Stamford	--
April–June 2010	Clear Fork: Lueders–Lambshead Ranch	82
	Paint Creek	21
	Possum Kingdom Lake	--
	Lake Stamford	--
September–October 2010	Clear Fork: Lueders–Lambshead Ranch	82
	California Creek	13
	Deadman Creek	13
	Possum Kingdom Lake	--

Field surveys for Brazos water snakes are concentrated primarily during the spring (April–May) and fall (September–October), as these times coincide with periods of greatest Brazos water snake activity and population densities, respectively.[19,20] Surveys along the river corridor consist of a team of two people floating down the river in a kayak or canoe and subjectively assessing the habitat for Brazos water snake suitability. Upon encountering

[19] Mueller, J. M. 1990. Population dynamics of the Concho water snake. Thesis, Texas A&M University, College Station.
[20] Greene, B. D. 1993. Life history and ecology of the Concho Water Snake, *Nerodia harteri paucimaculata*. Unpublished Ph.D. Dissertation, Texas A&M University, College Station.

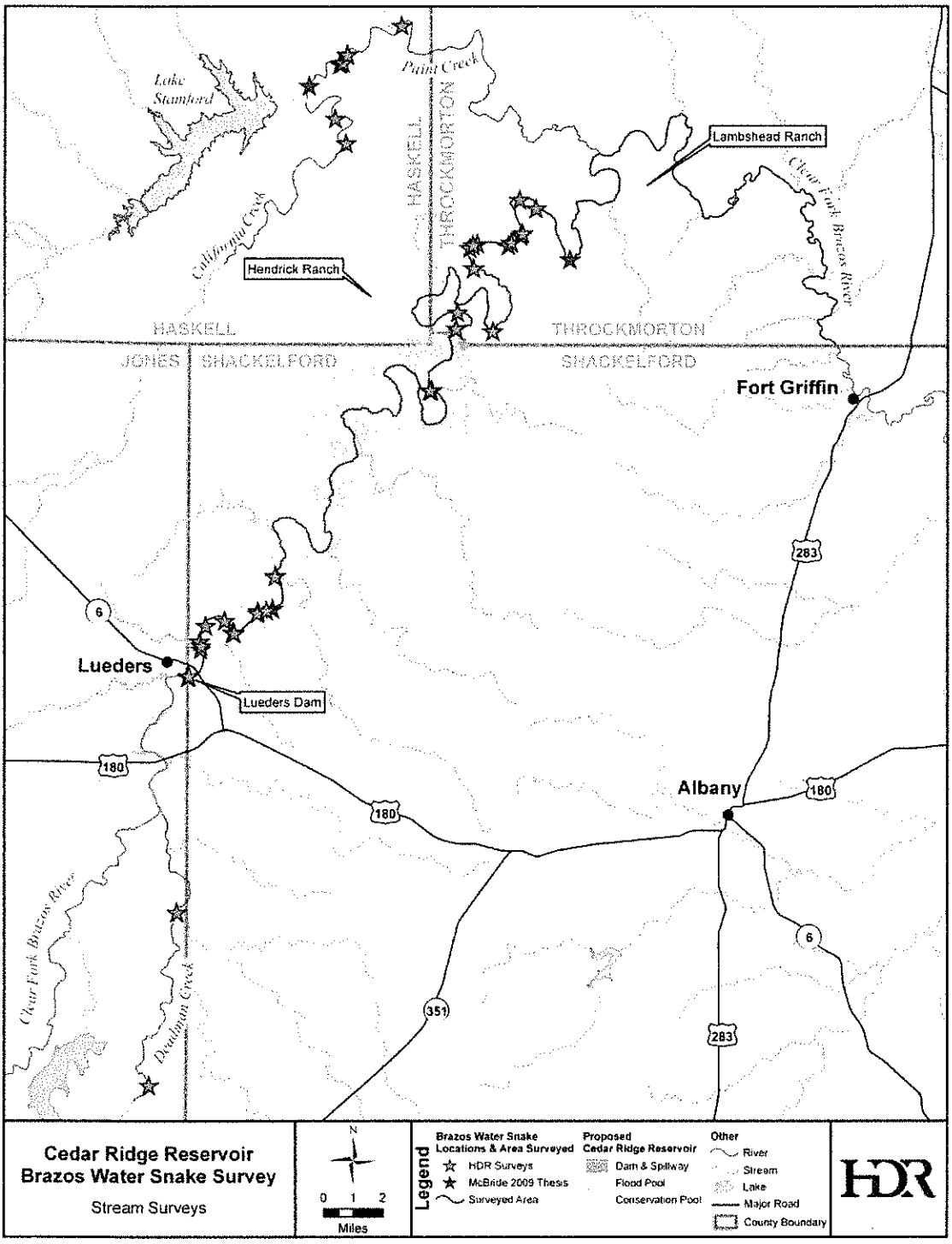


Figure G-2. Area Surveyed and Locations of Brazos Water Snakes, March 2009–October 2010, Including Locations Reported by McBride [21].

[21] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.

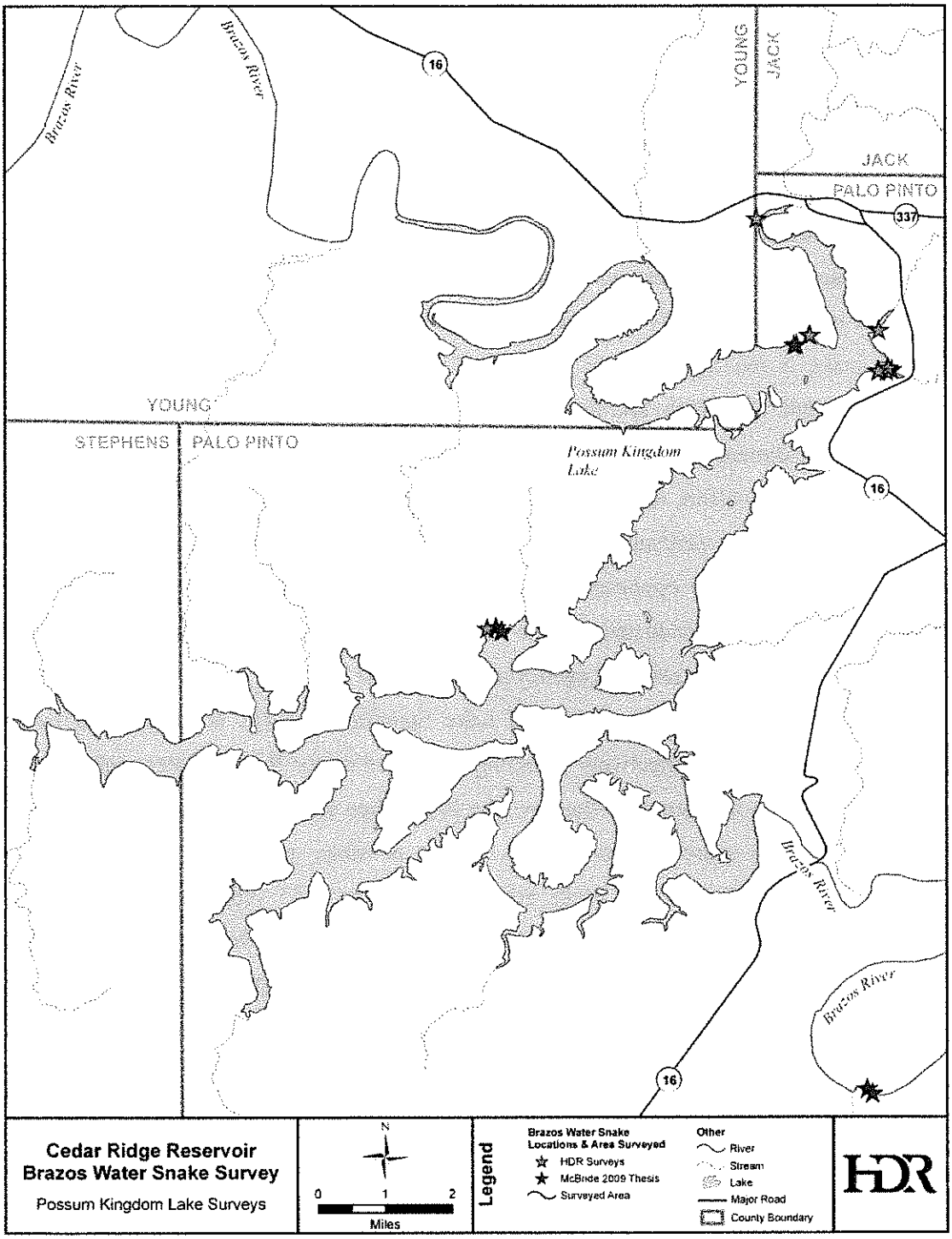


Figure G-3. Brazos Water Snake Locations within Possum Kingdom Lake, March 2009–October 2010, Including Locations Reported by McBride [22].

[22] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.

potentially suitable habitat (i.e., shallow rocky riffles), intensive searches on foot are then conducted.

Intensive searches of the shoreline consist of turning by hand and searching under any rock large enough to harbor a snake found within 10 feet (3 m) of the water's edge, as well as searching rock crevices, vegetation, and debris piles. The linear extent of potentially suitable habitat is recorded using a handheld Global Positioning System (GPS). Visual searches of the shoreline, vegetation, and surrounding water are also conducted while traveling between sites. An attempt is made to identify all snakes observed to species. The geographic location of each observed snake is recorded using a handheld GPS. Snakes are captured by hand, measured (snout-vent length, tail length, and mass), sexed, and released. If a Brazos water snake is found under a rock, the dimensions (shortest axis × longest axis × thickness) of the rock are measured. To account for survey effort, the time spent intensively searching on foot at each site is recorded, as well as the total time spent surveying the river corridor. In addition to these in-depth surveys, snakes were also observed opportunistically at five sites along the Clear Fork during Aquatic Life Monitoring surveys conducted in June 2009 (Appendix H), and at selected river crossings during a brief site visit with resource agency staff in August 2010.

Within Possum Kingdom Lake and Lake Stamford, surveys are conducted by small motorboat and consist of subjectively assessing the shoreline for Brazos water snake suitability (i.e., rocky shorelines adjacent to a shallow lake floor), then slowly floating close to the water's edge while visually searching for snakes. When possible, potentially suitable habitat is intensively searched on foot and rocks are turned by hand. To supplement visual searches, commercial minnow traps are used opportunistically in areas deemed potentially suitable. Minnow traps are placed partially submerged and parallel to the shoreline and tied to nearby vegetation, rocks, or debris. Once set, traps are left overnight and checked the following morning. The geographic coordinates of the traps and the total time traps are set are recorded.

Habitat characteristics of locations where Brazos water snakes are found within reservoir environments are quantified along 200-foot (60 m) segments of shoreline centered on the location where the snake was observed. Along each 200-foot segment, the shoreline substrate at the water's edge is classified into one of three size classes: silt–gravel (≤3.90 inches [99 mm]), cobble (3.94 inches–10.08 inches [100 mm–256 mm]), and boulder (>10.08 inches). Lake depth and lake floor substrate is assessed at 10-foot intervals along three 50-foot (15 m) transects that run perpendicular to the shoreline and are located at the center and ends of each 200-foot

segment. Lake floor substrate is categorized as rock, gravel, mud, or silt. Slope of the lake floor is calculated using linear regression of lake depth data. In addition to collecting habitat data at locations where snakes are found during active HDR surveys, data have also been collected at six locations previously reported from Possum Kingdom Lake in 2008[23].

G.2 Results

The results presented herein include analysis of data collected during HDR surveys from March 2009–October 2010. These surveys have encompassed 82 miles of the Clear Fork, 21 miles of Paint Creek, 13 miles of California Creek, and 13 miles of Deadman Creek, in addition to the shorelines of Possum Kingdom Lake and Lake Stamford (Table G-1, Figures G-2 and G-3). During all surveys, including a cursory reconnaissance survey of the Clear Fork in March 2009 (Table G-1), a total of 629.90 man-hours have been spent surveying for Brazos water snakes. A total of 549 snakes have been observed, and 488 (88.9%) were positively identified to species (Table G-2). Positively identified snakes comprise 11 different species, with the most commonly encountered snake being the Diamondback water snake (*Nerodia rhombifer*) (*N*=267, 48.6%; Table G-2). Ninety-five Brazos water snakes have been observed during all completed surveys. Of these, 64 (67.4%) were juveniles and 31 (32.6%) were adults. A total of 66 Brazos water snakes (69.5%) were found under rocks, and most of these (*N*=57; 86.4%) were juveniles. The dimensions of rocks found harboring Brazos water snakes were recorded from 46 unique rocks that had mean dimensions (±1 SE, range) of 16.54 inches (±1.01, 5.91–38.58) × 23.79 inches (±1.42, 7.48–44.09) × 2.66 inches (±0.17, 0.79–5.12).

G.2.1 Stream Surveys

Combining data from all surveys conducted along the Clear Fork, a total of 71 Brazos water snakes have been observed from 21 unique (greater than 656 feet [200 m] apart) locations (Figure G-2). Excluding the limited efforts during the initial reconnaissance survey and opportunistic searches, a total of 327.40 man-hours have been spent conducting in-depth surveys for Brazos water snakes along the Clear Fork, during which 32.35 man-hours were spent intensively searching potentially suitable habitat. A total of 7.03 linear miles of potentially suitable juvenile Brazos water snake habitat were observed along this 82 mile stretch of the Clear

[23] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.

Table G-2
Total Number of Snakes Observed by Species
Along the Clear Fork, Paint Creek, California Creek, Deadman Creek,
Possum Kingdom Lake, and Lake Stamford,
March 2009–October 2010.

Common Name	Scientific Name	Number Observed
Diamondback water snake	*Nerodia rhombifer*	267
Brazos water snake	*N. harteri harteri*	95
Blotched water snake	*N. erythrogaster transversa*	74
Western ribbon snake	*Thamnophis proximus*	33
Western rat snake (Texas rat snake)	*Scotophis obsoletus*	4
Western diamondback rattlesnake	*Crotalus atrox*	4
Graham's crayfish snake	*Regina grahamii*	3
Rough earth snake	*Virginia striatula*	3
Yellowbelly racer	*Coluber constrictor flaviventris*	3
Western coachwhip	*Masticophis flagellum testaceus*	1
Western massasauga	*Sistrurus catenatus tergeminus*	1
Unknown		61
	Total	549

Fork. Overall catch-per-unit-effort (CPUE) along the Clear Fork (excluding seven Brazos water snakes observed during the reconnaissance survey and opportunistic searches) has been one Brazos water snake per 5.12 man-hours (0.20 Brazos water snakes/man-hour) of survey effort.

Within the footprint of Cedar Ridge Reservoir (from the dam at Lueders downstream approximately 29 miles to the proposed dam location), 48 Brazos water snakes have been observed from 10 locations (Figure G-2). A total of 152.85 man-hours have been spent surveying for Brazos water snakes within the Cedar Ridge footprint (excluding the reconnaissance survey and opportunistic searches), and 16.76 man-hours have been spent intensively searching potentially suitable habitat. A total of 2.99 linear miles of potentially suitable juvenile habitat were observed within the Cedar Ridge Reservoir footprint. Along this stretch of the Clear Fork (excluding four Brazos water snakes observed during the reconnaissance survey and opportunistic searches), CPUE has been one Brazos water snake per 3.47 man-hours (0.29 Brazos water snakes/man-hour) of survey effort.

Along the remaining 53 miles of the Clear Fork that have been surveyed downstream of the proposed Cedar Ridge dam, 23 Brazos water snakes have been observed from 11 locations (Figure G-2). A total of 174.55 man-hours have been spent surveying for Brazos water snakes (excluding the reconnaissance survey and opportunistic searches), and 15.59 man-hours have been spent intensively searching potentially suitable habitat along this stretch. A total of 4.03 linear miles of potentially suitable juvenile habitat were observed downstream of the proposed Cedar Ridge dam. CPUE along this stretch (excluding three Brazos water snakes observed during the reconnaissance survey and opportunistic searches) has been one Brazos water snake per 8.73 man-hours (0.11 Brazos water snakes/man-hour) of survey effort.

Six Brazos water snakes have been observed from three locations along the 21 miles of Paint Creek below Lake Stamford (Figure G-2). A total of 38.17 man-hours have been spent surveying for snakes, during which 6.54 man-hours have been spent intensively searching potentially suitable Brazos water snake habitat. Approximately 4.17 linear miles of suitable juvenile habitat were observed along Paint Creek, and CPUE has been one Brazos water snake per 6.36 man-hours (0.16 Brazos water snakes/man-hour) of survey effort.

During surveys performed along California Creek, two Brazos water snakes have been observed from two unique locations (Figure G-2). A total of 21.67 man-hours have been spent conducting surveys for Brazos water snakes and 1.78 man-hours have been spent intensively searching potentially suitable habitat along this stretch. The linear distance of potentially suitable juvenile habitat observed totaled 1.17 miles. CPUE along California Creek has been one Brazos water snake per 10.84 man-hours (0.09 Brazos water snakes/man-hour).

Three Brazos water snakes have been observed along Deadman Creek from two locations (Figure G-2). A total of 22.47 man-hours have been spent surveying for Brazos water snakes along Deadman Creek. Potentially suitable habitat was limited along this creek and total man-hours spent intensively searching were not recorded at most sites along this stretch, as they were small, isolated, and contained little searchable cover. At these sites, only brief intensive searches (generally less than 2 minutes each) were required, and were typically conducted as the boat was being pulled through the riffle. CPUE along Deadman Creek has been one Brazos water snake per 7.49 man-hours (0.13 Brazos water snakes/man-hour) of effort.

G.2.2 Lake Surveys

Surveys of Possum Kingdom Lake have resulted in the observation of 13 Brazos water snakes from five locations (Figure G-3). Eleven Brazos water snakes have been found during active searches, and two snakes have been captured using minnow traps. A total of 158.93 man-hours have been spent actively surveying for Brazos water snakes, resulting in a CPUE of one Brazos water snake per 14.45 man-hours (0.07 Brazos water snakes/man-hour) of search effort. In addition to active searches, minnow traps were set in areas containing suitable Brazos water snake habitat during 2010 survey efforts. Minnow traps have been placed along a total of approximately 1,500 feet of shoreline between two locations, and have been set for 1,353.64 trap-hours (56.40 trap-days). Total CPUE of trapping efforts has been one Brazos water snake per 676.82 trap-hours (28.20 trap-days).

No Brazos water snakes have been found along the shorelines of Lake Stamford despite 31.60 man-hours of survey effort. However, it should be noted that the snake has never been reported from Lake Stamford and the shoreline does not include a substantive rocky component to serve as suitable habitat.

Localized habitat characteristics have been quantified from 14 specific localities where Brazos water snakes have been found within Possum Kingdom Lake, including six locations previously reported from 2008.[24] Lake floor slope has been surveyed along 38 transect lines across all 14 sites. At two sites slope data were collected only along a single transect line. Regression analysis of mean lake depth at each 10-foot interval across all sites found a mean slope of 0.1496 (R^2= 0.9559; Figure G-4). Linear regression of mean lake depth ±95% CI found slopes of 0.1346 (R^2= 0.9577) and 0.1645 (R^2= 0.9533) for mean depth – 95% CI and mean depth + 95% CI, respectively (Figure G-4). Linear regression of minimum lake depths found a slope of 0.0504 (R^2= 0.8151; Figure G-4), and regression of maximum lake depths found a slope of 0.2458 (R^2= 0.8990; Figure G-4). Lake floor substrate has been recorded along 37 transect lines across 13 sites. At two sites the lake floor substrate was only recorded along two transects. Across all sites, rock has been a primary component of the lake floor substrate, constituting 63.8% of all observations (N=185). At distances of 10 feet and 20 feet from the shoreline, rock has been a primary component of the lake floor substrate 90.5% and 75.7% of the time,

[24] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.

respectively (Figure G-5). As the distance from the shoreline increases, the presence of rock decreases and occurrences of mud and silt increase (Figure G-5). Shoreline substrate has been

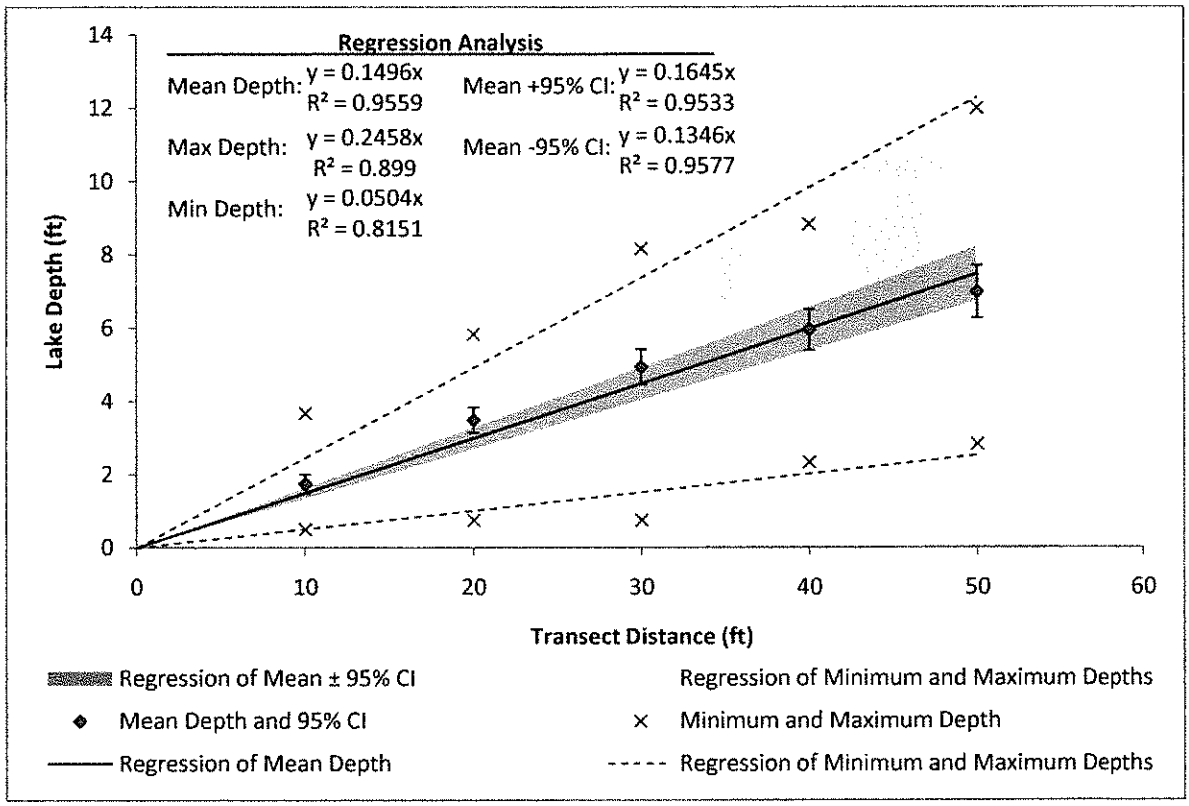


Figure G-4. Lake Floor Slope at Brazos Water Snake Capture Locations within Possum Kingdom Lake.

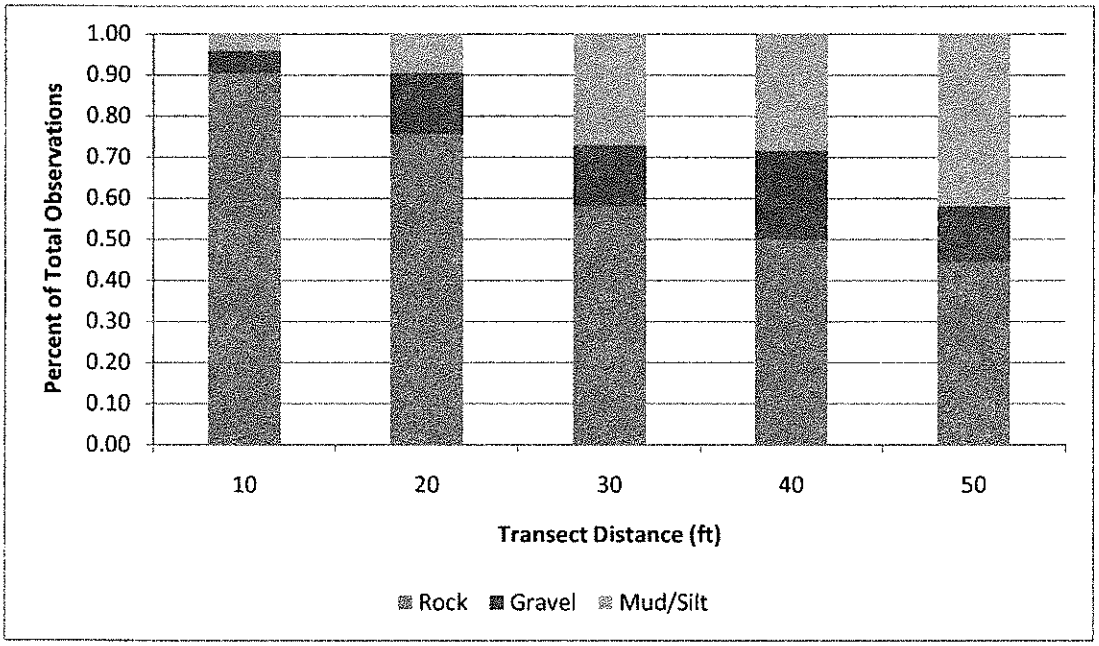


Figure G-5. Lake Floor Substrate Composition at Brazos Water Snake Capture Locations within Possum Kingdom Lake.

quantified at 11 sites and analysis of data across all sites found that rock in the cobble and boulder size class (i.e., greater than 3.94 in [10 cm]) comprised 56.4% of the shoreline surveyed.

G.3 Discussion

The preliminary results from Brazos water snake surveys presented above demonstrate that this species occurs within the area to be impacted by the proposed Cedar Ridge Reservoir project. The highest concentration of Brazos water snakes have been found within the upper reaches of the proposed Cedar Ridge Reservoir project, along the first seven river-miles of the Clear Fork downstream from the existing dam at Lueders (see Figure G-2). Surveys conducted to-date also demonstrate that Brazos water snake populations exist downstream of the proposed reservoir project, and along nearby stream segments that will not be affected by the proposed reservoir (see Figure G-2). Furthermore, Brazos water snakes have been found continuing to persist within Possum Kingdom Lake, nearly 70 years after construction (see Figure G-3). Surveys of Lake Stamford have failed to yield Brazos water snakes; however, it is important to note that Brazos water snakes have never been reported from this locality. Lake Stamford was included in survey efforts due to its proximity to Brazos water snake populations along Paint Creek.

The continued persistence of Brazos water snakes within Possum Kingdom Lake,[25,26] in addition to the documented occurrences of the closely related Concho water snake from three reservoirs along the Concho and Colorado Rivers,[27] indicates that this snake species can tolerate impoundment of its natural riverine environment so long as suitable habitat develops along the shoreline. While evidence suggests that the Brazos water snake can tolerate impoundment,[28,29,30] potential impacts from the proposed Cedar Ridge Reservoir project will be evaluated.

Based on the similarities between the geologic formations of Cedar Ridge Reservoir and O.H. Ivie Reservoir (Figure G-6), it is anticipated that mitigation measures can be developed to provide suitable habitat for Brazos water snakes.

As additional survey data are collected on Brazos water snake populations, habitat availability in the project vicinity, and the geologic conditions of the proposed reservoir site the potential adverse impacts and mitigation strategies will be evaluated. Information from the on-going surveys and evaluations of both adverse and beneficial effects will be provided to Resource Agencies as part of the on-going permitting effort.

[25] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.
[26] HDR Engineering Inc. (HDR). 2010. Current Study.
[27] Colorado River Municipal Water District (CRMWD). 1998. Petition to delist the Concho water snake (*Nerodia harteri paucimaculata*). Colorado River Municipal Water District, Big Springs, Texas.
[28] Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.
[29] McBride, D. L. 2009. Distribution and status of the Brazos water snake (*Nerodia harteri harteri*). Thesis, Tarleton State University, Stephenville, Texas.
[30] Colorado River Municipal Water District (CRMWD). 1998. Petition to delist the Concho water snake (*Nerodia harteri paucimaculata*). Colorado River Municipal Water District, Big Springs, Texas.

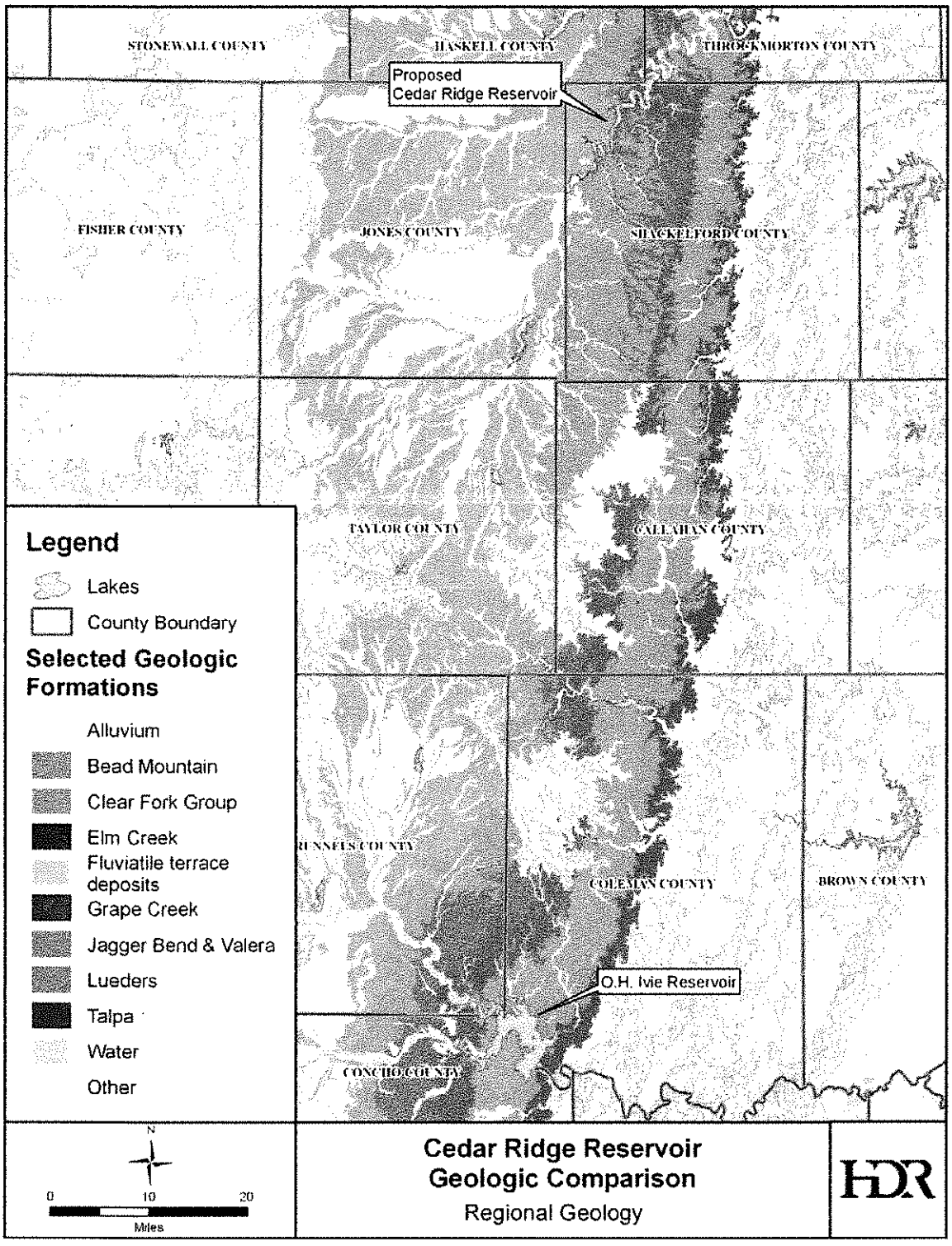


Figure G-6. Regional Geology Surrounding the Proposed Cedar Ridge Reservoir and O. H. Ivie Reservoir.

Appendix H
Aquatic Life Monitoring
Data Report

Table of Contents

Section **Page**

H.1 Introduction H-1
H.2 Methods and Materials H-1
H.2.1 Station Locations H-3
H.2.2 Physical Habitat Observation H-4
H.2.3 Standard Field Parameters H-6
H.2.4 Instantaneous Flow Measurements H-7
H.2.5 Biological Collections H-7
H.2.5.1 Aquatic Macrophytes H-7
H.2.5.2 Benthic Macroinvertebrates H-7
H.2.5.3 Fish H-9
H.2.6 Data Analyses H-10
H.2.6.1 Habitat H-10
H.2.6.2 Benthic Macroinvertebrates H-11
H.2.6.3 Fish H-13
H.3 Results H-16
H.3.1 Physical Description of Aquatic Sample Stations H-16
H.3.1.1 General Stream Habitat Characteristics H-16
H.3.1.2 Station Locations and Descriptions H-19
H.3.2 Water Quality H-21
H.3.3 Aquatic Life Monitoring Survey H-27
H.3.3.1 Habitat Quality H-29
H.3.3.2 Benthic Macroinvertebrate Community Evaluation H-35
H.3.3.3 Fish Community Evaluation H-60
H.4 Aquatic Life Use Summary H-87

Attachments

H-1 Stream Physical Characteristics Worksheets Physical Characteristics of Water Body Worksheets, Habitat Quality Index (HQI) Worksheets (Provided on Compact Disc)

H-2 Photographs, Aquatic Life Monitoring Locations (Provided on Compact Disc)

H-3 24-Hour Monitoring at Three Locations May and July 2010

List of Figures

Figure **Page**

Figure H-1. Reconnaissance Surveys Aquatic Life Monitoring Surveys H-2
Figure H-2. General Mesohabitat Types Aquatic Sampling Locations H-5
Figure H-3. Species Richness vs. Basin Size (km^2) H-15

List of Tables

Table **Page**

Table H-1. TCEQ Rapid Bioassessment Protocol Metric Evaluation Protocol for Benthic Macroinvertebrate Kicknet Samples H-12
Table H-2. Scoring Criteria for Assessment of Stream Fish Assemblages Subhumid Agricultural Plains (Ecoregions 27, 29, and 32) H-15
Table H-3. A Checklist of Representative Algal Species at Three River Locations July 2010 ..... H-18
Table H-4. Water Quality Parameters by Sampling Station 15-17 June 2009, 10-12 August 2009, 5-7 May 2010 and 19-21 July 2010 ..... H-24
Table H-5. Mean, Minimum and Maximum Dissolved Oxygen Concentration (mg/L) 24-Hour Dissolved Oxygen Monitoring at Three Locations May and July 2010 ..... H-24
Table H-6. Instantaneous Streamflow Measurements by Sampling Station 15–17 June 2009, 10–12 August 2009, 5–7 May 2010, and 19–21 July 2010 ..... H-29
Table H-7. Habitat Quality Index 15–17 June 2009, 10–12 August 2009, 5–7 May 2010, and 19–21 July 2010 ..... H-31
Table H-8. Checklist of Benthic Macroinvertebrate Taxa Collected by Kick Net 2009 and 2010 ..... H-37
Table H-9. Benthic Macroinvertebrate Taxa Collected by Kick Net at Five Locations 15–17 June 2009 ..... H-39
Table H-10. Aquatic Integrity Indicators 15–17 June 2009 ..... H-41
Table H-11. TCEQ Method Evaluation of Aquatic Integrity Benthic Macroinvertebrate Samples 15–17 June 2009 ..... H-43
Table H-12. Benthic Macroinvertebrate Taxa Collected by Kick Net 10–12 August 2009 ..... H-46
Table H-13. Aquatic Integrity Indicators 10–12 August 2009 ..... H-47
Table H-14. TCEQ Method Evaluation of Aquatic Integrity Benthic Macroinvertebrate Samples 10–12 August 2009 ..... H-49
Table H-15. Benthic Macroinvertebrate Taxa Collected by Kick Net 5–7 May 2010 ..... H-50
Table H-16. Aquatic Integrity Indicators 5–7 May 2010 ..... H-51
Table H-17. TCEQ Method Evaluation of Aquatic Integrity Benthic Macroinvertebrate Samples 5–7 May 2010 ..... H-55
Table H-18. Benthic Macroinvertebrate Taxa Collected by Kick Net 19–21 July 2010 ..... H-56
Table H-19. Aquatic Integrity Indicators 19–21 July 2010 ..... H-57
Table H-20. TCEQ Method Evaluation of Aquatic Integrity Benthic Macroinvertebrate Samples 19–21 July 2010 ..... H-59
Table H-21. Total Number of Fish Species Collected by Seine in June 2009 ..... H-62
Table H-22. Total Number of Fish Species Collected by Seine in August 2009 ..... H-63

List of Tables (Concluded)

Table **Page**

Table H-23. Total Number of Fish Species Collected by Seine in May 2010 ..... H-64
Table H-24. Total Number of Fish Species Collected by Seine in July 2010 ..... H-65
Table H-25. Metrics and Scoring Criteria for Fish Samples Based On Ecoregions 27, 29, and 32 Criteria 2009 Index and Critical Period H-66
Table H-26. Comparison of Present Survey Fish Collection Results with Historical River Collections and Area Reservoir Assemblages 15–17 June 2009, 10–12 August 2009, 5–7 May 2010 and 19–21 July 2010 ..... H-79
Table H-27. Application of Coefficient of Variation for Interpreting Mulitple Fish Samples Clear Fork Brazos River-Central Great Plains Ecoregion (ER 27) Segment 1232-Designated High Aquatic Life Use H-84

H.1 Introduction

A total of five sampling areas on the Clear Fork Brazos River (Clear Fork) within Shackelford and Throckmorton Counties were selected for Aquatic Life Monitoring (ALM). Final site selection was based on an inventory of wade-able portions of the river (i.e., small and shallow enough to adequately sample without a boat) taken during two field reconnaissance surveys conducted by HDR biologists in March 2009 and May 2009 (Figure H-1). Factors that restricted the choice of accessible locations were based on land access, physical barriers and safety concerns for the aquatic field crew.

Evaluation of stream physicochemical conditions, stream habitat, characterization of stream flow, and the assessment of the fish and macroinvertebrate community was conducted four times with two events scheduled during the non-critical (index) period (15 March–30 June and 1 October–15 October) on 15–17 June 2009 and 5–7 May 2010, and two events during the critical period (1 July–30 September) on 10–12 August 2009 and 19–21 July 2010. The primary purpose of the collection program for the project was to provide an accurate and detailed description of the existing aquatic environment by identifying and documenting the aquatic communities residing within the section of Clear Fork proposed for impoundment by the Cedar Ridge Reservoir.

H.2 Methods and Materials

The ALM protocol incorporates three aspects of the aquatic environment: water chemistry, physical habitat, and biological diversity. The methods and materials for the ALM sampling program followed the general monitoring, field measurement, field instrument calibration, quality assurance/quality control, and safety guidelines specified in the TCEQ's Surface Water Quality Monitoring Procedures Manual, Volume 1.[1] Habitat assessment, macroinvertebrate and fish community integrity, together with occurrences of aquatic vegetation, were also documented during the 2009 and 2010 surveys consistent with the methods and

[1]Texas Commission on Environmental Quality (TCEQ). 2008. *Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment, and Tissue.* Document No. RG-415. Monitoring Operations Division, Texas Commission on Environmental Quality, Austin, Texas

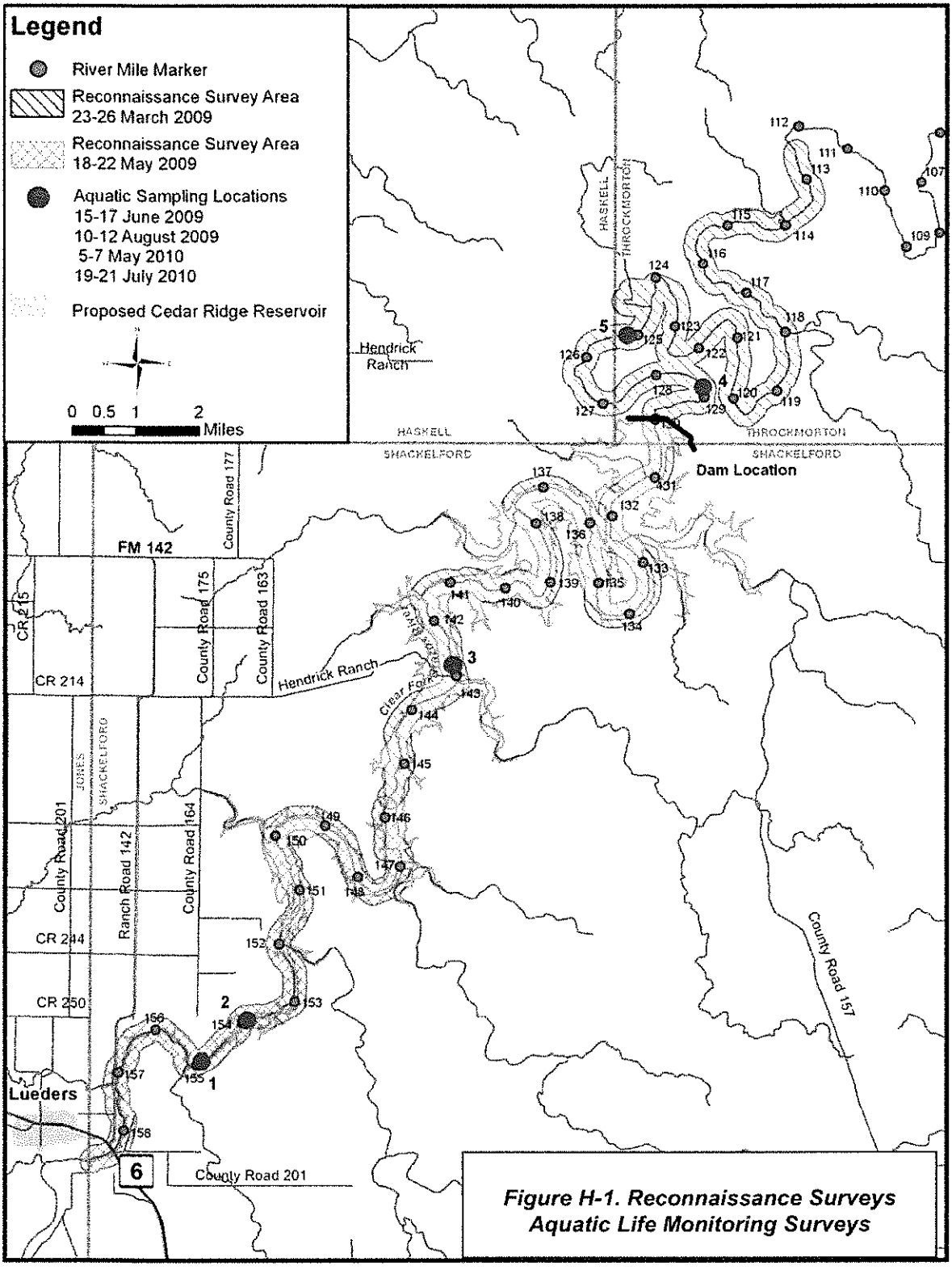


Figure H-1. Reconnaissance Surveys Aquatic Life Monitoring Surveys

procedures outlined in the TCEQ Biological Monitoring Fact Sheet[2] and the TCEQ Surface Water Quality Monitoring Procedures, Volume 2.[3]

In accordance to the standardized stream characteristics forms and with the Surface Water Quality Monitoring (SWQM) field sampling manual, stream habitat evaluations, flow characteristics, and fish and benthic macroinvertebrate populations were assessed twice during the calendar years 2009 and 2010. Localized rainfall occurred prior to each sampling event. Standard field parameters and stream flow were recorded concurrent to each ALM sampling event.

H.2.1 Station Locations

Aerial video footage recorded on 18 March 2009 from a helicopter was used to help identify potential sampling locations within the river channel most likely to be affected by reservoir impoundment. A field reconnaissance trip covering 33 miles of the Clear Fork by kayak was made from 23–26 March 2009. An additional 13 miles were inspected by floating the river during the initial Brazos Water Snake survey conducted from 18–22 May 2009. Several key aquatic project objectives of these two river surveys were (1) to evaluate the existing aquatic habitat conditions along the section of river between State Highway (SH) 6 near Lueders extending to the downstream river crossing on the Hendrick Ranch at the Perry Camp; (2) to evaluate the potential habitat available for two imperiled (federal status - Candidate) cyprinid species, smalleye shiner (*Notropis buccula*) and sharpnose shiner (*Notropis oxyrhynchus*); (3) determine the feasibility and efficiency of the use of a backpack electroshocker based on conductivity; and (4) selection of potential sampling locations for subsequent aquatic life monitoring.

Six potential aquatic sampling locations were identified during the initial field reconnaissance of the study area. An additional four locations were added for consideration after an examination of the river reach between SH 6 and the Round Valley Crossing in May 2009. A total of five river locations were then selected for physical habitat evaluation and biological collection for determination of species composition and relative abundance of benthic

[2]Texas Commission on Environmental Quality (TCEQ). 2006. *Biological Monitoring Fact Sheets.* TCEQ Procedures for Biological and Habitat Monitoring Effective May 17, 2006.

[3]Texas Commission on Environmental Quality (TCEQ). 2007. *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data.* Document No. RG-416. Monitoring Operations Division, Texas Commission on Environmental Quality, Austin, Texas.

macroinvertebrates and fish during the 2009 and 2010 index and critical periods (Figure H-1). Aquatic habitats observed in the 46 miles of river examined were categorized based on hydraulic characteristics into one of four general mesohabitat types (pool, riffle, run, and riffle/run complex areas). The section of river within the proposed reservoir footprint is primarily pool habitat of relatively varying widths and depths (Figure H-2). Long stretches of river channel between River Mile (RM) 158 and RM 130 were too deep to be safely sampled by wade-able stream procedures. Additionally, final site selection was limited by the lack of landowner permission or roads, or the presence of crew physical barriers that prohibited safe entry to the river.

Sampling occurred on 15–17 June 2009, 10–12 August 2009, 5–7 May 2010, and 19–21 July 2010 on privately owned lands at the following five monitoring stations: (1) directly downstream of Hoggys Crossing on private property at River Mile (RM) 155; (2) Flatlands Crossing on private property near RM 154; (3) Boys Camp Crossing immediately downstream of the confluence with Fish Creek on Hendrick Ranch property at RM 143; (4) Shelton Crossing on Hendrick Ranch property at RM 129; and (5) Krooked River Lodge Crossing on Hendrick Ranch property at RM 125. Three locations (Stations 1, 2, and 3) were sampled in the approximate length of creek selected for proposed impoundment upstream of the proposed Dam Site at RM 130. Station 1 was established slightly over 3.0 miles downstream of the SH 6 crossing. Station 2 was positioned approximately 1.0 river mile downstream of Station 1. Station 3 was established on the Hendrick Ranch approximately 11.0 river miles downstream of Station 2. Station 4 was established at a remote crossing located approximately 4.7 river miles downstream of Station 3 and approximately 1.1 river miles downstream of the area proposed for the dam structure. Station 5 was located near the Krooked River Ranch Lodge situated approximately 5.0 miles downstream of the proposed dam. Each location was marked with a global-positioning system (GPS) hand-held unit so these areas could be easily and accurately relocated as needed.

H.2.2 Physical Habitat Observation

A Habitat Quality Index (HQI) was prepared from riparian vegetation and physical habitat characteristics observed at five transect lines. Habitat quality is a representation of the physical conditions in a stream channel, the surrounding riparian zone, and the watershed land use. The riparian vegetation and physical characteristics were documented during each of the

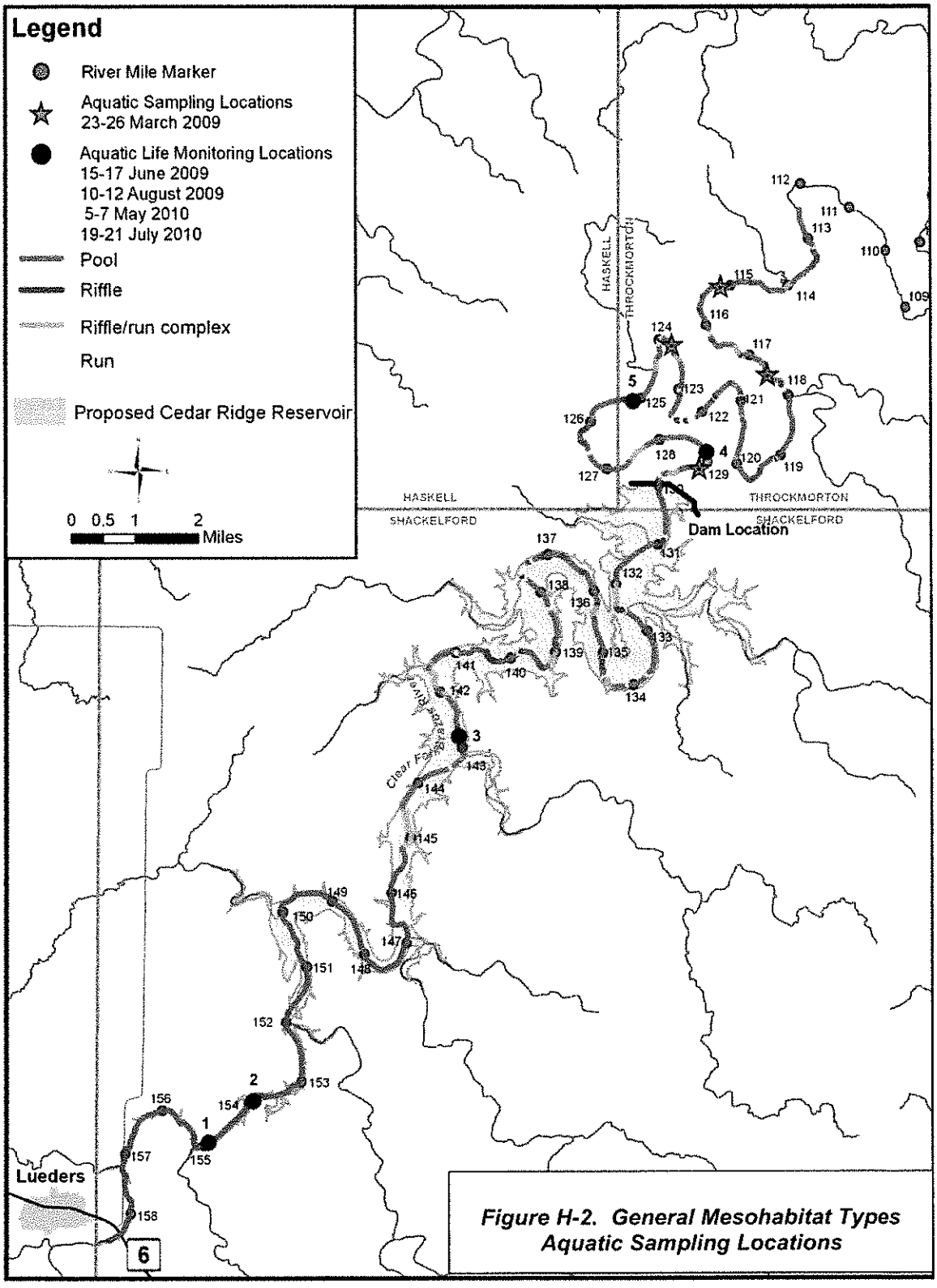


Figure H-2. General Mesohabitat Types Aquatic Sampling Locations

ALM sampling efforts with a series of cross sections and associated habitat evaluations. Transect placement at each selected site involved sections of river either upstream or downstream of a river crossing and measured at four evenly spaced distances of 125 m for a total of five cross sections (T1 through T5), which were considered to be representative of habitats within each stream reach. The riparian vegetation and physical habitat characteristics at each of the five transect locations were characterized by a series of attributes and associated aquatic habitat measurements as outlined in TCEQ's procedures for ALM surveys[4] and recorded on TCEQ's Part I-Stream Physical Characteristics Worksheet (Attachment H-1).

In-stream channel measurements include habitat type, number of riffles, dominant substrate type, percent of substrate composed of gravel, presence or absence of algae and aquatic macrophytes, in-stream cover types and percentage of each. Stream morphological parameters include channel sinuosity, channel obstructions/modifications, channel flow status, stream width and depth. Features that describe the riparian environment include width of natural vegetative buffer, aesthetics, percentage of riparian vegetation types, bank slope, bank stability, canopy cover and dominant types of riparian vegetation. The percentage of tree canopy cover was determined with a concave spherical densiometer. The percentage of the dominant riparian vegetation types along the left and right banks at each transect station was made by visual estimation. A Suunto clinometer was used to determine creek bank slope in degrees. At each stream site, a digital camera was used to document the upstream, downstream, left bank, and right bank habitat conditions at each transect.

H.2.3 Standard Field Parameters

In situ determinations of water temperature (°C), dissolved oxygen (DO) (mg/L), conductivity (µS/cm), and surface pH readings were obtained with a Yellow Springs Instrument (YSI) Model 650-04 display with high memory and barometer connected to a Model 600 XLM-M data sonde with temperature, conductivity, DO, and pH sensors concurrent. Each instrument (data sonde) was calibrated according to the TCEQ's and manufacturer's recommendations prior to field use, and post-calibrated upon return to the office. Light penetration was measured in meters with a 20-cm diameter black-and-white Secchi disk with the biological sampling efforts.

[4]Texas Commission on Environmental Quality (TCEQ). 2007. *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data.* Document No. RG-416. Monitoring Operations Division, Texas Commission on Environmental Quality, Austin, Texas.

Field measurements were made at the start of each diel (24-hour) sample during the 2010 survey and concurrent with all ALM sample events. Instantaneous readings of standard parameters were recorded from that portion of the river that exhibited 50% of the flow. To obtain diel samples, a calibrated, programmed instrument was placed securely at three locations and left unattended, recording at 15-minute intervals for a minimum of 24-hours. These instruments were retrieved the following day, post-calibrated, and the collected data downloaded into MSExcel® spreadsheets.

H.2.4 Instantaneous Flow Measurements

Cross-sectional flow measurements were taken at all stations during each of the four surveys to determine stream discharge in cubic feet per second (cfs). The average velocity (ft/s) was determined with a Marsh-McBirney Model 2000 Flo-Mate portable velocity meter and top-setting wading rod as outlined in Chapter 2 of the SWQM Procedures Manual, Volume 2 (TCEQ, 2007).[5] Stream flow discharge in cubic feet per second (cfs) was calculated by multiplying the section width by the section depth (ft^2) by the velocity (f/s).

H.2.5 Biological Collections

H.2.5.1 Aquatic Macrophytes

The presence or absence of rooted aquatic plants was recorded during each site visit.

H.2.5.2 Benthic Macroinvertebrates

Field methods were consistent with the protocols of the Surface Water Quality Manual developed by the TCEQ.[6] This manual provides standard guidelines which are periodically updated for the rapid biological assessment field protocol, laboratory analysis, and qualitative evaluation commonly used in this region. Qualitative sampling was conducted using a 12-inch wide, 500 micron mesh D-frame kick-net at five stream locations during flowing conditions on 15-17 June and 10-12 August of 2009. A minimum of 5 minutes of kick time per station was expended through all available microhabitats over stable substrates located in areas exposed to

[5] Texas Commission on Environmental Quality (TCEQ). 2007. *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data.* Document No. RG-416. Monitoring Operations Division, Texas Commission on Environmental Quality, Austin, Texas.

[6] Texas Commission on Environmental Quality (TCEQ). 2007. *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data.* Document No. RG-416. Monitoring Operations Division, Texas Commission on Environmental Quality, Austin, Texas.

current (e.g., large cobble, gravel bars, logs, woody snags, etc.). Sampling along each stream reach was conducted in a "zig-zag" pattern from downstream to upstream in order to best represent the longitudinal and cross-sectional areas. Kick-net samples were collected by placing the framed net on the streambed facing upstream and using the foot or hand to disturb the bottom substrate allowing dislodged material to flow into the net. Processing of the kick-net samples was accomplished in the field by thoroughly washing the sample in the kick-net then placing appropriate sample aliquots in a shallow white pan. The sample was stirred in the pan to disperse the contents as evenly as possible and individual specimens were removed by forceps. This process was repeated until a minimum of 160 individuals were picked. Organisms were placed into individual containers filled with 70% ethanol and returned to the HDR Austin laboratory for taxonomic identification, enumeration, and metric calculations. Each sample bottle was labeled using waterproof ink in the field with the field collector initials, station number, date, and time of collection. A chain of custody (COC) inventory form was kept to ensure precise laboratory sample tracking and integrity.

Laboratory identification of benthic invertebrates was conducted with a dissecting microscope (45X) to provide the lowest practical taxon level (LPTL) for each specimen. Consistent with TCEQ protocol (TCEQ, 2007)[7], the LPTL is primarily considered the level of genus, with some difficult groups such as midges, crustaceans and worms identified to less specific taxonomic levels such as family or class. Several standard taxonomic reference manuals was used for invertebrate identification.[8,9,10,11,12,13]

---

[7] Texas Commission on Environmental Quality (TCEQ). 2007. *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data.* Document No. RG-416. Monitoring Operations Division, Texas Commission on Environmental Quality, Austin, Texas.

[8] Merritt, R.W., K.W. Cummins, and M.B. Berg. 2008. *An Introduction to the Aquatic Insects of North America*, 4th Edition. Kendall/Hunt Publishing Co., Dubuque, Iowa.

[9] Wiggins, Glenn B. 2000. Larvae of the North American Caddisfly Genera (Trichoptera) 2nd Edition. University of Toronto Press. Toronto, Canada.

[10] Pennak, Robert W. 1989. *Fresh-Water Invertebrates of the United States Protozoa to Mollusca.* 3rd Edition. Wiley-Interscience Publication. New York, New York.

[11] Thorp, James H., Alan P. Covich. 2001. *Ecology and Classification of North American Freshwater Invertebrates.* 2nd Edition. Academic Press. San Diego, California.

[12] Westfall, Minter J. JR., and Michael L. May. 1996. Damselflies of North America. Scientific Publishers. Gainesville, Florida.

[13] Needham, James G., Minter J. Westfall, JR. and Michael L. May. 2000. *Dragonflies of North America.* Revised Edition. Scientific Publishers. Gainesville, Florida.

H.2.5.3 Fish

For standard TCEQ protocol, the collection of fish usually involves the combination of two collection methods, seine and electrofishing, as each sampling gear is biased toward different species and sizes of fish, to obtain a representative fish collection. However, high water conductivities ranging from 2209 to 2768 µS/cm were recorded throughout the river during the March 2009 reconnaissance survey. High water conductivity (e.g., 1,000–3,000 µS/cm) and high alkalinity causes backpack electrofishing to become less effective for accurately depicting fish populations. A tow-barge system, which produces more power in hard water than a backpack unit, was not readily available for this study.

The high water conductivities dictated the increased number of seine hauls to compensate for the decision to not utilize a backpack electroshock unit due lack of effectiveness and safety based on site conditions. Therefore, a standardized adjustment was made in the subsequent collections of fish as specified on Page 3-2 in Chapter 3 (Freshwater Fish) of the 2007 SWQM Procedures Manual, Volume 2.[14] The fish populations were collected from accessible habitat areas by two different seine types in a downstream direction at each sampling location in an attempt to capture a representative collection of fish from Clear Fork in the study area. The size of net used was dependent on the extent of the area to be sampled, type of habitat encountered, and physical factors present such as bottom type, water depth, obstacles below the surface of the water, and type of landing areas. The fish fauna was sampled with a 6.1-m x 1.5-m common-sense minnow seine with a mesh size of 0.32-cm during all sampling events and to a lesser extent by a 9.1-m x 1.22-m x 0.64-cm bag seine with a 1.82-m x 1.82-m bag in the center. Seine samples were taken in gently sloping areas, exposed shorelines and shallow-to-deep pool areas at accessible locations. A total of 15 seine hauls, each approximately 10 m long, were taken at every station during each survey in an attempt to capture a representative collection of fish from the study portion of the Clear Fork. Several efforts were made by kicking the substrate in numerous riffle areas while moving downstream to a stationary seine.

The majority of the netted fish were sorted and placed into plastic bottles containing 10% formalin when seine hauls at their respective stations/reaches were completed and returned to HDR Austin laboratory for positive identification. In the field, larger, easily identified fish were

[14] Texas Commission on Environmental Quality (TCEQ). 2007. *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data.* Document No. RG-416. Monitoring Operations Division, Texas Commission on Environmental Quality, Austin, Texas.

examined for condition, estimated lengths and weights before being released in the shoreline section where they were captured. Additionally, all fish collected from each seine sample were identified to species and visually examined for obvious diseases, parasites, and other abnormalities. Some species of fish residing in the Clear Fork are difficult to differentiate (e.g., minnows and sunfish) and made it necessary to collect voucher specimens for more detailed examination in order to confirm speciation. Fish identification quality assurance was achieved by meeting with Mr. Gordon Linam, Stream Assessment Team Leader of Texas Parks and Wildlife Department (TPWD) in San Marcos, Texas, to confirm fish species identified by HDR Engineering, Inc. A minimum of one specimen of each identified fish species collected during every survey was preserved in 70% ethanol and kept as a voucher collection. Three taxonomic references were used.[15,16,17]

H.2.6 Data Analyses

H.2.6.1 Habitat

Physical habitat assessments were conducted at all five stations to evaluate the habitat effects on biota. The same two-person team evaluated the habitat variables encountered during each survey to reduce bias and subjectivity. As discussed in Section 2.2, TCEQ Habitat Assessment Forms used to record required data in the field were compiled from field information taken at all locations. General observations for the entire evaluated reach, coupled with observations and measurements taken at the five specific transect locations at each location including the presence or absence of rooted aquatic plants, were recorded on the Stream Physical Characteristics Worksheet—Part I. Several parameters including in-stream habitat, epifaunal substrate, water depth and width, bank erosion/stability, pool/glide/run/riffle quality and shading were scored based on visual observation.

Using this information, a summary of the general physical characteristics and averages of the stream at each location were determined from information noted on the field worksheet and recorded on the Physical Characteristics of Water Body—Part II summary worksheet. A total of nine habitat parameters contained on the Habitat Quality Index (HQI)—Part III form were then

[15]Hubbs, Clark. 1970. *Key to the Freshwater Fishes of Texas*. Unpublished.
[16]Douglas, N.H. 1974. *Freshwater Fishes of Louisiana*. Louisiana Wildlife Fish Comm., Baton Rouge.
[17]Hubbs, C., R.J. Edwards, and G.P. Garrett. 1991. *An Annotated Checklist of the Freshwater Fishes of Texas, with Keys to Identification of Species.* Texas Journal of Science, supplement, 43:1-56.

evaluated and rated on a numeric scale of 0 to 4 (highest) and total habitat score calculated based on the worksheet values summarized in Part II and other relevant observations taken during each visit. The ratings were then totaled to provide a final habitat ranking. The highest value possible using this habitat assessment technique is 31.

A HQI was calculated for the five stations following summation of these values to determine the aquatic habitat quality during the summer season (index period) and late summer season (critical period). The habitat quality worksheets for each of the five stations are found in Tables H-1-1 through H-1-20 in Appendix H, Attachment H-1. At each ALM stream site, a digital camera was used to document the upstream and downstream habitat conditions from each of the five transect lines. Photographs were taken upstream, downstream, right bank and left bank for documentation of current stream habitat conditions during each site visit and for descriptive purposes to supplement the physical habitat evaluation at the time of each field effort and are found in Appendix H, Attachment H-2.

H.2.6.2 Benthic Macroinvertebrates

Evaluation of the benthic macroinvertebrate data primarily followed the metric and scoring criteria guidelines provided in the TCEQ Surface Water Quality Manual qualitative assessment of kick samples. This protocol was selected because it is specific to samples collected in Texas. This method evaluates the sample based on 12 metric parameters which assess the diversity, tolerance to pollution, community structure and trophic balance of the sample. The rubric for each of the 12 metric parameters and overall scoring criteria developed by the TCEQ[18] is presented in Table H-1. Each of the 12 metrics are calculated with a score of 1, 2, 3, or 4, so a total score can range from 12 (i.e., 12 x 1) to 48 (i.e., 12 x 4).

Diversity is assessed by three parameters: total number of taxa (taxa richness) identified to the lowest practical taxon (LPT), total number of mayfly/stonefly/caddisfly taxa (EPT taxa), and total number of taxa that are not in class Insecta (Non-insect taxa). Ecosystems with high integrity are typically complex and display high diversity of taxa. In each of these parameters, increasing taxa number translates to a corresponding increase in aquatic integrity. Streams with

[18] Harrison, B. 1996. *Metric set for use in setting aquatic life use designations using benthic macroinvertebrate samples collected from Texas streams following Rapid Bioassessment Protocols.* Water Planning and Assessment Division, Research and Environmental Assessment Section, Surface Water Quality Monitoring Team, Texas Natural Resources Conservation Commission, Austin, Texas.

high aquatic integrity will likely have more than seven EPT taxa, more than four non-insect taxa and more than fifteen total taxa overall.

Relative sensitivity to chemical and physicochemical conditions is reflected by a TCEQ Pollution Tolerance Index (PTI) which ranges from 10 (pollution tolerant) to 0 (pollution intolerant). The PTI was established to compare an organism's ability to cope with adverse ambient conditions including, but not limited to nutrient enrichment and low dissolved oxygen concentrations. The relative sensitivity to these aquatic stressors is assessed by three parameters: a weighted average value of the PTI values (Hilsenhof Biotic Index), a ratio of the total number of individuals with PTI <6 to the total number of individuals with PTI >6 (Ratio of intolerant to tolerant taxa), and the relative dominance of the pollution tolerant family Hydropsychidae to the other relatively pollution intolerant caddisflies (% of total Trichoptera as Hydropsychidae). An increasing ratio of intolerant to tolerant taxa indicates increasing aquatic integrity due to the higher percentage of pollution tolerant composition. Conversely, decreasing Hilsenhof Biotic Index values and decreasing percentages of Hydropsychidae indicate increasing aquatic integrity.

Table H-1.
TCEQ Rapid Bioassessment Protocol Metric Evaluation Protocol for Benthic Macroinvertebrate Kicknet Samples

Metric	*Scoring Criteia*			
	4	*3*	*2*	*1*
Taxa richness	> 21	15-21	8-14	< 8
EPT taxa abundance	> 9	7-9	4-6	< 4
Hilsenhof Biotic index (HBI)	< 3.77	3.77-4.52	4.53-5.27	>5.27
% Chironomidae	0.79-4.10	4.11-9.48	9.49-16.19	< 0.79 or >16.19
% Dominant taxon	< 22.15	22.15-31.01	31.02-39.88	> 39.88
% Dominant FFG	< 36.50	36.50-45.30	45.31-54.12	> 54.12
% Predators	4.73-15.20	15.21-25.67	25.68-36.14	< 4.73 or >36.14
Ratio of intolerant:tolerant taxa	> 4.79	3.21-4.79	1.63-3.20	< 1.63
% of total Trichoptera as Hydropsychidae	< 25.50	25.51-50.50	50.51-75.50	> 75.50 or no Trichoptera
# of non-insect taxa	> 5	4-5	2-3	< 2
% Collector-gatherers	8.00-19.23	19.24-30.46	30.47-41.68	< 8.00 or >41.68
% of total number as Elmidae	0.88-10.04	10.05-20.08	20.09-30.12	< 0.88 or >30.12
Aquatic life use point score ranges:	Exceptional: > 36; High: 29-36; Intermediate: 22-28; Limited: < 22			

Community structure is evaluated by three parameters: the number of individuals of the most numerous taxon divided by the total number of individuals in the sample (% Dominant

taxon), the number of midges divided by the total number of individuals in the sample (% Chironomidae), and the total number riffle beetles divided by the total number of individuals in the sample (% Elmidae). Increasing dominance of any these categories indicates decreasing aquatic integrity, however depauperate percentages of midges and riffle beetles could also indicate poor integrity. Generally speaking, a value of 33 percent or more in any of these groups indicates an impaired community.

Trophic structure is determined by the relative abundance of the different Functional Feeding Groups (FFG) in a community, including predators, collector-gatherers, scrapers, filtering-collectors, and shredders. Trophic balance is evaluated by three parameters: the total number of individuals of the numerically dominant functional feeding group (% Dominant FFG), the number of individual predators divided by the sample total (% Predators), and the number of individual collector-gatherers divided by the sample total (% Collector-gatherers). Less than 45 percent of the dominant functional feeding group, and less than 30 percent predators or collector-gatherers is generally indicative of well balanced trophic composition. Although the values for each individual metric parameter is used for sample-to-sample comparison, the overall aquatic integrity of each stream reach is evaluated based on a composite score of the 12 metrics.

H.2.6.3 Fish

For the biological evaluation, all fish collected by seine were combined in the data set and treated identically. Because watershed characteristics and fish communities from the Clear Fork differ from those for midwestern headwater streams originally used by Karr et al[19] (1986), the community trophic structure status and intolerance/tolerance data as described by Linam and Kleinsasser[20] (1998) along with a regionalized adaptation of the Index of Biotic Integrity (IBI) developed by Linam et al.[21] (2002) for representative Texas streams in Ecoregions 27 (Central Great Plains), 29 (Central Oklahoma/Texas Plains), and 32 (Blackland Prairies) was calculated to provide a fish aquatic life use rating for each station. The cumulative score of this index consisting of eleven separate metrics falling within three broad categories (species composition,

[19]Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R.Yant, and I.J. Schlosser. 1986. *Assessing biological integrity in running waters, a method and its rationale.* Special Publication 5. Illinois Natural History Survey, Champaign, Illinois. 28 pp.

[20]Linam, G. W. and L.J. Kleinsasser. 1998. *Classification of Texas Freshwater Fishes into Trophic and Tolerance Groups*. Texas Parks and Wildlife Department, River Studies Report No. 14, Austin. 8 pp.

[21]Linam, G.W., L.J. Kleinsasser, and K.B. Mayes. 2002. *Regionalization of the Index of Biotic Integrity for Texas Streams (River Studies Report No. 17)*. Texas Parks and Wildlife Department. Austin, Texas.

trophic composition and fish abundance) provides a baseline evaluation of the overall condition of the fish community residing in study area section of the Clear Fork (Table H-2; Figure H-3). After the metrics are calculated, they are each converted to a score of 1, 3, or 5 in order to facilitate comparisons between sampling sites, watersheds, or regions. The resulting scores can range from Limited to Exceptional. For each study location, the 11 metrics were tabulated using the raw data. When only one sampling technique is applied, the metric score for only that specific gear type is used. Therefore, metric 9b (number of individuals/electrofishing) was excluded from the original IBI program for final calculations. After calculating a final score, an integrity class was assigned to the five stream reaches based on that score. Mr. Linam (TPWD) was contacted to review an example of the seine-only IBI scoring spreadsheet for accuracy. In addition, coefficient of variation (CV%) determined for Ecoregions 27, 29, and 32[22] was calculated for each fish sample collection to provide a measure of variability (See Table 26 in Section H.3.3.3.5).

[22] TCEQ. DRAFT 2010 guidance for assessing and reporting surface water quality in Texas (June 6, 2009). In compliance with Section 305(b) and 303(d) of the Federal Clean Water Act. Texas Commission on Environmental Quality, Austin.

Table H-2.
Scoring Criteria for Assessment of Stream Fish Assemblages
Subhumid Agricultural Plains (Ecoregions 27, 29, and 32)

Metric Category	Metric Name	Score		
		5	3	1
Species Richness and Composition	1. Total number of fish species	*	*	*
	2. Number of native cyprinid species	>3	2-3	<2
	3. Number of benthic invertivore species	>1	1	0
	4. Number of sunfish species	>3	2-3	<2
	5. Percentage of individuals as tolerant species (excluding western mosquitofish)	<26%	26-50%	>50%
Trophic Composition	6. Percentage of individuals as omnivores	< 9%	9-16%	> 16%
	7. Percentage of individuals as insectivores	> 65%	33-65%	< 33%
	8. Percentage of individuals as piscivores	> 9%	5-9%	< 5%
Fish Abundance and Condition	9. Number of individuals in sample a. Number of individuals/seine haul b. Number of individuals/electrofishing	> 87	36-87 Not calculated	< 36
	10. Percentage of individuals as non-native species	< 1.4%	1.4-2.7%	> 2.7%
	11. Percentage of individuals with disease or other anomaly	< 0.6	0.6-1.0%	> 1.0%
Fish Species:	*Fish species richness versus drainage basin size (km^2). See Figure H-2			
Aquatic Life Use: **Exceptional**: ≥ 49; **High:** 41-48; **Intermediate:** 35-40; **Limited:** < 35				

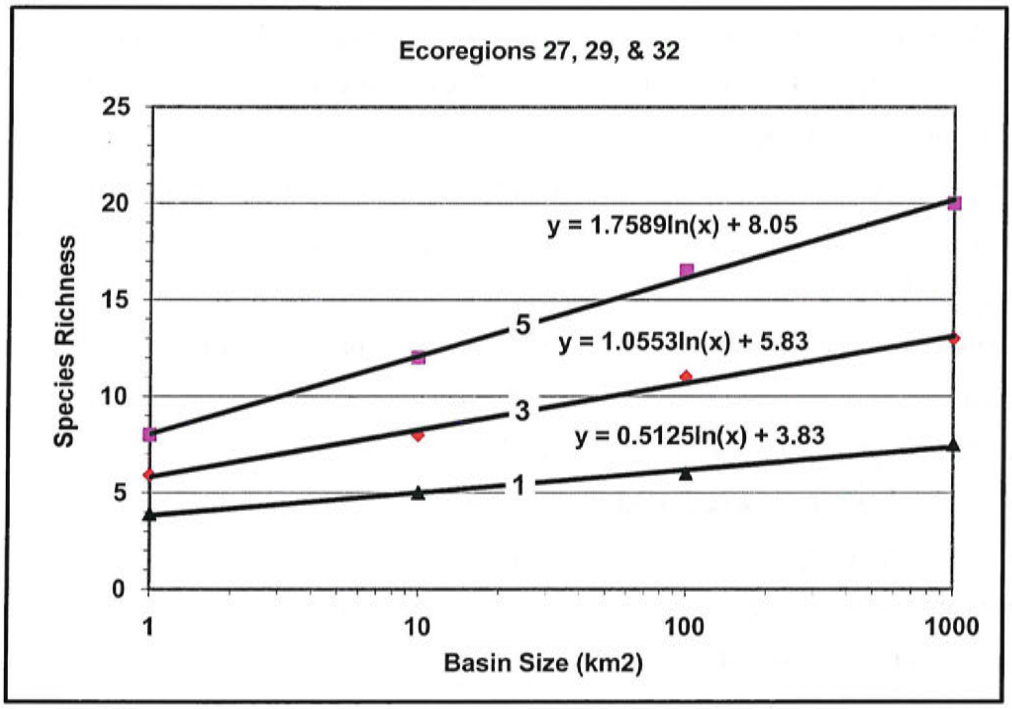


Figure H-3. Species Richness vs. Basin Size (km^2)

H.3 Results

H.3.1 Physical Description of Aquatic Sample Stations

H.3.1.1 General Stream Habitat Characteristics

The Clear Fork, a fifth-order stream and a major tributary of the Brazos River, is a relatively small watershed with a length of almost 180 miles. The headwaters originate in eastern Scurry County near the City of Snyder and flows in an easterly direction for approximately 55 miles through central Fisher and southern Jones County before turning northwest of Fort Phantom Hill Reservoir. The river continues in a northward direction through eastern Jones and the northwest corner of Shackelford County and enters southwestern Throckmorton County where the channel bends to the east. The channel proceeds in a general northeasterly direction after it loops back into Shackelford County and through Throckmorton, Stephens, and Young counties for about 75 miles, where it joins the main stem Brazos River at South Bend, just upstream of Possum Kingdom Reservoir.

The section of the river in Haskell, Shackelford, and Throckmorton counties is predominately a rural, unmanaged river system characterized by muddy water, steep banks, and low overhanging black willow, pecan, mesquite, and American elm trees. The flood plain area generally is utilized for farming and ranching, but these activities within the river corridor are not normally noticeable from river level because of steep banks. Except during periods of heavy rainfall, the river moves slowly.

Aquatic habitats found in this region include impoundments of all sizes, perennial river habitats, and tributary streams. The Clear Fork comprises the riverine environment of the study reach and can be divided into distinct reaches with well-defined units (pools, runs, and riffle areas) according to the prevailing flow regime. Typical of plains streams, the river experiences large variations in discharge, exhibiting an annual pattern of prolonged periods of low flow punctuated by high flow events. The Clear Fork at Fort Griffin ordinarily experiences summer (June–October) low flows, and periods of zero flow lasting from a few days to nearly three months may occur every few years. During those periods, perennial pools continue to occupy substantial areas of streambed. Although the river may be subject to large variations in discharge, it is characteristically a continuously flowing system containing species characteristic of, and in some cases restricted to, small riverine systems.

The most prevalent riverine habitat available to aquatic organisms in the study area are the long, slow flowing pools of wide variety relative to widths and depth. The pools, which are often in excess of 1.5 meters in depth, are typically floored by small and large gravel, cobble, rock, boulder, and bedrock. The pool areas were noted by their biological character to be permanent or usually persistent. In several areas, the river channel is constricted, forming shallow, relatively fast-flowing riffle habitats. The riffle areas tend to be very shallow, ranging from 5 cm to 30 cm and are generally floored by large gravel and cobble substrates. The presence of riffle areas is dependent upon the volume of water flowing down the creek. The faster flowing habitats and more suitable substrate provide a more diversified and abundant macroinvertebrate food base than occurs in pools, as well as shallow water habitat for many small species of fish. Major riffles exist in areas of relatively large rock substrates and steep stream gradient. The rock size of the substrate was generally large and provided abundant microhabitats for benthic invertebrates and fish. Secondary riffles, subject to repositioning of pea-gravel or pea-gravel-sand substrates were not encountered.

The riparian community is generally composed of four vegetation types based upon substrate and elevation above the river's surface. Variations of these primary types occur throughout the stream reach based on changes in the composition of woody and herbaceous species and the physiognomy of localized conditions and specific range sites. The first type, aquatic beds, occurs in only a few places within the river and growth was limited to the shoreline margins at all sampling locations. Sparse patches of emergent aquatic species observed during the field survey included eleocharis (*Eleocharis parvula*), fragrant flat sedge (*Cyperus odoratus*) and William Emory's caric sedge (*Carex emoryi*). The second, sand and gravel bars, occur sporadically along the river margins, but are more common in the bend areas. These areas are characterized by scoured banks and bars within or adjacent to the active river channel without significant vegetative cover. This type was especially evident at Stations 4 and 5 and to a lesser degree at Station 3. The third type, sloughs, are scattered throughout the length of the river reconnoitered occupying areas immediately adjacent to or separated by just a few meters from the main channel. These areas tend to support emergent vegetation if water is present for any length of time. This community type was not observed at any of the sampling locations. The river banks form the fourth type of community. Streamside riparian areas composed of woody and herbaceous species have different vegetation production capacities based on a range of factors such as soils, hydraulic controls, or slope gradients. Stream banks composed primarily of

sand and clay at all locations ranged from steep and vertical to low and terraced. The woody vegetation tends to overhang the well-shaded banks, but the channel is never narrow enough to have complete canopy coverage.

Moderate to abundant growth of filamentous algae (*Oedogonium* sp. and *Cladophora* sp.) was noted in all riffle areas during the March 2009 survey. Both are green algae (*Chlorophyceae*) genera that are common in streams and are relatively tolerant of hard water and nutrient enrichment. An algal die-off was observed in June 2009, but dense strands of new growth were again encountered in the sample zone riffles during the August 2009 survey. Similarly in 2010, riffle zones exhibited excessive filamentous algal growth during the May 2010 visit, but development was not as heavy on the substrate in July 2010. Random grab samples taken in July 2010 from filamentous algal mats observed in the flowing riffle areas of three ALM locations indicate a source of organic material for consumers (e.g., insects and other invertebrates). The decomposition of abundant algal growths may temporarily deplete these shallow interstitial substrate areas of dissolved oxygen which could affect habitat utilization by riffle-dwelling species. The algal community, which changes how light and nutrients are distributed in water, was dominated by green algae (Chlorophyta), diatoms (Bacillariophyta), and blue-green algae (Cyanobacteria) (Table H-3).

Table H-3.
A Checklist of Representative Algal Species at Three River Locations July 2010

Scientific Name
Cyanobacteria (blue-green)
Oscillatoria sp.
Schizothrix sp.
Spirulina sp.
Chlorophyta (green)
Cosmarium sp.
Oedogonium sp.
Protoderma sp.
Bacillariophyta (diatoms)
Cocconeis sp.
Encyonema sp.
Frustulia sp.
Gyrostigma sp.
Navicula sp.
Nitzchia sp.
Nitzchia acicularis

H.3.1.2 Station Locations and Descriptions

Station 1 was established at RM 155 directly downstream of Hoggys Crossing on private property at latitude 32° 48' 56.808" N, longitude 099° 34' 17.929" W (Figure H-1). This is the uppermost river access selected for monitoring found approximately 3.0 miles downstream of the SH 6 crossing. The total drainage area upstream of this location is approximately 2,564 mi^2. A shallow riffle area occurs in the upper end of the sample zone at Transect 1, and a second occupies the lower end at Transect 4, each floored with large gravel and cobble. At high flow, the small riffle areas completely disappear, whereas these areas were more prominent during the August survey as sampling was conducted under a lower flow regime than observed in June. Water depth ranged from 0.07 ft in the riffle area at Transect 1 to over 4.9 ft in the downstream section of river downstream of Transect 4. While rocky throughout, the substrate composition proceeding downstream of Transect 4 generally changed, with decreasing particle size and increasing amounts of sand in the pool areas below the second riffle area. Asian clam (*Corbicula fluminae*) shells make up a large portion of the substrate composition along the right bank near Transect 3. The river banks were gently sloping to vertical and densely covered by an understory consisting of herbaceous vegetation that include greenbriar (*Smilax bona-nox*), bermudagrass (*Cynadon dactylon*), switchgrass (*Panicum virgatum*), Johnsongrass (*Sorghum halepense*), and saplings of the overstory species such as black willow (*Salix nigra*), mesquite (*Prosopis glandulosa*), American elm (*Ulmus americana*), and common hackberry (*Celtis laevigata*).

Station 2 was established about 1.0 river mile downstream of Station 1 near RM 154 at the Flatlands Crossing located on private property at coordinates latitude 32° 49' 23.953" N, longitude 099° 34' 17.929" W (Figure H-1). Total drainage area upstream of this location is 2,567 mi^2. Land use along the northern banks of this reach is mostly under cultivation. Pool and run/riffle habitats found in this section of the river are partitioned by the crossing. Upstream of the crossing, the pool substrates are almost solid bedrock with an overlying silt layer. Depths exceed 6 ft upstream of Transect 1. The channel narrowed considerably downstream of the crossing where flow velocities across a short riffle area were more noticeable. Bottom materials were composed of gravel and cobble but became sandier with distance downstream. Except for the south bank downstream of the crossing, the riparian habitat is extensive and undisturbed throughout the sample reach. American elm, black willow, and mesquite are the most common

overstory species, and they occur as saplings in the shrub layer as well. Johnsongrass, bermudagrass, povertyweed (*Baccharis neglecta*), and goldenrod (*Solidago canadensis*) are commonly scattered in the herbaceous layer.

Station 3 is located at RM 143 approximately 11.0 river miles downstream of Station 2. The upper end of the sample zone was established downstream of the confluence with Fish Creek and adjacent with the Hendrick Ranch Boys Camp property at coordinates latitude 32° 54' 12.963" N, longitude 099° 30' 49.075" W (Figure H-1). Total drainage area upstream of this location is 2,693 mi^2. Unlike the river crossings observed at the other four locations, a 70-ft long reinforced concrete slab has been constructed across the river to facilitate camp-activity traffic prior to closure. A long deep pool limited accessibility for habitat inventory and biological assessment at and above Fish Creek. Below this non-flowing tributary, aquatic habitat consisted of a long deep pool directly upstream of a concrete low water dam. Considerable amounts of large rock and cobble substrates dominate the streambed in this reach, along with scattered deposits of sand and gravel along the stream margins. The channel narrowed downstream and became less deep characterized by several connected shallow riffle/run areas floored with rock, cobble, gravel, and coarse sand. The river banks were low and become more terraced along the left bank downstream of the crossing. Accelerated water velocities across the smooth concrete surface probably inhibit fish moving upstream. Young fish and larger longnose gar were observed moving downstream across the slab. This structure does not chronically contribute sediment to the stream, and it appears to sustain the largest floods without failing. Herbaceous vegetation consisting primarily of bermudagrass comprises the dominant vegetation type throughout the study reach.

Station 4 is located at RM 129 approximately 4.7 river miles downstream of Station 3 at coordinates latitude 32° 58' 05. 693" N, longitude 099° 26' 48.635" W (Figure H-1). This remote crossing is approximately 1.1 river miles downstream of the area proposed for the current dam structure. The total drainage area upstream of this location is 2,739 mi^2. Portions of this river section flow through a steep-walled, rocky ridgeline through ranchland that, although relatively undeveloped, has experienced past clearing to facilitate cattle grazing. Sediments upstream of the crossing consist largely of cobble and assorted-sized gravel in the pool habitats that dominated the sample zone. The channel at the crossing consisted of a 100-ft length of exposed limestone slabs and slow runs among gravel-cobble riffles. A shallow pool was encountered near Transect 4 before the river splits for a short distance into two channels as it

bends to the north. The river rejoins, forming a narrow channel adjacent to the steep ridgeline along the right (east) bank flowing through a series of high velocity riffle and run habitat. Streamside tree cover throughout the sample zone was dominated by mesquite, black willow, with pecan observed only along the left bank at Transect 4. The shrub and herbaceous species found occurring in the general vicinity included goldenrod, ragweed, switchgrass, and bermudagrass.

Station 5 is located at RM 125 and extends upstream and downstream of the river crossing near Krooked River Ranch headquarters approximately 5.0 miles downstream of the proposed dam structure at coordinates latitude 32° 58' 52. 367" N, longitude 099° 28' 02.388" W (Figure H-1). Total drainage area upstream of this location is 2,745 mi^2. Although the location of this station is just below the proposed dam, aquatic habitats at this station are similar to the four upstream locations. The purpose of siting this station (and Station 4) downstream of the proposed dam is that data collected from these areas could serve as a baseline for possible changes in macroinvertebrate and fish populations resulting from construction and operation of the dam. Deep pool habitat occurred upstream of the river crossing between two riffle areas found at Transects 1 and 3. Downstream of the gravel crossing, the channel width decreased, and pool depths became shallower. Sediments consisted largely of assorted-sized gravel with scattered patches of cobble covered by a thin layer of fine sand and silt. Stream banks are steep and high along the left bank in the upstream portion of the sample zone decreasing in elevation as a steep bluff arises along the right bank as the channel bends to the northeast downstream of the crossing. Characteristic species bordering the river at this location include American elm, black willow, mesquite, goldenrod, ragweed, and bermudagrass.

H.3.2 Water Quality

Identification of the nature and source of water quality conditions along with evaluations based on the Texas Surface Water Quality Standards (TSWQS) helps to assess permit requirements with respect to water quality conditions and trends in the Brazos River Basin and provides data to support the development of cost-effective water quality management programs. Elevated bacteria levels are the most common problem caused by several factors such as agricultural and urban runoff, wastewater treatment plants, and animal feeding operations.[23,24]

[23]Texas Commission on Environmental Quality (TCEQ). 2008. 2008 Texas water quality inventory and 303(d) list. http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/08twqi/twqi08.html

[24]Brazos River Authority (BRA). 2009. *Brazos River basin highlights report 2009*. Brazos River Authority.

Elevated levels of nitrogen, phosphorus, nutrients, total dissolved solids, chloride, and sulfate are found in many locations within the basin. High nutrient levels can cause golden algal blooms resulting in low DO levels. These depressed DO levels have caused large fish kills in the past.[25]

The majority of the base flow to the Clear Fork includes runoff from rural lands from numerous tributaries, groundwater seepage from the Seymour Aquifer and effluent from the Abilene Wastewater Treatment Plant. The quantity and quality of water received by the portion of river to be inundated is dependant on the volume and quality of the water from each of these sources. Although the Clear Fork is considered perennial, flow periodically ceases, and its perennial surface waters are confined to isolated perennial pools.

The 2008 Texas Water Quality Inventory (305(b)) and 303(d) List promulgated by TCEQ identifies water bodies that do not meet—or are not expected to meet—applicable water quality standards. The TCEQ identifies surface water quality standards and appropriate water uses for each classified river segment in Texas. For each classified stream, specific numerical water quality criteria or assigned beneficial uses have been assigned (Appendix A, 31 Texas Administrative Code, §307.10). Relevant to the study area, the TCEQ-defined Segment 1232 of the Brazos River Basin (Clear Fork Brazos River) has the following established appropriate water uses and specific water quality standards:

- Narrative Criteria
  - Contact Recreation
  - High Aquatic Life
- Numeric Standards

– Chloride	1,250 mg/L
– Sulfate	2,200 mg/L
– Total Dissolved Solids	4,900 mg/L
– Dissolved Oxygen	5.0 mg/L
– pH Range	6.5–9.0
– Indicator Bacteria (*E. coli*)	126/100 ml
– Temperature	93° F (33.8° C)

Within the Brazos River Basin, a number of streams and stream segments are listed on the 303(d) List due to various reasons including low DO levels, high levels of bacteria, low and high pH, nutrients, total dissolved solids, chlorides, and sulfates.[26] Segment 1232 (Clear Fork Brazos River) is not included on the 2008 List of Impaired Water Bodies for Texas (303(d) List) for any of the above parameters.[27] The 2008 305(b) assessment for Segment 1232 identifies

[25] Ibid.

[26] Brazos River Authority (BRA). 2009. *Brazos River basin highlights report 2009*. Brazos River Authority.

[27] Texas Commission on Environmental Quality (TCEQ). 2008. 2008 Texas water quality inventory and 303(d) list. http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/08twqi/twqi08.html

concerns for nitrate, orthophosphorus, total phosphorus, chlorophyll a, and depressed dissolved oxygen levels in the unclassified tributaries to this river segment.

Another primary water quality concern as a result of elevated chlorides and associated TDS concentrations throughout the basin are the potential lethal effects of golden algae (*Prymnesium parvum*) to the aquatic environment. Golden algae is a microscopic one cell, flagellated member of the yellow-green algae family (Chrysophyta) generally found in brackish water, but has been documented in waters with salinities ranging from essentially freshwater to 3.5 times that of seawater. The conditions necessary for such an algae "bloom" are not clearly understood at this time. Research has indicated that this algal species is able to remain dormant in sediments until conditions are optimal for large increases in its population. The majority of golden algae fish kills occur during the winter months when the water is cold, which is a period of the year not favorable for the typical green algae populations. Under normal conditions, gills regulate the exchange of dissolved ions and gases between water and fish. After toxins enter the gills, fish lose this ability, which results in their death. It is thought that these toxins also increase a fish's susceptibility to low levels of toxins that may already exist in the water. Golden algae toxicity is influenced by environmental factors and diminishes with an increase in salinity. Ultra-violet light and visible light also inactivate the toxin, as does a pH value of less than six (acidic) or greater than nine (basic). Certain bacteria found in nature also break down the toxin. TPWD is coordinating work efforts with university researchers, other state agencies, river authorities, and interested parties to better understand and manage the potentially harmful golden algae in Texas. A technical report addressing the biology and ecology of golden algae in Texas lakes, including Lake Granbury and Lake Whitney, was issued in October 2010 by researchers from Texas AgriLife Research, Baylor University, and the University of Texas at Arlington.[28]

Concurrent with the habitat/biological assessment efforts and water quality sampling, instantaneous measurements of temperature (°C), conductivity (µS/cm), dissolved oxygen (mg/L) pH, and Secchi depth (m) were recorded during the 2009 and 2010 surveys (Table H-4). The averages and ranges of oxygen measurements collected at 15 minute intervals over 24-hour periods are summarized in Table H-5. Raw diel measurements of all recorded parameters are located in Attachment H-3.

[28] Texas AgriLife Research. 2010. *Lake Granbury and Lake Whitney Assessment Initiative.* College Station, Texas.

Table H-4.
Water Quality Parameters by Sampling Station
15-17 June 2009, 10-12 August 2009, 5-7 May 2010 and 19-21 July 2010

Station	Date	Time	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Percent Saturation (%)	Conductivity (µS/cm)	pH (S.U.)	Secchi Depth (m)
1 Hoggy Crossing	15 June	10:05	27.40	6.20	78.1	1488	8.30	0.15
	10 August	08:05	20.95	7.35	82.6	425	8.11	0.17
	6 May	10:08	22.60	9.60	112.8	2439	8.90	0.12
	July			NO	SITE	VISIT		
2 Flatland Crossing	15 June	15:55	29.20	8.00	105.4	1530	9.00	0.21
	10 August	12:43	29.70	17.80	234.5	1030	8.70	0.27
	6 May	14:06	23.60	14.30	169.6	2433	9.00	0.29
	July			NO	SITE	VISIT		
3 Boys Camp Crossing	16 June	10:35	28.40	7.90	102.3	1504	9.70	0.30
	11 August	10:33	29.70	6.90	91.5	709	8.80	0.41
	7 May	13:27	23.50	9.50	113.0	2170	9.00	0.29
	19 July	15:34	32.6	10.40	143.3	1283	9.10	0.20
	20 July	09:30	30.30	5.50	72.7	1286	8.50	0.29
4 Shelton Crossing	16 June	10:25	28.70	12.90	166.9	1408	10.50	0.39
	12 August	07:38	26.60	5.37	67.0	600	8.40	0.33
	7 May	08:08	22.20	7.90	91.6	1869	7.90	0.90
	20 July	15:10	32.3	8.50	117.6	1297	8.50	0.39
	21 July	08:43	29.6	6.00	79.4	1278	8.90	0.33
5 KRR Lodge Crossing	16 June	15:37	31.00	17.8	243.9	1358	10.80	0.20
	11 August	15:14	29.70	7.11	93.7	560	8.80	0.40
	5 May	18:44	23.70	14.00	166.7	1792	9.40	0.21
	19 July	14:40	32.60	10.70	147.7	1436	9.20	0.28
	20 July	17:55	32.80	10.90	151.7	1346	9.30	0.43

Table H-5.
Mean, Minimum and Maximum Dissolved Oxygen Concentration (mg/L)
24-Hour Dissolved Oxygen Monitoring at Three Locations
May and July 2010

Date	Description	Location		
		Station 5 Krooked River Ranch Crossing	Station 3 Boys Camp Crossing	Lueders City Park Downstream of Hwy 6
5–6 May 2010	Mean	**	10.09	8.12
	Minimum	**	8.73	6.54
	Maximum	**	13.72	12.16
	Exceedance*	**	0	0

	Measurements Taken	96	96	96
19–20 July 2010	Mean	**	7.79	5.33
	Minimum	**	6.64	4.30
	Maximum	**	10.42	7.62
	Exceedance*	**	0	51
	Measurements Taken	96	96	96

*Exceedances occurred when dissolved oxygen values fell below 5.0 mg/L demonstrated by the number of times this situation occurred based on the number of measurements taken every 15 minutes over the 24-hr recording period.

**Measurements determined to be unreliable; data sonde post calibration check for dissolved oxygen did not meet quality assurance requirements.

Water temperature determines the amount of oxygen water can contain when at equilibrium with the atmosphere. Temperatures recorded at the five biological monitoring stations during the index periods varied from a low of 27.4 °C at Station 1 to 31.0 °C at Station 5 in June 2009 and ranged from 22.2 °C recorded at Station 4 to 23.7 °C at Station 5 in May 2010. The critical period temperatures measured during 2009 and 2010 ranged from 20.9 °C to 29.7 °C in August 2009 and 29.6 °C to 32.8 °C in July 2010. Dissolved oxygen (DO) levels at the surface (0.3 m or 1.1 ft) were above 5.0 mg/L at every location measured during the two year study period. DO levels were generally above saturation with most values in excess of 75% solubility. Recorded supersaturation levels (>100%) at all five locations suggest high levels of photosynthetic activity of algae suspended in the water column. The maximum DO and percent saturation level recorded was 17.8 mg/L (234.5%) at Station 2 in the early afternoon on 10 August and the identical DO level representing 243.9% saturation was measured at Station 5 on 16 June in mid-afternoon. A range of 80 to 125% saturation is excellent for most aquatic organisms; however, a level of 112% or more may be harmful to fish cardiovascular systems (AWRI, 2010).

Conductivity measurement of a watershed is usually influenced by local geology or from anthropogenic activities (i.e., fertilizer runoff and wastewater discharges). The conductivity of water is directly linked to the concentration and mobility of dissolved ions and the ability to pass an electrical current. With the exception of the August 2009 survey, high water conductivities in excess of 1,250 µS/cm were recorded throughout the river. Conductivity measurements were much lower in August where values ranged from 425 µS/cm at Station 1 to 1,030 µS/cm at

Station 2. Although all surveys were preceded by thunderstorm activity, dilution by rainwater in the area was more pronounced during August 2009 that reduced the conductivity levels in the surface layer.

The pH of the Clear Fork is slightly alkaline, which is typical for this region as the river bed and terrace soils are characterized by Clairemont-Grandfield-Clearfork mildly to moderately alkaline loam, clay, and sand floodplain soils. Several values (7) outside of the TCEQ standard pH range for Segments 1232 (6.5–9.0) were measured during this study (Table H-4). On three occasions, pH values of 9.0 matched the numeric upper limit. These high pH measurements were correlated with high DO levels and percent saturation that suggest elevated photosynthetic activity. Algal blooms have dramatic effects on pH values when sufficient light and nutrients are available. Photosynthesis can cause a depletion of dissolved oxygen in the water column during the night and a rise of pH during the daylight hours by removing carbon dioxide from the water. Algal blooms produce large amounts of oxygen that may lead to supersaturated levels of DO in the water column. These conditions can also be created when a large quantity of algae die and decompose. This may be an indicator of potential threat to aquatic organisms, especially during the warm to hot summer months. Dense spring and late summer blooms, composed primarily of blue-green algae, green algae, and diatoms were present at high relative abundance during the two reconnaissance surveys in 2009 and in the shallow pool and riffle habitats present at each sampling site in 2009 and 2010. The physical nature of attached algae ranged from single, microscopic cells to massive crusts and masses of filaments many feet in length. The stream assemblages are consistent with moderate to high TDS water and characteristic of organic enrichment which suggests impoundment of mesotrophic or eutrophic water.

Turbidity measures the cloudiness and the materials, such as algae and microbes, suspended in the water. Secchi disc depth (transparency) averaged about 0.25 m (0.82 ft) during the June sampling period, 0.33 m (1.1 ft) in August, 0.36 m (1.2 ft) in May, and 0.29 m (0.95 ft) in July. During each survey, turbidity varied among the five locations. Daily variations also occurred at the same location during July. Excessively turbid water, suggesting sediment-laden runoff, was observed in the river after the area received heavy rainfall prior to the June sample event. Although somewhat higher average transparencies were measured in the following sample events, the consistently low Secchi depths recorded in the river are probably due to the high algal concentrations common at all locations.

Measurements of diurnal variations of temperature, dissolved oxygen concentrations, conductivity, and pH in the river recorded in the mixed surface layer at three locations by programmable YSI multiprobe instruments during May and July are found in Attachment H-3. No diel DO values were below 5.0 mg/L at the Boys Camp (Station 3) and at the Lueders City Park upstream of the Big Country Baptist Assembly during 5–6 May 2010 (Table H-5). Of the 96 recordings taken at Lueders City Park during 19–21 July 2010, 51 measurements fell within the 4.30 to 4.93 mg/L range but ended with a 24-hr average of 5.33 mg/L. (Unfortunately, the diurnal measurements for dissolved oxygen taken at Station 5 during both survey periods can not be reported with confidence. Neither of the post-deployment calibration data checks met the acceptable ranges of specific performance criteria related to accuracy and precision, usually an indication of a failed probe. Diurnal fluctuations were noticeable and reflect the algal processes in the river. Generally, dissolved oxygen concentrations were the least from around 5 a.m. to 11 a.m., and the greatest from roughly 1 p.m. to 7 p.m. DO measurements will be collected during the 2011 surveys at this location.)

Streamflows in the Clear Fork are monitored by the U.S. Geological Survey (USGS) at two locations above and below the proposed reservoir site: Fort Griffin (USGS Gage No. 08085500) located downstream and the upstream at Nugent (USGS Gage No. 08084000). Flow is highly dependent on upper watershed inflow and the rate of evaporation/transpiration during dry periods. The total discharge values (cfs) calculated for each of the five locations (except where noted) during the four field efforts are presented in Table H-6. Sampling was conducted under somewhat high flow rates during June 2009, May 2010, and July 2010 after weather-induced runoff resulting from storm systems that passed through the area. Stream flow characteristics did not change significantly after localized heavy storm events prior to and during the August survey.

H.3.3 Aquatic Life Monitoring Survey

Stream habitat and aquatic biota (benthic macroinvertebrates and fish) were collected at each location four times (with the exception of Stations 1 and 2 in July 2010) during the two-year study to evaluate aquatic life use. Habitat assessments and biological collections were conducted along a standardized length of 500 meters during the 2009–2010 study period at four of the selected monitoring locations on 15–17 June 2009, 10–12 August 2009, 5–7 May 2010, and 19–21 July 2010 (Figure H-1). Deep pool habitat upstream and downstream of the river crossing at

Station 2 restricted the length of the sample zone to a sample length of 400 meters. In-stream, multi-probe data loggers measured DO, temperature, conductivity, and pH over a 24-hour period at three locations in May and July 2010. Analysis of a minimum of 200 benthic macroinvertebrates (163 at Station 2 and 173 at Station 3 in June 2009) together with the fisheries data collected by a minimum of 15 seine hauls sampled from all available microhabitats was integrated through the use of comparative statistical parameters and available benthic and fish community trophic structure data to provide an aquatic life use rating for each stream investigated. Weather conditions in the basin were generally wetter than previous years as significant storm events occurred in the watershed prior to each site visit. The current classification of the Clear Fork is "high aquatic life use" which is that designated by TCEQ for classified stream Segment 1232 of the Brazos River. The aquatic life use criterion for dissolved oxygen in Segment 1232 is 5.0 mg/L.

Table H-6.
Instantaneous Streamflow Measurements by Sampling Station
15–17 June 2009, 10–12 August 2009, 5–7 May 2010, and 19–21 July 2010

Date	Weather Conditions	Station 1 Hoggy Crossing		Station 2 Flatlands Crossing		Station 3 Boys Camp		Station 4 Shelton Crossing		Station 5 Lodge Crossing	
		Stream Width (m)	Discharge (cfs)	Stream Width (m)	Discharge (cfs)	Stream Width (m)	Discharge (cfs)	Stream Width (m)	Discharge (cfs)	Stream Width (m)	Discharge (cfs)
Index Period											
15 June	Clear; hot; calm, sunny	18.41	45.28	21.40	39.34	--	--	--	--	--	--
16 June	Clear; hot; calm, sunny	--	--	--	--	18.41	36.46	--	--	15.36	48.04
17 June	Clear; hot; calm, sunny	--	--	--	--	--	--	13.23	26.94	--	--
6 May	Partly cloudy; calm; warm to hot	14.48	35.01	18.29	39.21	--	--	--	--	--	--
7 May	Clear; cool to warm; humid	--	--	--	--	19.93	28.60	7.77	36.20	--	--
5 May	Partly cloudy; cool; calm; rain in area;	--	--	--	--	--	--	--	--	6.31	42.04
Critical Period											
10 August	Clear, warm to hot, sunny	17.34	11.53	21.09	11.51	--	--	--	--	--	--
11 August	Clear, hot, and sunny into early afternoon; overcast, rain and cool in late afternoon	--	--	--	--	17.80	7.11	--	--	14.63	10.87
12 August	Clear, warm, calm	--	--	--	--	--	--	12.19	9.11	--	--
20 July	Partly cloudy; hot; light wind	--	Not measured	--	Not measured	21.34	47.26	8.23	50.88	5.94	51.79

H.3.3.1 Habitat Quality

In spite of the evident differences in stream size and water availability, habitat quality was quite similar between the five sampling locations (Table H-7). Each sampling reach included at least one example of riffle, run, and pool habitat type. The tree-lined banks of the Clear Fork contribute leafy detritus to the river. Areas not densely shaded supported grasses typical to the area. Low to moderate amounts of terrestrial plant debris, ranging from small tree branches to leaf litter, provides the predominant source of in-stream cover. No significant stands of

submergent or emergent aquatic vegetation are found along the study reach of the Clear Fork watershed. The cross sections measured at each transect show that the creek channels are relatively shallow and wide. Evidence of wildlife utilization was noted by footprints of deer and raccoon along the shoreline margins. There was considerable evidence of recent flooding (i.e., woody deposits lodged in tree branches high above the current water level) at all sites. The physical habitat availability in the Clear Fork is susceptible to fluctuating depths and higher magnitude of stream velocities. The Stream Physical Characteristics Worksheets (Attachment H-1, Tables H-1-1 through H-1-20) were compiled for all four surveys.

The Clear Fork at Station 1 had an average wetted stream width of 18.41 m and an average water depth of 0.40 m in June 2009, an average wetted width of 17.34 m and an average depth of 0.39 m in August 2009, and an average wetted width of 16.64 m and an average depth of 0.42 m in May 2010. This station was not visited in July. The river section investigated is almost straight having two poorly defined stream bends, a low percentage of canopy cover (26%), low percentage (27%) of stream bank erosion and an average bank slope of around 54 degrees. A total of three riffle areas were present within the upper half of the sample zone, and the dominant substrate is cobble with a high percentage of gravel composition. The maximum pool width observed was measured at 25.60 m, the maximum pool depth was 1.56 m, and the pool coverage over the 500 m channel reach inspected was estimated at 40 percent. The HQI results for the three surveys indicated a value of 24.5, 23.5, and 24.5 (Table H-7), which corresponds with the High aquatic habitat subcategory. The total value compiled from the worksheets for August was slightly lower than the two index period surveys. This small decrease in scoring was attributed to the channel flow status as a result of receding water conditions observed during the hot summer months. The total flow measured during June 2009 was 45.28 cfs compared to 11.53 cfs during August 2009 and 35.01 cfs in May 2010.

Table H-7.
Habitat Quality Index
15–17 June 2009. 10–12 August 2009. 5–7 May 2010. and 19–21 July 2010

Metric	Station 1 Hoggy Crossing 15 June 2009	Station 2 Flatlands Crossing 15 June 2009	Station 3 Boys Camp 16 June 2009	Station 4 Shelton Crossing 17 June 2009	Station 5 Krooked River Ranch 16 June 2009
	Score	Score	Score	Score	Score
1. Available Instream Cover	3 Common	2 Rare	2 Rare	3 Common	2 Rare
2. Bottom Substrate Stability	4 Stable	3 Moderately Stable	4 Stable	4 Stable	4 Stable
3. Number of Riffles	3 Common	3 Common	3 Common	3 Common	3 Common
4. Dimensions of Largest Pool	4 Large	4 Large	4 Large	4 Large	4 Large
5. Channel Flow Status	3 High	3 High	3 High	3 High	3 High
6. Bank Stability	1.5 Mod. Stable/Mod Unstable	0.5 Mod. Unstable/Unstable	2 Stable/Mod Unstable	1.5 Mod. Stable/Mod Unstable	1 Mod. Stable/Unstable
7. Channel Sinuosity	1 Low	1 Low	1 Low	2 Moderate	2 Moderate
8. Riparian Buffer Vegetation	3 Extensive	3 Extensive	2 Wide	3 Extensive	2 Wide
9. Aesthetics of Reach	2 Natural	2 Natural	2 Natural	2 Natural	2 Natural
Total Score	24.5	21.5	23.0	25.5	23.0
Aquatic Life Use*	High	High	High	High/Exceptional	High

Metric	Station 1 Hoggy Crossing 10 August 2009	Station 2 Flatlands Crossing 10 August 2009	Station 3 Boys Camp 11 August 2009	Station 4 Shelton Crossing 12 August 2009	Station 5 Krooked River Ranch 11 August 2009
	Score	Score	Score	Score	Score
1. Available Instream Cover	3 Common	2 Rare	2 Rare	3 Common	2 Rare
2. Bottom Substrate Stability	4 Stable	3 Moderately Stable	4 Stable	4 Stable	4 Stable
3. Number of Riffles	3 Common	3 Common	3 Common	3 Common	3 Common
4. Dimensions of Largest Pool	4 Large	4 Large	4 Large	4 Large	4 Large
5. Channel Flow Status	2 Moderate	2 Moderate	1 Low	2 Moderate	2 Moderate
6. Bank Stability	1.5 Mod. Stable/Mod Unstable	0.5 Mod. Unstable/Unstable	2 Moderately Stable	1.5 Mod. Stable/Mod Unstable	1 Mod. Stable/Unstable
7. Channel Sinuosity	1 Low	1 Low	1 Low	2 Moderate	2 Moderate
8. Riparian Buffer Vegetation	3 Extensive	3 Extensive	2 Wide	3 Extensive	2 Wide
9. Aesthetics of Reach	2 Natural	2 Natural	2 Natural	2 Natural	2 Natural
Total Score	23.5	20.5	21.0	24.5	22.0
Aquatic Life Use*	High	High	High	High	High

*Aquatic Life Use Point Score Ranges:
Exceptional = 26-31; High = 20-25; Intermediate = 14-19; Limited = <13

Table H-7.
Habitat Quality Index
15–17 June 2009, 10–12 August 2009, 5–7 May 2010, and 19–21 July 2010 (Concluded)

Metric	Station 1 Hoggy Crossing 6 May 2010	Station 2 Flatlands Crossing 6 May 2010	Station 3 Boys Camp 7 May 2010	Station 4 Shelton Crossing 7 May 2010	Station 5 Krooked River Ranch 7 May 2010
	Score	Score	Score	Score	Score
1. Available Instream Cover	3 Common	2 Rare	2 Rare	3 Common	2 Rare
2. Bottom Substrate Stability	4 Stable	4 Stable	4 Stable	4 Stable	4 Stable
3. Number of Riffles	3 Common	3 Common	3 Common	3 Common	3 Common
4. Dimensions of Largest Pool	4 Large	4 Large	4 Large	4 Large	4 Large
5. Channel Flow Status	3 High	3 High	3 High	3 High	3 High
6. Bank Stability	1.5 Mod. Stable/Mod Unstable	0.5 Mod. Unstable/Unstable	2 Stable/Mod Unstable	1.5 Mod. Stable/Mod Unstable	1.5 Mod. Stable/Mod Unstable
7. Channel Sinuosity	1 Low	1 Low	1 Low	2 Moderate	2 Moderate
8. Riparian Buffer Vegetation	3 Extensive	3 Extensive	2 Wide	3 Extensive	2 Wide
9. Aesthetics of Reach	2 Natural	2 Natural	2 Natural	2 Natural	2 Natural
Total Score	24.5	22.5	23.0	25.5	23.5
Aquatic Life Use*	High	High	High	High/Exceptional	High

Metric	Station 1 Hoggy Crossing July 2010	Station 2 Flatlands Crossing July 2010	Station 3 Boys Camp 20 July 2010	Station 4 Shelton Crossing 20 July 2010	Station 5 Krooked River Ranch 21 July 2010
	Score	Score	Score	Score	Score
1. Available Instream Cover			2 Rare	2 Rare	2 Rare
2. Bottom Substrate Stability	NO ACCESS	NO ACCESS	4 Stable	4 Stable	4 Stable
3. Number of Riffles			3 Common	3 Common	3 Common
4. Dimensions of Largest Pool	NO MEASUREMENTS	NO MEASUREMENTS	4 Large	4 Large	4 Large
5. Channel Flow Status			3 High	3 High	3 High
6. Bank Stability	OR	OR	2 Moderately Stable	1.5 Mod. Stable/Mod Unstable	1.5 Mod. Stable/Mod Unstable
7. Channel Sinuosity			1 Low	2 Moderate	2 Moderate
8. Riparian Buffer Vegetation	SAMPLES WERE TAKEN	SAMPLES WERE TAKEN	2 Wide	3 Extensive	2 Wide
9. Aesthetics of Reach			2 Natural	2 Natural	2 Natural
Total Score			23.0	24.5	23.5
Aquatic Life Use*			High	High	High

*Aquatic Life Use Point Score Ranges:
Exceptional = 26-31; High = 20-25; Intermediate = 14-19; Limited = <13

The Clear Fork at Station 2 had an average wetted stream width of 21.40 m with an average water depth of 0.57 m in June 2009, an average wetted width of 21.09 m with an average depth of 0.48 in August, and an average wetted width of 21.92 m with an average depth of 0.55 m in May 2010. Access to the river via this property was not permitted in July 2010. The main channel exhibited deeper pooled areas with a wider channel throughout the sample zone, less steep creek banks, more potential for bank erosion and the highest tree canopy percentage of all stations investigated (33%). This length of the river has two moderately defined and one poorly defined stream bends. A total of two riffle areas were present within the sample zone, and the dominant substrate is gravel. After summation of the HQI metric values for June (21.5), August (20.5), and May (22.5), the habitat data indicated a High aquatic habitat rating (Table H-6). During 2009, the slightly lower score in August was attributed to a drop in the channel water level that did not reach the base of both river banks in 25% of the sample zone. The highest score observed in May was due to a higher percentage of gravel substrates observed throughout the sample zone in addition to a higher channel flow status. The total flow measured during June 2009 was 39.34 cfs compared to 11.51 cfs during August 2009 and 39.21 cfs in May 2010.

The Clear Fork at Station 3 had an average wetted stream width of 18.41 m with an average water depth of 0.36 m in June 2009, an average wetted width of 17.80 m with an average depth of 0.25 m in August, an average wetted width of 18.31 m with an average depth of 0.33 m in May 2010, and an average wetted width of 18.84 m with an average depth of 0.38 m in July 2010. The sample reach has two moderately defined and one poorly defined stream bends. There are four cobble/gravel riffle areas within the lower portion of the sample zone, deep pool habitat was common in the river upstream of Transect 2, and the dominant substrate type was cobble. Bank stability is moderately stable with a low potential for erosion (10.5%) and bank angles that averaged 36.5 degrees. The HQI results compiled from the worksheets (Table H-6) correspond to a High habitat ranking. An identical value of 23.0 was calculated from the June, May, and July measurements, whereas a total score of 21.0 was determined for August. This was the greatest scoring difference between sampling events of all stations as the lower channel flow status score calculated for August was attributed to a decrease in water level, exposing more channel bottom that contributed to fish sampling difficulty. The riffle zones in the shallower downstream reach were more prominent during the August 2009 ALM event since sampling was conducted under a lower and more representative seasonal flow regime (7.11 cfs) than experienced during the June 2009 (36.46 cfs), May 2010 (28.60 cfs), and July 2010 (47.26 cfs)

surveys. A major intermittent tributary, Fish Creek, joins the main streambed of the Clear Fork upstream of the sample zone and opposite the Boys Camp facility. No surface inflow emanating from this creek was ever observed entering the river during numerous site visits made to this location, suggesting that flow becomes subsurface in the lower reach of this drainage.

The Clear Fork at Station 4 had an average wetted stream width of 13.23 m with an average water depth of 0.31 m in June, an average wetted width of 12.19 m with an average depth of 0.21 m in August, an average wetted width of 13.11 m with an average depth of 0.29 m in May, and an average wetted width of 13.01 m with an average depth of 0.32 m in July. The sample length has low sinuosity with one well defined and two poorly defined stream bends; a very high percentage of gravel-sized or larger substrate (87%); and available in-stream cover is common. There were three riffle areas within the sample zone, and the dominant substrate type was cobble. The resulting habitat quality metric score for this aesthetically pleasing section of river channel was rated as High/Exceptional during both index periods with a cumulative value of 25.5 and a combined average of 24.5 during the critical period surveys (Table H-7) as little evidence of human disturbance was noted. Receding water levels in the river were recognized for the slightly lower score in 2009 as sampling was conducted at 9.11 cfs compared with 26.94 cfs in June. Available in-stream cover was slightly less during July 2010 as persistent higher flows measured in May (36.20 cfs) and July (50.88) appear to have kept the river channel free of coarse woody debris accumulation.

The Clear Fork at Station 5 had an average wetted stream width of 15.36 m with an average water depth of 0.50 m in June, an average wetted width of 14.63 m with an average depth of 0.40 m in August, an average wetted width of 14.33 m with an average depth of 0.49 m in May, and an average wetted width of 14.84 m with an average depth of 0.50 m in July. This portion of the river has one well defined, two moderately defined, and one poorly defined stream bends. There were a total of two cobble/gravel riffles in the sample zone found at T1, and at T3 that were more evident under a lower flow regime (10.87 cfs) than observed in June 2009 (48.04 cfs), May 2010 (42.04 cfs), and July 2010 (51.79 cfs). Additionally, this station exhibited a very high percentage of gravel substrate (96.0%), low percentage of stream bank erosion (25.5%), an average bank slope of 58 degrees, and a very low percentage (20.5%) of tree canopy cover. The HQI results indicated a habitat value of 23.0 in June and 22.0 in August, and an identical score of 23.5 during the May and July visits, which corresponds with the High aquatic habitat subcategory (Table H-7). The slight difference in the total scoring was again due to the lack of

water coverage within the river channel in 2009 and a combination of increased water coverage and a slightly higher value for stream bank stability.

H.3.3.2 Benthic Macroinvertebrate Community Evaluation

Benthic macroinvertebrates are bottom-dwelling organisms that use water bodies as habitat for one or more parts of their life cycle. Benthic macroinvertebrates inhabit a variety of substrates in streams and rivers, from the bottom sediments (silt, sand, gravel, and cobble) to vegetation or debris piles along margins or in pools. The density and diversity of the benthic fauna of this region are influenced by the quality of the water they inhabit, including substrate character, organic content of the substrate, persistence of water, and predator-prey relationships.

Examination of benthic macroinvertebrate community structure and composition can provide insight to the integrity of water quality and aquatic habitat of the water body. Assumptions about the water quality and habitat can be inferred from the benthic macroinvertebrate community since most of the organisms are generally restricted in their mobility (unable to move great distances), and many of the organisms live for several years, which requires them to integrate the effects of both chemical and physical perturbations over time. Changes in water chemistry, such as nutrient enrichment and toxic contamination, in addition to changes in stream characteristics (such as morphology, erosion, and sedimentation) will be reflected by changes in the macroinvertebrate community structure and composition. Therefore benthic macroinvertebrate assemblages reflect the substrates, flow regimes, and food supplies available at the time of collection. Benthic macroinvertebrate communities generally show low diversity where scoured sandy clays dominate streambeds. An increase in substrate surface area and stratification (e.g., layers of cobble, leaf packs, and submerged vegetation) generally promotes the establishment of a diverse and stable benthic macroinvertebrate community.

The density and diversity of the benthic fauna of this region is influenced by the quality of the physical habitat and chemical composition of the water they inhabit, including physico-chemical parameters, substrate character, organic content of the substrate, persistence of water, and predator-prey relationships. The balance of trophic structure and community composition is influenced by the stability and integrity of these components. An aspect of community composition evaluated for each sample included the abundance and diversity of benthic macroinvertebrates belonging to the Ephemeroptera (mayflies), Plecoptera (stoneflies), and

Trichoptera (caddisflies) benthic groups. Together, these three benthic groups are considered relatively pollution sensitive and constitute the EPT index, which is used as an indicator of water quality. A higher number of taxa from the EPT group indicate healthy water chemistry and aquatic habitat. The diversity and abundance of other groups such as riffle beetles (family Elmidae) and non-insect invertebrates also provide indicators of community balance. In addition to these components of an individual sample, the percent composition of the functional trophic level and pollution tolerance for each taxon (established by the TCEQ) is evaluated to provide a cumulative assessment of the entire sample. These metric parameters provide insight to the overall integrity of the community.

The dominant substrate along the evaluated reaches of the Clear Fork was generally loose, large gravel, cobble, and rock in the shallow fast-flowing run habitats alternating with the predominance of soft, sandy and clayey mud bottoms in the deeper pool areas. Substrate diversity—in addition to in-stream riparian cover consisting of variable amounts of dead woody debris such as leaves, logs, branches, and roots along the stream edge—increases the stability of available aquatic habitat for macroinvertebrate colonization. Table H-8 presents a checklist of the benthic macroinvertebrate assemblages collected by station during the 2009 and 2010 surveys. A total of 4,188 individuals representing 64 taxa were collected and identified to the lowest practical taxonomic level (LPTL). The benthic community was relatively similar as 26 of the 64 total taxa identified were present at all five locations. Although approximately 21% of the taxa were restricted to one location, the remaining 79% were collected from two or more sites. Mayflies (*Ephemeroptera*) and caddisflies (*Trichoptera*), two major groups widely considered to be representative of exceptional aquatic integrity, were consistently represented at all five sites. Although certain taxa that tolerate poor water quality such as flatworms (*Dugesia*) and amphipods (*Hyallela*) were present at most locations, these organisms are not unexpected at even the most pristine of habitats.

Table H-8.
Checklist of Benthic Macroinvertebrate Taxa Collected by Kick Net
2009 and 2010

Phylum	Class	Order	LPTL	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5
Platyhelminthes	Turbellaria	Tricladida	*Dugesia*	✓	✓	✓	✓	✓
Mollusca	Bivalvia	Veneroida	*Corbicula flaminae*	✓	✓	✓	✓	
			Musculium	✓	✓	✓	✓	✓
			Eupera cubensis	✓	✓	✓		
	Gastropoda	Basommatophora	*Physa/Physella*	✓	✓	✓	✓	✓
		Limnophila	*Gyraulus*			✓		
Annelida	Oligochaeta		Oligochaeta*	✓		✓	✓	✓
	Hirudinea		Hirudinea*	✓	✓	✓	✓	✓
Arthropoda	Insecta	Diptera	Chironomidae*	✓	✓	✓	✓	✓
			Sciomyzidae*			✓		
			Bezzia		✓			
			Culicoides	✓				
			Simulium		✓		✓	✓
			Euparyphus			✓		
			Tabanus				✓	✓
		Coleoptera	*Stenelmis*	✓	✓	✓	✓	✓
			Dubiraphia	✓	✓	✓	✓	✓
			Hexacylloepus	✓	✓		✓	✓
			Coptotomus	✓				
			Hydroporus			✓		
			Helichus	✓	✓	✓	✓	✓
			Gyretes	✓	✓			✓
			Helophorus	✓				
			Berosus	✓	✓	✓	✓	✓
			Hydrochus		✓		✓	
			Tropisternus	✓		✓	✓	
			Peltodytes	✓	✓	✓	✓	
			Scirtes	✓	✓	✓	✓	✓
			Laccophilus	✓	✓	✓	✓	✓
		Lepidoptera	*Petrophila*	✓	✓			✓
		Ephemeroptera	*Callibaetis*				✓	
			Camelobaetidius	✓				
			Fallceon quilleri	✓	✓	✓	✓	✓
			Stenonema	✓	✓	✓		✓
			Isonychia	✓	✓	✓		✓
			Tricorythodes	✓	✓	✓	✓	✓
			Neochoroterpes	✓	✓	✓	✓	✓
			Caenis	✓	✓	✓	✓	✓
		Hemiptera	*Trichocorixa*	✓	✓	✓	✓	✓
			Metrobates				✓	
			Rheumatobates		✓			
			Trepobates		✓		✓	✓
			Belostoma	✓		✓	✓	
			Ranatra	✓	✓	✓		
			Rhagovelia	✓	✓	✓	✓	✓
			Pelocoris	✓				
		Odonata	*Erpetogomphus*	✓	✓	✓	✓	✓
			Dromogomphus	✓			✓	
			Phyllogomphoides	✓	✓		✓	
			Macromia	✓	✓		✓	
			Argia	✓	✓	✓	✓	✓
			Enallagma	✓	✓	✓	✓	
			Haeterina	✓	✓	✓	✓	✓

Table H-8.
Checklist of Benthic Macroinvertebrate Taxa Collected by Kick Net
2009 and 2010 (Concluded)

Phylum	Class	Order	LPTL	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5
		Trichoptera	*Helicopsyche*	✓				
			Cheumatopsyche	✓	✓	✓	✓	✓
			Hydropsyche	✓	✓	✓	✓	✓
			Hydroptila			✓	✓	✓
			Nectopsyche	✓	✓	✓	✓	✓
			Oecetis	✓	✓	✓	✓	✓
			Chimarra			✓	✓	✓
	Malacostraca	Amphipoda	*Hyalella*	✓	✓	✓	✓	✓
		Decapoda	Cambaridae	✓	✓		✓	✓
			Palaemonetes	✓	✓	✓	✓	✓
	Hydracarina (acari)		*Hydracarina**				✓	

An evaluation of the diversity, tolerance to pollution, community structure, and trophic balance of benthic macroinvertebrate samples can provide insight to the overall aquatic integrity of the system. Diversity of more than 15 taxa per sample and greater than seven genera of mayflies, stoneflies, and caddisflies (EPT taxa) are both indicators of good aquatic integrity. A low Hilsenhof Biotic Index (< 4.52), a high ratio of intolerant to tolerant taxa (> 3.21), and more than 4 non-insect taxa are also indicators of good aquatic integrity. A balanced trophic community is indicative of a stable and well structured ecosystem as well. Metric parameters which indicate this balanced system are typically less than 25% of any one functional feeding group such as predators or collector-gatherers in addition to low dominance of any one group or taxon. Additional indicators of a healthy community include: less than 10% midges, less than 20% riffle beetles, and less than half of all caddisflies of the family Hydropsychidae. Overall, the samples indicated high diversity as a result of the prevalence of groups that are generally indicative of an aquatic system with high integrity.

H.3.3.2.1 June 2009

A total of 970 individuals representing 41 taxa were collected and identified to the LPTL using standard taxonomic references (Table H-9). Taxa present at all five stations during the June sample event included a flatworm (*Dugesia*), leeches (Hirudinea), an amphipod (*Hyallela*), a riffle beetle (*Stenelmis*), midges (Chironomidae), a damselfly (*Argia*), two caddisflies (*Nectopsyche* and *Cheumatopsyche*), water strider (*Rhagovelia*), and two mayflies (*Neochoroterpes* and *Tricorythodes*). The taxa present and overall diversity of Stations 2, 3, and

Table H-9.
Benthic Macroinvertebrate Taxa Collected by Kick Net at Five Locations
15–17 June 2009

Lowest Identified Taxon	Invertebrate Group Common Name	Parameter Code*	Pollution Tolerance Index (PTI)**	Functional Feeding Group (FFG)***	Number of Individuals By Station				
					1	2	3	4	5
Dugesia	Flatworm	90075	7.5	CG/P	12	12	2	19	7
Corbicula fluminae	Asian clam	93037	6	FC	2			1	
Musculium	Fingernail clam	93028	****	FC	7	1	1		
Physa/Physella	Snail	92874	6	SCR	12	10	4		
Oligochaeta*	Worm	90382	8	CG					1
Hirudinea*	Leech	90913	8	P	3	3	1	1	1
Chironomidae*	Fly	92491	6	P/CG/FC	6	3	1	5	12
Culicoides	Fly	92480	7	P/CG	1				
Simulium	Fly	92596	4	FC					1
Tabanus	Fly	92622	7	P				1	
Stenelmis	Beetle	92253	7	SCR/CG	31	29	70	55	64
Hexacylloepus	Beetle	92235	2	SCR/CG	2	1			
Helichus	Beetle	92217	4	SCR/CG		3	6	1	
Gyretes	Beetle	92092	6	P	2	2			
Berosus	Beetle	92154	9	CG	2	1		3	
Hydrochus	Beetle	92165	****	SHR		1			
Tropisternus	Beetle	92180	10	P	2		2		
Peltodytes	Beetle	92100	8	SHR/P	2	1			
Scirtes	Beetle	92206	****	SHR	2		2	4	
Fallceon quilleri	Mayfly	91651	4	SCR/CG				1	
Tricorythodes	Mayfly	91594	5	CG	42	30	2	28	2
Neochoroterpes	Mayfly	91557	2	SCR/CG	13	9	7	4	5
Caenis	Mayfly	91600	7	SCR/CG	14	7	2	1	
Trichocorixa	True bug	92044	5	P/CG	9	4		2	
Belostoma	True bug	91988	10	P	1		2		
Ranatra	True bug	92002	7	P	1	1			
Rhagovelia	True bug	91923	6	P	4	4	5	7	14
Petrophila	Moth	92686	5	SCR					5
Erpetogomphus	Dragonfly	91713	1	P	5		1	3	
Argia	Damselfly	91683	6	P	1	1	8	12	2
Enallagma	Damselfly	91687	6	P	3		7	14	
Haeterina	Damselfly	91669	6	P	1	3	3	4	
Helicopsyche	Caddisfly	92376	2	SCR	2				
Cheumatopsyche	Caddisfly	92292	6	FC	4	7	11	8	63
Hydropsyche	Caddisfly	92296	5	FC				2	34
Hydroptila	Caddisfly	92324	2	SCR			2		3
Nectopsyche	Caddisfly	92304	3	SHR/CG/P	8	5	9	3	6
Oecetis	Caddisfly	92391	5	P/SHR	2		4	2	2
Chimarra	Caddisfly	92268	2	FC				2	
Hyalella	Amphipod	91241	8	CG/SHR	11	22	13	14	1
Palaemonetes	Shrimp	91397	4	CG	2	3	8	5	
Total Individuals					209	163	173	202	223
Total Taxa					31	24	24	26	17

* Five digit codes created by the USEPA to describe parameters in their Storage and Retrieval database and are linked to descriptions of benthic macroinvertebrate species.
** PTI designations numerically ascend from (0) pollution intolerant to (10) pollution tolerant (TCEQ,2007)
*** P=predator, CG=collector/gatherer, SCR=scraper, SHR=shredder, FC=filtering collector (TCEQ, 2007)
**** No pollution tolerance index value is provided for taxon

4 were more similar than that of Stations 1 and 5. Station 1 displayed more diversity than the other stations in June 2009, while Station 5 had the least with approximately half as many taxa as station 1.

Noteworthy organisms typically very intolerant of poor conditions such as low dissolved oxygen include the riffle beetle (*Hexacylloepus*), the dragonfly (*Erpetogomphus*), the mayfly (*Neochoroterpes*), and three caddisflies (*Helicopsyche*, *Hydroptila*, and *Chimarra*). Numerically dominant taxa included the riffle beetle (*Stenelmis*), mayfly (*Tricorythodes*), and the caddisfly (*Cheumatopsyche*). Table H-10 presents the results of these metric parameters from the samples collected on the Clear Fork from the five sample stations during 15–17 June 2009.

The sample collection taken from Station 1 contained considerably more taxa than the other June samples. Despite this, 29 out of 31 taxa were identified at one or more other stations, and therefore it only contained few taxa which were unique to the five stations. These taxa were *Culicoides*, a small fly in the family Ceratopogonidae (biting midges), and snail-case caddisfly *Helicopsyche*. The snail-case caddisfly is intolerant to low concentrations of dissolved oxygen and prefers perennial swiftly flowing clean water with sandy stream beds. *Culicoides* is not considered an indicator of high aquatic integrity, but is common to this region. Despite the overall higher diversity, this sample did not have the highest number of combined mayflies/stoneflies/caddisflies, however it did have the most non-insect taxa. Although the overall ratio of intolerant to tolerant taxa is low and the Hilsenhof Biotic Index is high (indicators of sub-optimal quality), it is not uncommon for streams in central and north central Texas to have these characteristics. The presence of several pollution-intolerant taxa such as the dragonfly *Erpetogomphus* indicates the potential for this stream to maintain good conditions. The mayfly *Tricorythodes* was the numerically dominant taxon and, comprising only 20.1% of the sample, it is an indicator of a balanced community. Collector-gatherers dominated the trophic groups, and predators totaled a less-than-desirable 19.5% of the total sample. Low numbers of chironomid larvae help support the assertion that the community structure is well balanced. Although the trophic structure and pollution sensitivity was sub-optimal, this sample was representative of good diversity and community structure.

Table H-10.
Aquatic Integrity Indicators
15–17 June 2009

Metric Parameter		Station				
		1	2	3	4	5
		Value	Value	Value	Value	Value
Total Number	Total number of individuals in the sample	209	163	173	202	223
Taxa Richness	Total number of different taxa identified to lowest practical taxon	31	24	24	26	17
EPT Taxa	Total number mayfly, stonefly, and caddisfly taxa in the sample	7	5	7	9	7
Hilsenhof Biotic Index	Community score of tolerance to poor conditions	5.71	6.06	6.1	6.14	5.93
% Chironomidae	Ratio of the total number of midges in the sample to the total individuals of all specimens	2.87	1.84	0.58	2.48	5.38
% Dominant Taxon	Taxon with the most numerous individuals divided by total number of individuals in sample	20.10	18.40	40.46	27.23	28.70
% Dominant Functional Feeding Group	Ratio of numerically dominant Functional Feeding Group to total individuals	46.49	49.20	36.61	43.15	45.74
% Predators	Total number of predatory individuals divided by the total number of all individuals in sample	19.46	15.42	20.42	27.80	12.33
Ratio of Intolerant : Tolerant Taxa	Ratio of tolerant individuals (PTI >6) to intolerant (PTI<6)	0.74	0.52	0.30	0.37	0.35
% of Trichoptera as Hydropsychidae	The percent of Hydropsychid caddisflies of the total of all types of caddisflies	25.00	58.33	42.31	58.82	89.81
Number of non-insect taxa	Number of taxa that are not in the class Insecta	7	6	6	5	4
% Collector-Gatherers	Total number of collector-gatherer individuals divided by the total number of all individuals	46.49	49.20	36.61	43.15	21.30
% of total number as Elmidae	Ratio of number of riffle beetles to total individuals in sample	15.79	18.40	40.46	27.23	28.70

The dominant taxon at Station 3 was the riffle beetle (*Stenelmis*). At over 40%, this relative dominance was higher than any other sample. No other taxon in the sample had more than 13 individuals compared to the 70 *Stenelmis* beetles present here. This imbalance in the benthic community impacted other metric parameters bringing down the overall site evaluation. However, this sample was one of the only two June stations to contain the pollution sensitive caddisfly *Hydroptila*. The presence of several pollution-intolerant taxa such as *Hydroptila* and the dragonfly *Erpetogomphus* indicates the potential for this stream to maintain good conditions. This sample included a mix of good diversity, sensitive taxa, good trophic balance, and poor community structure.

The sample collection taken at Station 4 was the only one in June to contain the caddisfly (*Chimarra*), the mayfly (*Fallceon quilleri*), and the horsefly (*Tabanus*). Although the mayfly and the horsefly are not necessarily reflective of high aquatic integrity, the caddisfly (*Chimarra*) is a pollution intolerant caddisfly which typically prefers high dissolved oxygen in clear perennial rocky streams. The presence of several pollution-intolerant taxa such as the dragonfly *Erpetogomphus* indicates the potential for this stream to maintain good conditions. The dominant taxon was *Stenelmis* beetle. This site had a higher EPT value that the other June stations because it had more combined mayflies and caddisflies (9 total taxa). This diversity improved the overall site evaluation for several parameters. However, a high percentage of collector-gatherers and predators depressed the metric parameters relating to trophic structure. Overall, this sample indicated a biologically diverse and well balanced community with some pollution sensitive taxa.

Station 5 was sampled on 16 June 2009. Despite the fact that there were more individuals collected in this sample than in the other June samples, there was less overall diversity (17 taxa) than the other June samples. Even though there was considerably lower diversity, there were similar numbers of sensitive mayfly and caddisfly taxa. This was one of two June stations to contain the pollution sensitive caddisfly *Hydroptila*. In addition, it was the only station in June to contain the aquatic moth (*Petrophila*) and blackfly (*Simulium*). Neither taxa are necessarily considered indicators of high quality environments, but based on their absence in other samples; it indicates that this site has potential for increased niches.

Station 5 was the only station in June that contained a freshwater worm (*Oligochaete*) and the fewest non-insect taxa. Dominant taxa included the riffle beetle (*Stenelmis*) and caddisfly (*Cheumatopsyche*). In fact, this sample had more *Cheumatopsyche* (63) than all other June stations combined (30). *Cheumatopsyche* is in the family Hydropsychidae, which is generally considered to be more pollution tolerant compared to the other caddisflies and therefore, this high number relative to other caddisflies is not an indicator of high integrity. Despite this, a relatively high percentage of filterer-collectors, a low percentage of collector-gatherers (21.3 %), and low percentage of predators (12.3%) indicate a relatively well-balanced trophic structure.

The benthic macroinvertebrate samples from four of the five river locations indicated High aquatic integrity in the stream, whereas Station 3 exhibited a community of Intermediate integrity (Table H-11). Some metric indicators such as a low proportion of pollution intolerant

taxa and a high relative proportion of hydropsychid caddisflies indicates that the stream does not provide optimal conditions. Despite this, most stations indicate excellent conditions as shown by the ample diversity of mayflies, caddisflies, non-insect taxa, and overall high taxa diversity. Station 3 was not similar to the other stations in that it showed higher numbers of chironomids (midges), elmids (riffle beetles) and dominant taxon which lowered its overall ALU score. However, the overall community structure, diversity, and trophic groups indicate that the aquatic integrity of this stream is indicative of high aquatic life use as indicated by the benthic macroinvertebrate samples in June 2009.

Table H-11.
TCEQ Method Evaluation of Aquatic Integrity
Benthic Macroinvertebrate Samples
15–17 June 2009

	Station				
	1	2	3	4	5
Metric	Score	Score	Score	Score	Score
Taxa Richness	4	4	4	4	3
EPT Taxa Abundance	3	2	3	3	3
Hilsenhof Biotic Index	1	1	1	1	1
Percent Chironomidae	4	4	1	4	3
Percent Dominant Taxon	4	4	1	3	3
Percent Dominant FFG	2	2	3	3	2
Percent Predators	3	3	3	2	4
Ratio of Intolerant : Tolerant Taxa	1	1	1	1	1
% Trichoptera as Hydropsychidae	4	2	3	2	1
Number of non-insect taxa	4	4	4	3	3
Percent Collector-Gatherers	1	1	2	1	3
Percent of total number as Elmidae	3	3	1	2	2
Total	34	31	27	29	29
TCEQ Aquatic Life Use Score*	High	High	Intermediate	High	High
*Limited = ≤22, Intermediate = 22-28, High = 29-36, Exceptional = ≥36					

H.3.3.2.2 August 2009

The bioassessments at five sample stations during 10–12 August 2009 resulted in a total of 1,266 benthic macroinvertebrates representing 50 taxa. The average number of individuals per sample in August (253) was larger than the average number in June (194). Not surprisingly, there was a corresponding increase in the average number of taxa per sample (29 compared to 24) and several taxa not represented in June. There were a total of 12 taxa collected in the August samples that were not present in the June samples. These taxa included a snail

(*Gyraulus*), two flies (*Bezzia* and *Euparyphus*), two diving beetles (*Coptotomus* and *Hydroporus*), four mayflies (*Callibaetis*, *Camelobaetidius*, *Stenonema* and *Isonychia*), a water strider (*Metrobates*), a dragonfly (*Macromia*), and a water mite (*Hyracarina*). Of these additional taxa, the four mayflies and dragonfly are indicators of high aquatic integrity. This increase in diversity was one factor that increased the overall evaluation seen at each of the five stations.

Taxa present at all five August stations included *Physella* (a snail), *Chironomids* (midges), *Hyallela* (amphipod), *Stenelmis* and *Dubiraphia* (riffle beetles), *Berosus* (beetle), *Argia* (damselfly), *Oecetis*, *Cheumatopsyche*, and *Hydropsyche* (caddisflies), *Rhagovelia* (water strider), and the three mayflies (*Neochoroterpes*, *Tricorythodes*, and *Caenis*). Consistent with results of the June sampling event, numerically dominant taxa included *Stenelmis*, *Tricorythodes* and *Cheumatopsyche*. Taxa collected at the five stations during the August 2009 sample events are presented in Table H-12. Table H-13 shows the results of these metric parameters from the samples collected on the Clear Fork on August 10–12, 2009.

The presence of several pollution-intolerant taxa at Station 1 such as the mayfly (*Neochoroterpes*), riffle beetle (*Hexacylloepus*), and the dragonfly (*Erpetogomphus*) indicate the potential for this stream to maintain good conditions. This sample contained the highest relative percentage of pollution sensitive individuals as shown by the Hilsenhof Biotic Index and the high ratio of intolerant to tolerant taxa. Conversely, a slightly higher percentage (8.5%) of midges (Chironomidae) depressed the overall evaluation of this sample. This was the only station in August to contain the diving beetle (*Coptotomus*) and the mayfly (*Camelobaetidius*). Although the beetle does not provide much information, the mayfly is generally considered an indicator of aquatic integrity. This station showed high diversity overall, but due mostly to the presence of a combined total of eleven mayfly and caddisfly taxa. Despite this high diversity, there were surprisingly few non-insect taxa (four). In addition to high diversity, the community structure was excellent as evidenced by optimal riffle beetle percentage and low dominance in taxa individuals.

Station 2 contained fewer individuals than the other August samples, yet still had more than any sample from the June event. Despite a poor Hilsenhof Biotic Index value, the presence of several pollution-intolerant taxa such as the mayfly (*Neochoroterpes*) and the dragonfly (*Erpetogomphus*) indicate the potential for this stream to maintain good conditions. This was the only station in August to contain the fly (*Bezzia*) which, aside from the benefit of more taxa

richness does not provide valuable information on aquatic integrity. The high percentage of collector-gatherers does not indicate a well structured trophic regime; however, the percentage of predators was not very high. Despite less-than-desirable trophic composition and high percentage of Hydropsychid caddisflies, this station showed overall high diversity and high integrity community structure.

Despite poor Hilsenhof Biotic Index values, the presence of several pollution-intolerant taxa at Station 3 included *Chimarra*, *Hydroptila*, and *Neochoroterpes,* indicating the potential for this stream to maintain good conditions. This was the only station in August to contain the snail (*Gyraulus*), the fly (*Euparyphus*), the beetle (*Hydroporus*), the true bug (*Ranatra*), and the caddisfly (*Hydroptila*). Although most of these organisms are not indicative of high ecological integrity, the caddisfly (*Hydroptila*) is very sensitive to poor conditions, and its presence in the sample is salient. Despite some sub-optimal characteristics such as a low ratio of intolerant to tolerant taxa, this station showed high diversity, excellent trophic composition, and excellent community structure.

Station 4 contained the highest taxa richness of all samples and not surprisingly was the only station in August to contain several taxa including the Asian clam (*Corbicula*), the mayfly (*Callibaetis*), the true bug (*Metrobates*), the aquatic mite (*Hydracarina*), and two dragonflies (*Dromogomphus* and *Macromia*). There was more dragonfly diversity and non-insect diversity than any other station. This is potentially the result of diverse in-stream habitat and structure. This station showed very high diversity overall. Despite poor Hilsenhof Biotic Index values, the presence of several pollution-intolerant taxa such as the mayfly (*Neochoroterpes*), the caddisfly (*Chimarra*), and the dragonfly (*Erpetogomphus*) indicate the potential for this stream to maintain good conditions. Based on diversity, community structure, and trophic composition, this sample is more indicative of high biological integrity than any of the June and August samples.

Table H-12.
Benthic Macroinvertebrate Taxa Collected by Kick Net, 10–12 August 2009

Lowest Identified Taxon	Invertebrate Group Common Name	Parameter Code*	Pollution Tolerance Index (PTI)**	Functional Feeding Group (FFG)***	Number of Individuals By Station				
					1	2	3	4	5
Dugesia	Flatworm	90075	7.5	CG/P			7	11	2
Corbicula fluminae	Asian clam	93037	6	FC				2	
Musculium	Fingernail clam	93028	****	FC	2	6	3	14	
Physa/Physella	Snail	92874	9	SCR	6	27	11	20	17
Gyraulus	Snail	92885	8	SCR			1		
Oligochaeta	Worm	90382	8	CG			2	1	
Hirudinea	Leech	90913	8	P	1	1		4	
Chironomidae	Fly	92491	6	P/CG/FC	21	16	11	12	12
Bezzia	Fly	92478	7	P		1			
Euparyphus	Fly	92609	****	SCR/CG			1		
Tabanus	Fly	92622	7	P				1	2
Stenelmis	Beetle	92253	7	SCR/CG	16	23	32	31	53
Dubiraphia	Beetle	92230	5	SCR/CG	2	2	1	1	5
Hexacylloepus	Beetle	92235	2	SCR/CG	2				1
Coptotomus	Beetle	92116	****	P	1				
Hydroporus	Beetle	92128	9	P			1		
Helichus	Beetle	92217	4	SCR/CG		1	3		2
Gyretes	Beetle	92092	6	P	2	1			1
Berosus	Beetle	92154	9	CG	3	5	2	4	4
Peltodytes	Beetle	92100	8	SHR/P		1		3	
Scirtes	Beetle	92206	****	SHR		1			1
Callibaetis	Mayfly	91650	4	CG				2	
Camelobaetidius	Mayfly	91647	4	CG	1				
Fallceon quilleri	Mayfly	91651	4	SCR/CG	5		2	2	3
Stenonema	Mayfly	91620	4	SCR/CG	5	1			1
Isonychia	Mayfly	91590	3	FC	3				2
Tricorythodes	Mayfly	91594	5	CG	46	54	48	22	37
Neochoroterpes	Mayfly	91557	2	SCR/CG	34	4	2	5	11
Caenis	Mayfly	91600	7	SCR/CG	6	2	9	27	3
Trichocorixa	Mayfly	92044	5	P/CG	1	9			
Metrobates	True bug	91942	****	P				7	
Belostoma	True bug	91988	10	P	5		5	2	
Ranatra	True bug	92002	7	P			1		
Rhagovelia	True bug	91923	6	P	4	5			1
Petrophila	Moth	92686	5	SCR	1	2			3
Erpetogomphus	Dragonfly	91713	1	P	2	2		4	
Dromogomphus	Dragonfly	91711	4	P				1	
Macromia	Dragonfly	91769	3	P				2	
Argia	Damselfly	91683	6	P	12	12	35	14	2
Enallagma	Damselfly	91687	6	P		3	4	3	
Haeterina	Damselfly	91669	6	P	5	2		1	28
Cheumatopsyche	Caddisfly	92292	6	FC	33	9	41	13	37
Hydropsyche	Caddisfly	92296	5	FC	13	5	4	15	13
Hydroptila	Caddisfly	92324	2	SCR			1		
Nectopsyche	Caddisfly	92304	3	SHR/CG/P	9	7		3	7
Oecetis	Caddisfly	92391	5	P/SHR	2	2	2	3	1
Chimarra	Caddisfly	92268	2	FC			3	27	6
Hyalella	Amphipod	91241	8	CG/SHR	4	8	6	8	7
Palaemonetes	Shrimp	91397	4	CG		21	5	5	10
*Hydracarina**	Mite	91525	6	P				1	
Total Individuals					247	233	243	271	272
Total Taxa					29	29	27	33	28

* Five digit codes created by the USEPA to describe parameters in their Storage and Retrieval database and are linked to descriptions of benthic macroinvertebrate species.
** PTI designations numerically ascend from (0) pollution intolerant to (10) pollution tolerant (TCEQ,2007)
*** P=predator, CG=collector-gatherer, SCR=scraper, SHR=shredder, FC=filtering-collector (TCEQ, 2007)
**** No pollution tolerance index value is provided for taxon

Table H-13.
Aquatic Integrity Indicators
10–12 August 2009

Metric Parameter		Station 1 Value	Station 2 Value	Station 3 Value	Station 4 Value	Station 5 Value
Total Number	Total number of individuals in the sample	247	233	243	271	272
Taxa Richness	Total number of different taxa identified to lowest practical taxon	29	29	27	33	28
EPT Taxa	Total number mayfly, stonefly and caddisfly taxa in the sample	11	8	9	10	11
Hilsenhof Biotic Index	Community score of tolerance to poor conditions	5.11	5.53	6.00	5.61	5.62
% Chironomidae	Ratio of the total number of midges in the sample to the total individuals of all specimens	8.50	6.87	4.53	4.43	4.41
% Dominant Taxon	Taxon with the most numerous individuals divided by total number of individuals in sample	18.62	23.18	19.75	11.44	19.49
% Dominant Functional Feeding Group	Ratio of numerically dominant Functional Feeding Group to total individuals	39.47	48.36	37.93	30.07	37.30
% Predators	Total number of predatory individuals divided by the total number of all individuals in sample	17.61	17.45	22.29	19.74	15.32
Ratio of Intolerant: Tolerant Taxa	Ratio of tolerant individuals (PTI >6) to intolerant (PTI<6)	1.07	0.95	0.42	0.58	0.60
% of Trichoptera as Hydropsychidae	The percent of Hydropsychid caddisflies of the total of all types of caddisflies	80.70	60.87	88.24	45.90	78.13
Number of non-insect taxa	Number of taxa that are not in the class Insecta	4	5	7	9	4
% Collector-Gatherers	Total number of collector-gatherer individuals divided by the total number of all individuals	39.47	48.36	37.93	30.07	37.30
% of total number as Elmidae	Ratio of number of riffle beetles to total individuals in sample	8.10	10.73	13.58	11.81	21.69

Station 5 contained more individuals (272) than any other station. Despite poor Hilsenhof Biotic Index values, the presence of several pollution-intolerant taxa included *Chimarra*, *Neochoroterpes*, and *Hexacylloepus* indicates the potential for this stream to maintain good conditions. This was the only station in August that did not contain taxa unique to the sample. This station showed high diversity overall, but especially in the mayflies and caddisflies (11 taxa total). However, there were few non-insect taxa (four) present. This diversity, coupled with low percent taxon dominance, indicates high aquatic integrity.

As shown in Table H-14, the benthic macroinvertebrate samples from all five stations indicated high or exceptional aquatic integrity in the stream. Similar to the June 2009 samples, some of the metric indicators of August 2009 samples were not optimal, such as a low proportion of pollution intolerant taxa and a high Hilsenhof Biotic Index. However, the overall diversity, and diversity of indicator groups such as mayflies and caddisflies, in addition to select sensitive pollution tolerant taxa, supports the assertion that the stream is of high quality and is able to support a diverse and well balanced benthic ecosystem.

Table H-14.
TCEQ Method Evaluation of Aquatic Integrity
Benthic Macroinvertebrate Samples
10–12 August 2009

Metric	Station 1 Score	2 Score	3 Score	4 Score	5 Score
Taxa Richness	4	4	4	4	4
EPT Taxa Abundance	4	3	3	4	4
Hilsenhof Biotic Index	2	1	1	1	1
Percent Chironomidae	2	3	3	3	3
Percent Dominant Taxon	4	3	4	4	4
Percent Dominant FFG	3	2	3	4	3
Percent Predators	3	3	3	3	3
Ratio of Intolerant : Tolerant Taxa	1	1	1	1	1
% Trichoptera as Hydropsychidae	1	2	1	3	1
Number of non-insect taxa	3	3	4	4	3
Percent Collector-Gatherers	2	1	2	3	2
Percent of total number as Elmidae	4	3	3	3	2
Total	33	29	32	37	31
TCEQ Aquatic Life Use Score*	High	High	High	Exceptional	High
*Limited = <22, Intermediate = 22-28, High = 29-36, and Exceptional = >36					

H.3.3.2.3 May 2010

The biomonitoring at five sample stations during 5–7 May 2010 resulted in a total of 1,228 individual benthic macroinvertebrates distributed over 46 taxa. An inventory of taxa collected at the five stations during the May 2010 sample events is presented in Table H-15. Samples had an average sample size of 246 individuals and an average number of 28 taxa per sample. Taxa at the five stations were similar with 15 of the 46 taxa consistently collected in all samples. Taxa common to all five stations sampled in May included flatworms (*Dugesia*), snails (*Physella*), fingernail clams (*Musculium*), amphipods (*Hyallela*), two beetles (*Stenelmis* and *Berosus*), a water strider (*Rhagovelia*), a dragonfly (*Erpetogomphus*), midges (*Chironomidae*), a grass shrimp *(Palaemonetes*), a damselfly (*Argia*), a caddisfly (*Nectopsyche*), and three mayfly species (*Caenis, Neochoroterpes,* and *Tricorythodes*). The taxa present and overall diversity at the two upstream locations (Stations 1 and 2) were more similar and exhibited higher taxa richness than the three downstream stations, despite a smaller sample size. Station 5 had the fewest number of taxa (19) with approximately half as many taxa as station 1 (37).

Table H-15.
Benthic Macroinvertebrate Taxa Collected by Kick Net
5–7 May 2010

Lowest Identified Taxon	Invertebrate Group Common Name	Parameter Code*	Pollution Tolerance Index (PTI)**	Functional Feeding Group (FFG)***	Number of Individuals By Station				
					1	2	3	4	5
Dugesia	Flatworm	90075	7.5	CG/P	1	2	9	7	14
Corbicula fluminae	Asian clam	93037	6	FC	6	2			
Musculium	Fingernail clam	93028	****	FC	6	7	15	17	5
Eupera cubensis	Fingernail clam	93026	****	SCR	1	1			
Physa/Physella	Snail	92874	9	SCR	8	5	8	6	22
Oligochaeta*	Worm	90382	8	CG	2		1	3	3
Hirudinea*	Leech	90913	8	P	1		1	3	
Chironomidae*	Fly	92491	6	P/CG/FC	18	28	21	20	19
Sciomyzidae	Fly	92633	****	P			1		
Simulium	Fly	92596	4	FC		1		17	68
Dubiraphia	Beetle	92230	5	SCR/CG	1	4	4	1	
Stenelmis	Beetle	92253	7	SCR/CG	29	13	41	50	26
Hexacylloepus	Beetle	92235	2	SCR/CG	2	1		1	
Helichus	Beetle	92217	4	SCR/CG	1				
Helophorus	Beetle	92168	8	SHR	1				
Berosus	Beetle	92154	9	CG	3	6	6	6	4
Hydrochus	Beetle	92165	****	SHR				1	
Tropisternus	Beetle	92180	10	P				1	
Laccophilus	Beetle	92096	10	P	1	1		5	11
Fallceon quilleri	Mayfly	91651	4	SCR/CG	1	1			
Tricorythodes	Mayfly	91594	5	CG	24	26	7	10	2
Neochoroterpes	Mayfly	91557	2	SCR/CG	7	8	8	11	5
Caenis	Mayfly	91600	7	SCR/CG	8	28	21	20	6
Stenonema	Mayfly	91620	4	SCR/CG	6	3			
Isonychia	Mayfly	91590	3	FC	4	5	1		
Trichocorixa	True bug	92044	5	P/CG	4	16	1	3	1
Rheumatobates	True Bug	91944	5	P		2			
Trepobates	True Bug	91946	10	P		1			
Belostoma	True bug	91988	10	P	2				
Rhagovelia	True bug	91923	6	P		1			
Pelocoris	True bug	92059	7	P	1				
Dromogomphus	Dragonfly	91711	4	P	2				
Erpetogomphus	Dragonfly	91713	1	P	7	6	10	3	3
Phyllogomphoides	Dragonfly	91696	1	P	1				
Macromia	Dragonfly	91769	3	P	2	1			
Argia	Damselfly	91683	6	P	7	1	12	9	1
Enallagma	Damselfly	91687	6	P	5	6	6	9	
Haeterina	Damselfly	91669	6	P	3	4	4		
Helicopsyche	Caddisfly	92376	2	SCR	1				
Cheumatopsyche	Caddisfly	92292	6	FC	2	5	43	18	
Hydropsyche	Caddisfly	92296	5	FC		2			
Hydroptila	Caddisfly	92324	2	SCR				2	
Nectopsyche	Caddisfly	92304	3	SHR/CG/P	3	10	5	6	4
Hyalella	Amphipod	91241	8	CG/SHR	19	17	34	23	41
Cambaridae	Crayfish	91409	5	CG	1	2		1	1
Palaemonetes	Shrimp	91397	4	CG	21	23	14	8	7
Total Individuals					212	239	273	261	243
Total Taxa					37	33	23	27	19

* Five digit codes created by the USEPA to describe parameters in their Storage and Retrieval database and are linked to descriptions of benthic macroinvertebrate species.
** PTI designations numerically ascend from (0) pollution intolerant to (10) pollution tolerant (TCEQ,2007)
*** P=predator, CG=collector-gatherer, SCR=scraper, SHR=shredder, FC=filtering-collector (TCEQ, 2007)
**** No pollution tolerance index value is provided for taxon

Notable pollution-intolerant organisms collected during this sampling event include a riffle beetle (*Hexacylloepus*), two species of club-tailed dragonflies (*Erpetogomphus and Phyllogomphoides*), a mayfly (*Neochoroterpes*), and two caddisfly species (*Helicopsyche* and *Hydroptila*). Numerically dominant taxa included a riffle beetle (*Stenelmis*), midges (Chironomidae), an amphipod (*Hyallela*), a blackfly (*Simulium*), and a mayfly (*Caenis*). Table H-16 presents the results of these metric parameters from the samples collected on the Clear Fork from the five sample stations during 5–7 May 2010.

Table H-16.
Aquatic Integrity Indicators
5–7 May 2010

Metric Parameter		Station 1 Value	Station 2 Value	Station 3 Value	Station 4 Value	Station 5 Value
Total Number	Total number of individuals in the sample	212	239	273	261	243
Taxa Richness	Total number of different taxa identified to lowest practical taxon	37	33	23	27	19
EPT Taxa	Total number mayfly, stonefly and caddisfly taxa in the sample	9	9	6	6	4
Hilsenhof Biotic Index	Community score of tolerance to poor conditions	5.64	5.55	6.19	6.18	6.26
% Chironomidae	Ratio of the total number of midges in the sample to the total individuals of all specimens	8.49	11.72	7.69	7.66	7.82
% Dominant Taxon	Taxon with the most numerous individuals divided by total number of individuals in sample	13.68	11.72	15.75	19.16	27.98
% Dominant Functional Feeding Group	Ratio of numerically dominant Functional Feeding Group to total individuals	45.99	48.61	35.10	36.27	32.65
% Predators	Total number of predatory individuals divided by the total number of all individuals in sample	19.58	18.69	17.40	16.73	12.41
Ratio of Intolerant: Tolerant Taxa	Ratio of tolerant individuals (PTI >6) to intolerant (PTI<6)	0.75	0.93	0.24	0.35	0.62
% of Trichoptera as Hydropsychidae	The percent of Hydropsychid caddisflies of the total of all types of caddisflies	33.33	41.18	89.58	69.23	0.0
Number of non-insect taxa	Number of taxa that are not in the class Insecta	10	8	7	8	7
% Collector-Gatherers	Total number of collector-gatherer individuals divided by the total number of all individuals	45.99	48.61	35.10	36.27	29.29
% of total number as Elmidae	Ratio of number of riffle beetles to total individuals in sample	15.09	7.53	16.48	19.92	10.70

The sample collection taken from Station 1 contained more taxa than the other May samples. A total of seven taxa were collected solely from Station 1. These taxa included two beetle species (*Helichus* and *Helophorus*), two true bug genera (*Belostoma* and *Pelocoris*), two species of dragonflies (*Dromogomphus* and *Phyllogomphoides*), and a snail-case caddisfly (*Helicopsyche*). The *Helicopsyche* and *Phyllogomphoides* are intolerant to low concentrations of dissolved oxygen and prefer perennial, cool, clean water with sandy stream beds. Station 1 was the only station in which these two taxa were collected during the 2010 surveys. The remaining five insect species exclusive to this river reach are not considered indicators of high aquatic integrity and have developed dispersal mechanisms to escape poor environmental conditions. The two upstream locations (Stations 1 and 2) had the highest EPT rating (9) of all samples indicating superior water quality. The EPT rating is the total combined number of taxa of mayflies, stoneflies, and caddisflies. Although no plecopteran (stonefly) species were represented in the study sample collections, their absence is not unexpected since the emergence periods of most stoneflies are concentrated during the winter in northern and central Texas. The low overall ratio of intolerant to tolerant taxa and high Hilsenhof Biotic Index values are both indicators of sub-optimal ecological quality; not uncommon characteristics for streams in central and north central Texas. The presence of several pollution-intolerant taxa including several dragonflies, mayflies, and caddisflies indicates the potential for this stream to maintain good water quality conditions. The riffle beetle (*Stenelmis*) was numerically dominant but comprised only 13.7% of the sample. This low dominance is one indicator of a balanced community. The dominant trophic group at Station 1 is the collector-gatherers. Midge larvae (Chironimidae) accounted for only 8.5 percent of the total sample, supporting the assertion of a well-balanced community structure. Although the overall trophic structure and pollution sensitivity were sub-optimal, this sample was representative of good diversity and community structure.

The benthic macroinvertebrate assemblage at Station 2 was very similar to that of the Station 1 population. The mayfly (*Caenis*) shared community dominance with chironomid midge larvae. Although the high dominance of taxa differed from Station 1, the extent of relative abundance was almost identical (29 individuals at Station 1 vs. 28 individuals at Station 2). This sample contained four taxa distinctive to the May sample event including three true bugs (*Rheumatobates*, *Trepobates*, and *Rhagovelia*) and a net-spinning caddisfly (*Hydropsyche*). The true bugs are highly mobile organisms and not indicators of good water quality; however, the caddisfly is a moderately pollution-intolerant representative and a filter-

collector. Other pollution-intolerant taxa identified include two dragonflies (*Erpetogomphus* and *Macromia*), two mayflies (*Neochoroterpes* and *Isonychia*), a caddisfly (*Nectopsyche*), and a riffle beetle (*Hexacylloepus*). Similarities to Station 1 were observed in the overall ratio of intolerant to tolerant taxa, Hilsenhof Biotic Index, EPT rating, percent of representative functional food groups, and percent dominance, suggesting little temporal variation in community balance and trophic structure within the upstream study reach. Both upstream locations scored a total value of 31, or High, on the TCEQ-based aquatic life use rating system.

The dominant taxon at Station 3 was a tolerant filter feeding caddisfly (*Cheumatopsyche*) accounting for a relatively low degree of dominance with 16% of the total station catch. Other numerically dominant taxa included the riffle beetle *Stenelmis* and the amphipod *Hyallela*. A single larval, dipteran taxon (Sciomyzidae) was restricted to this location in sample distribution. Although this fly is aquatic in its early stages of life, it is not an indicator of water quality. All other collected taxa were common to two or more other stations during the May sample event. Although diversity ranked as the second lowest of the May collections, the total number of taxa (23) was sufficient to achieve the highest value for the species richness metric. The high percentage composition of Hydropsychid caddisflies (89.6), when compared to the other caddisfly representatives, is not an indicator of high quality conditions; however, other categories of community structure were optimal. These categories included a high diversity of non-insect taxa, low dominant taxon, and a low dominance of functional feeding groups. This sample contained the highest weighted percentage of pollution-intolerant taxa (i.e., lowest Hilsenhof Biotic Index value) and had an overall score of 32, which corresponds to a High aquatic life use.

The caddisfly *Hydroptila* and the two beetles *Hydrochus* and *Tropisternus* were collected only at Station 4 in the spring. While both beetles are not necessarily characteristic of high aquatic integrity, the *Hydroptila* is a pollution-intolerant caddisfly which typically prefers high dissolved oxygen in clear perennial rocky streams. Despite a relatively low EPT value, the presence of several other pollution-intolerant taxa such as the riffle beetle (*Hexacylloepus*), the mayfly (*Neochoroterpes*), and the dragonfly (*Erpetogomphus*) indicates the potential for this stream to maintain excellent conditions. The dominant taxon was the riffle beetle *Stenelmis*; however, dominance was low and indicates optimal community balance. Additionally, a balanced trophic structure was demonstrated by the dominant functional feeding group, predators and collector-gatherers. Overall, the macroinvertebrate assemblage showed a biologically

diverse and fairly stable aquatic community comprised of pollution-sensitive taxa and typical of a high aquatic life use rating.

Despite the comparable sample size of 243 individuals collected at Station 5, there was noticeably lower taxa richness (19) in this sample than in the other stations, which contained 37, 33, 23, and 27 taxa per sample. Although a taxa richness of 19 is not optimal, it is still a respectable level of diversity in the TCEQ aquatic life use rating system. The total numbers of taxa in the EPT (mayfly/stonefly/caddisfly) groups were also the lowest of all spring collections. Consistent with the lower diversity, there were no unique taxa collected at this site. Most taxa in this sample (79 percent) were common to the four other stations in May. Despite these apparently poor diversity indicators, trophic balance was excellent as evidenced by optimal levels of percent predators, and dominant functional feeding groups were complimented by sub-optimal percent collector-gatherers. In addition to these good attributes, the only caddisflies present were not in the family Hydropsychidae, which generally indicates higher pollution sensitivity. Community balance of other indicator groups was good as well; including sub-optimal percentages of riffle beetles and midges. The overall aquatic life use score of 35 was higher that the other stations and resulted in a rating of High aquatic life use.

The benthic macroinvertebrate samples from the five station locations indicated High aquatic integrity (Table H-17). All samples exhibited good scores for taxa richness, non-insect diversity, taxa dominance, predator dominance, and riffle beetle dominance. These parameters and moderately good scores in other parameters counterbalanced the overall poor results derived from the Hilsenhof Biotic Index and ratio of intolerant to tolerant taxa values.

H.3.3.2.4 July 2010

Kick-net sampling at three stations on 20 July 2010 resulted in a total of 724 benthic macroinvertebrates representing 36 taxa. As previously mentioned, the upstream portion of the study area at Stations 1 and 2 were not sampled. The average number of individuals per sample in July was similar to the average number in May with 241 and 246, respectively. A comparison of the average number of taxa per sample in July (25) shows a similar average number of taxa per sample (25 in July compared to 28 in May) and only one additional taxa not represented in

Table H-17.
TCEQ Method Evaluation of Aquatic Integrity
Benthic Macroinvertebrate Samples
5–7 May 2010

Metric	Station				
	1	2	3	4	5
	Score	Score	Score	Score	Score
Taxa Richness	4	4	4	4	3
EPT Taxa Abundance	3	3	2	2	2
Hilsenhof Biotic Index	1	1	1	1	1
Percent Chironomidae	3	2	3	3	3
Percent Dominant Taxon	4	4	4	4	3
Percent Dominant FFG	2	2	4	4	4
Percent Predators	3	3	3	3	4
Ratio of Intolerant : Tolerant Taxa	1	1	1	1	1
% Trichoptera as Hydropsychidae	2	2	1	2	4
Number of non-insect taxa	4	4	4	4	4
Percent Collector-Gatherers	1	1	2	2	3
Percent of total number as Elmidae	3	4	3	3	3
Total	31	31	32	33	35
TCEQ Aquatic Life Use Score*	High	High	High	High	High
*Limited = <22, Intermediate = 22-28, High = 29-36, and Exceptional = >36					

the May samples. The additional taxon was *Peltodytes*, a small beetle that is highly mobile and not a reliable indicator of water quality.

Sample composition between the three areas was very similar as 12 of the 36 taxa identified during July were common to each station. The taxa present at all three July stations included a flatworm (*Dugesia*), a leech (Hirudinea), a snail (*Physella*), a fingernail clam (*Musculium*), a riffle beetle (*Stenelmis*), a hydrophilid beetle (*Berosus*), a mayfly (*Tricorythodes*), two damselfly species (*Argia* and *Haeterina*), two caddisfly species (*Cheumatopsyche* and *Hydropsyche*), and a grass shrimp (*Palaemonetes*). The numerically dominant taxa of the July event included a riffle beetle (*Stenelmis*), a damselfly (*Argia*), and a caddisfly (*Cheumatopsyche*). Taxa collected at the three stations during the July 2010 sample events are presented in Table H-18. Table H-19 presents the results of these metric parameters from the samples collected on the Clear Fork on 19-21 July 2010.

Table H-18.
Benthic Macroinvertebrate Taxa Collected by Kick Net, 19–21 July 2010

Lowest Identified Taxon	Invertebrate Group Common Name	Parameter Code*	Pollution Tolerance Index (PTI)**	Functional Feeding Group (FFG)***	Number of Individuals By Station****				
					1	2	3	4	5
Dugesia	Flatworm	90075	7.5	CG/P			4	5	7
Corbicula fluminae	Asian clam	93037	6	FC			2	6	
Musculium	Fingernail clam	93028	*****	FC			5	12	8
Eupera cubensis	Fingernail clam	93026	*****	SCR			1		
Physa/Physella	Snail	92874	9	SCR			1	1	1
Oligochaeta	Worm	90382	8	CG			4	3	
Hirudinea	Leech	90913	8	P			4	8	1
Chironomidae	Fly	92491	6	P/CG/FC			22		3
Tabanus	Fly	92622	7	P				2	4
Simulium	Fly	92596	4	FC					1
Stenelmis	Beetle	92253	7	SCR/CG			33	32	53
Hexacylloepus	Beetle	92235	2	SCR/CG					3
Helichus	Beetle	92217	4	SCR/CG			1		
Peltodytes	Beetle	92100	8	SHR/P			1		
Berosus	Beetle	92154	9	CG			4	5	3
Tropisternus	Beetle	92180	10	P			1		
Laccophilus	Beetle	92096	10	P			3		
Petrophilia	Moth	92686	5	SCR					1
Fallceon quilleri	Mayfly	91651	4	SCR/CG				1	3
Caenis	Mayfly	91600	7	SCR/CG			1		
Isonychia	Mayfly	91590	3	FC			1		1
Tricorythodes	Mayfly	91594	5	CG			4	4	10
Neochoroterpes	Mayfly	91557	2	SCR/CG			1		13
Trepobates	True bug	91946	10	P				1	4
Belostoma	True bug	91988	10	P			8	1	
Rhagovelia	True bug	91923	6	P			8	1	
Erpetogomphus	Dragonfly	91713	1	P			1		2
Argia	Damselfly	91683	6	P			42	47	27
Haeterina	Damselfly	91669	6	P			18	3	4
Cheumatopsyche	Caddisfly	92292	6	FC			25	48	82
Hydropsyche	Caddisfly	92296	5	FC			29	1	2
Chimarra	Caddisfly	92268	2	FC				12	20
Nectopsyche	Caddisfly	92304	3	SHR/CG/P			6	9	2
Oecetis	Caddisfly	92391	5	P/SHR			2	1	
Hyalella	Amphipod	91241	8	CG/SHR			1		
Palaemonetes	Shrimp	91397	4	CG			12	15	6
Total individuals					--	--	245	218	261
Total taxa					--	--	29	22	24

* Five digit codes created by the USEPA to describe parameters in their Storage and Retrieval database and are linked to descriptions of benthic macroinvertebrate species.
** PTI designations numerically ascend from (0) pollution intolerant to (10) pollution tolerant (TCEQ,2007)
*** P=predator, CG=collector-gatherer, SCR=scraper, SHR=shredder, FC=filtering collector (TCEQ, 2007)
****Stations 1 and 2 were not sampled
***** No pollution tolerance index value is provided for taxon

Table H-19.
Aquatic Integrity Indicators
19–21 July 2010

Metric Parameter		Station				
		1	2	3	4	5
		Value	Value	Value	Value	Value
Total Number	Total number of individuals in the sample	--	--	245	218	261
Taxa Richness	Total number of different taxa identified to lowest practical taxon	--	--	29	22	24
EPT Taxa	Total number mayfly, stonefly and caddisfly taxa in the sample	--	--	8	7	8
Hilsenhof Biotic Index	Community score of tolerance to poor conditions	--	--	6.13	5.89	5.61
% Chironomidae	Ratio of the total number of midges in the sample to the total individuals of all specimens	--	--	8.98	0.0	1.15
% Dominant Taxon	Taxon with the most numerous individuals divided by total number of individuals in sample	--	--	17.14	22.02	31.42
% Dominant Functional Feeding Group	Ratio of numerically dominant Functional Feeding Group to total individuals	--	--	39.93	36.24	44.06
% Predators	Total number of predatory individuals divided by the total number of all individuals in sample	--	--	39.93	31.65	18.07
Ratio of Intolerant: Tolerant Taxa	Ratio of tolerant individuals (PTI >6) to intolerant (PTI<6)	--	--	0.31	0.31	0.34
% of Trichoptera as Hydropsychidae	The percent of Hydropsychid caddisflies of the total of all types of caddisflies	--	--	79.25	69.01	79.25
Number of non-insect taxa	Number of taxa that are not in the class Insecta	--	--	9	7	5
% Collector-Gatherers	Total number of collector-gatherer individuals divided by the total number of all individuals	--	--	21.97	22.48	23.05
% of total number as Elmidae	Ratio of number of riffle beetles to total individuals in sample	--	--	13.47	14.68	20.31

Unlike the May sampling event, Station 3 exhibited more species diversity than found in the Stations 4 and 5 collections. Although this location yielded seven additional taxa not present in the other two July samples, these taxa are generally not indicators of good water quality. Despite a poor Hilsenhof Biotic Index value of 6.13, the presence of several pollution-intolerant taxa at Station 3 included the dragonfly (*Erpetogomphus*) and the mayfly (*Neochoroterpes*), indicating the potential for this stream to maintain good conditions. Unique to the May and June sample events, the dominant taxon was a damselfly (*Argia*). Despite some undesirable characteristics such as a low ratio of intolerant-to-tolerant taxa, this station showed excellent community structure with indicators like low community dominance. Scoring for high

biodiversity, excellent trophic composition, and excellent community structure resulted in a High aquatic life use rating.

Similar to most stations, Station 4 contained high overall diversity, high non-insect diversity, and a sub-optimal EPT (mayfly/stonefly/caddisfly) diversity. Despite poor Hilsenhof Biotic Index values, the presence of several pollution-intolerant taxa such as two caddisflies (*Chimarra* and *Nectopsyche*) and the dragonfly (*Erpetogomphus*) indicate the potential for this stream to maintain good habitat conditions. Unlike the other samples from May and July, the sample from Station 4 did not contain any midge larvae. While a low percent community composition of chironomids is considered optimal, the lack of fly larvae will equally depress the aquatic life use score. Although the community structure of a stream reach might be considered imbalanced if chironomids were absent, their presence in May indicate otherwise. The dominant taxa included the caddisfly (*Cheumatopsyche*), damselfly (*Argia*), and beetle (*Stenelmis*). Application of the TCEQ macroinvertebrate scoring criteria resulted in a High aquatic life use rating with a value of 32.

Station 5 contained more total individuals (261) than the other July stations. The sample was numerically dominated by the caddisfly *Cheumatopsyche,* represented by 82 individuals accounting for 31% of the total station catch. This sample contained more representatives of this pollution tolerant taxa than at Stations 3 and 4 combined. This taxa is generally regarded as more pollution tolerant when compared to other caddisflies and therefore, this high number relative to other caddisflies is not an indicator of high integrity. However, other taxa including pollution-intolerant representatives such as the caddisfly (*Chimarra*), the dragonfly (*Erpetogomphus*), the mayfly (*Neochoroterpes*), and the riffle beetle (*Hexacylloepus*) were present. These four taxa were the most pollution-sensitive of all taxa identified in the July sample set. In addition, this station exhibited the only sample of the 2010 sample events to contain *Petrophila*, a moderately pollution-sensitive moth whose larval form is aquatic. Unlike the other samples from May and July, Station 5 showed a relatively high percent (20) of riffle beetles. A high percent of riffle beetles is not intrinsically bad; however, very high numbers may indicate poor conditions. Despite poor Hilsenhof Biotic Index and ratio of intolerant-to-tolerant values, other indicators, such as a low percentage of midges, suggests good community structure. The high diversity, coupled with sub-optimal trophic balance, is indicative of high aquatic integrity.

As shown in Table H-20, the benthic macroinvertebrate collections from all three stations sampled indicated high aquatic integrity in the stream, and scoring was consistent with the May

sample event. As was the case in May, two of the metric indicators calculated for the July samples were poor, such as the proportion of pollution intolerant taxa and the Hilsenhof Biotic Index. However, the overall diversity, and diversity of indicator groups such as mayflies and caddisflies, in addition to a few select sensitive pollution tolerant taxa, supports the contention that the stream is of high quality and is able to support a diverse and well-balanced benthic ecosystem.

Table H-20.
TCEQ Method Evaluation of Aquatic Integrity
Benthic Macroinvertebrate Samples
19–21 July 2010

Metric	Station 1 Score	Station 2 Score	Station 3 Score	Station 4 Score	Station 5 Score
Taxa Richness			4	4	4
EPT Taxa Abundance			3	3	3
Hilsenhof Biotic Index			1	1	1
Percent Chironomidae	NO	NO	3	1	4
Percent Dominant Taxon			4	4	2
Percent Dominant FFG	SAMPLE	SAMPLE	3	4	3
Percent Predators			1	2	3
Ratio of Intolerant : Tolerant Taxa	TAKEN	TAKEN	1	1	1
% Trichoptera as Hydropsychidae			1	2	1
Number of non-insect taxa			4	4	3
Percent Collector-Gatherers			3	3	3
Percent of total number as Elmidae			3	3	2
Total	--	--	31	32	30
TCEQ Aquatic Life Use Score*	--	--	High	High	High
*Limited = <22, Intermediate = 22-28, High = 29-36, and Exceptional = >36					

H.3.3.2.5 Discussion

A total of 4,188 individuals distributed over 64 taxa were collected during the four field efforts. All stations displayed relatively high overall diversity in addition to the high diversity of sensitive groups such as mayflies and caddisflies. With only one exception (Station 4 in July), all samples had relatively low density numbers of midges (Chironomidae), which have the tendency to proliferate in less suitable habitat conditions. A low density of midges is typically indicative of good aquatic integrity. Three different genera of riffle beetles that occupy different stream habitats were identified: *Stenelmis, Hexacylloepus*, and *Dubiraphia*. While the *Stenelmis* riffle beetle is found in a wide variety of environments, *Hexacylloepus* beetles typically are

found only in environments with swift, perennial flow with excellent water quality, and *Dubiraphia* beetles are typically associated with large perennial lake environments. The mayfly (*Neochoroterpes*), present in all but one sample (Station 4 in July), exhibits low tolerance to poor water quality conditions, providing evidence that all stream reaches consistently support superior aquatic integrity. Other pollution intolerant taxa present in one or more samples included the dragonflies (*Erpetogomphus, Macromia, and Phyllogomphoides*), mayfly (*Neochoroterpes*), riffle beetle (*Hexacylloepus*), and four caddisfly genera (*Helicopsyche*, *Hydroptila*, *Nectopsyche*, and *Chimarra*).

Habitat parameters collected during benthic assessments provide additional information in evaluating the benthic community results. In-stream habitat such as undercut banks, overhanging brush, macrophytes, and snags provide niches to a variety of invertebrate groups, and in sufficient quantities can increase the diversity and community structure significantly. As indicated on the field sheets, all five stations contained these four structural components of in-stream habitat to varying degrees. Stream substrate is also important to the diversity and complexity of the benthic macroinvertebrate community. Vertically stratified and diverse stream substrates provide a wide variety of micro-niches and interstitial spaces which tend to increase the complexity of the ecosystem. Field notes indicate the five stations are primarily dominated by gravel with some soft bottom substrates, which provide ample interstitial spaces but tend to be highly mobile depending on size and embeddedness. Stations 1 and 2 included a small amount of sand substrate, and both Stations 2 and 3 also include some bedrock. This diversity of habitat provides adequate niches to support a high integrity biological community.

Only 3 of the 64 taxa (*Stenelmis*, *Tricorythodes, and Argia*) were common to all samples and are widespread in the intermittent and perennial streams in this part of Texas. All three taxa, are considered moderately pollution sensitive organisms. Generally, the diversity, community structure, and trophic balance of the stream reaches sampled indicated a healthy aquatic ecosystem. This is reflected in the TCEQ aquatic life use ranking of High at most sample locations investigated.

H.3.3.3 Fish Community Evaluation

Sampling was conducted on a qualitative basis to obtain relative abundance and species composition of the fish community. Since water conductivities were consistently greater than those feasible for backpack electrofishing, fish populations were collected at each sampling

location in a downstream to upstream direction primarily using a 20-foot common-sense minnow seine. Seines are selective sampling methods and are biased in the types and sizes of fish collected. The mesh size and length of a seine will determine the size of fish which can be caught, and may affect how efficiently the seine can be pulled. A 30-ft bag seine was also used in the larger snag-free pool habitats over smooth bedrock bottom surfaces. However, this habitat type was not very common in the locations investigated. Pulling the bag seine through channel expanses of large cobble and snaggy shoreline conditions proved ineffective in the catchability of larger and faster swimming individuals, as well as smaller forage species and smaller-sized juveniles of larger fish, due to evasive movements through a larger meshed net resulting in low capture efficiency. Thus, the use of the bag seine was discontinued after the June 2009 sampling period. Riffles were sampled by placing the net across an area about fifteen ft in width and kicking the substrate, moving downstream toward the net.

A checklist of fish species collected, the total number of individuals collected by seine during each of the four field efforts in addition to TPWD designated functional feeding groups, and DO tolerance classification levels, is presented in Tables H-21, H-22, H-23, and H-24, respectively. Since the seine collection effort was held constant for all stations sampled, the data presented can be compared across stations for each location and should be a constant proportion of the actual fish population. These data do not represent the total fish population, either in number or by species present, since fish are highly mobile organisms and avoid collection gear.

An IBI was calculated for the five stations using the raw fish data along with the 11 metric parameters developed by Linam et al.[29] (2002) for the stream fishes found in the Central Great Plains of Texas (Ecoregion 27). Using the specific metrics for species richness and composition, trophic composition, and fish abundance and condition, an IBI score was tabulated by collection event for each sample site investigated in 2009 and 2010. For comparability, these IBI scores were examined for any noted differences between each sampling event. Application of the scoring and evaluation criteria is presented in Table H-25. The proportion of pollution tolerant individuals was high at most stations sampled. No diseased fish were collected during this survey.

[29] Linam, G.W., L.J. Kleinsasser, and K.B. Mayes. 2002. *Regionalization of the Index of Biotic Integrity for Texas Streams (River Studies Report No. 17)*. Texas Parks and Wildlife Department. Austin, Texas.

Table H-21.
Total Number of Fish Species Collected by Seine in June 2009

Species		Type	Parameter Code*	Trophic Group**	Tolerance Class***	Station 1 Hoggy Crossing 15 June 2009 Seine	Station 2 Flatlands Crossing 16 June 2009 Seine	Station 3 Boys Camp Crossing 16 June 2009 Seine	Station 4 Shelton Crossing 17 June 2009 Seine	Station 5 KRR Crossing 17 June 2009 Seine
Scientific Name	Common Name									
Lepisosteus osseus	Longnose gar		98341	P	T	4		7		2
Dorosoma cepedianum	Gizzard shad		98430	O	T	4	109	17	14	124
Cyprinella lutrensis	Red shiner		98474	IF	T	1447	1498	4401	3453	5605
Notropis buchanani	Ghost shiner		98467	IF		119	10	39	26	68
Cyprinus carpio	Common carp		98437	O	T	1			1	
Pimephales vigilax	Bullhead minnow		98498	IF		6	85	24	11	54
Ictalurus punctatus	Channel catfish		98561	O	T	1		3		1
Pylodictis olivaris	Flathead catfish		98570	P			1			
Gambusia affinis	Western mosquitofish		98713	IF	T	37	4	137	35	383
Menidia beryllina	Inland silverside		98728	IF		53	43	6	4	5
Lepomis cyanellus	Green sunfish	sunfish	99094	P	T					1
Lepomis gulosus	Warmouth	sunfish	99095	P	T	2				
Lepomis humilis	Orangespotted sunfish	sunfish	99096	IF		8		3		4
Lepomis macrochirus	Bluegill	sunfish	99097	IF	T	2	6	9	3	4
Lepomis megalotis	Longear sunfish	sunfish	99099	IF			5	6	6	13
Micropterus salmoides	Largemouth bass	sunfish	99090	P		2	3	2		
Pomoxis annularis	White crappie	sunfish	99108	P			3	4	9	
Aplodinotus grunniens	Freshwater drum		98958	IF	T				1	
					TOTAL TAXA	13	11	13	11	12
					TOTAL INDIVIDUALS	1686	1767	4658	3562	6264

* Five digit codes created by the USEPA to describe various parameters in their Storage and Retrieval database and are linked to descriptions of fish species.
**Trophic group designations are as follows: IF - invertivore; P - piscivore; O - omnivore; and H - herbivore
***Tolerance designations are: T - tolerant; I - intolerant. Those species without a tolerance designation are considered intermediate.

Table H-22.
Total Number of Fish Species Collected by Seine in August 2009

Species		Type	Parameter Code*	Trophic Group**	Tolerance Class***	Station 1 Hoggy Crossing 10 Aug 2009 Seine	Station 2 Flatlands Crossing 10 Aug 2009 Seine	Station 3 Boys Camp Crossing 11 Aug 2009 Seine	Station 4 Shelton Crossing 12 Aug 2009Seine	Station 5 KRR Crossing 11 Aug 2009 Seine
Scientific Name	Common Name									
Lepisosteus osseus	Longnose gar		98341	P	T	1		4	7	3
Dorosoma cepedianum	Gizzard shad		98430	O	T	79	10	1	3	7
Cyprinella lutrensis	Red shiner		98474	IF	T	2039	1070	1949	2091	2775
Notropis buchanani	Ghost shiner		98467	IF		19		133	10	37
Pimephales vigilax	Bullhead minnow		98498	O	T	56	1990	377	266	1675
Cyprinus carpio	River carpsucker		98511	O	T		3			
Ictalurus punctatus	Channel catfish		98561	O	T	5	24	1		
Pylodictis olivaris	Flathead catfish		98570	P		1	1			
Gambusia affinis	Western mosquitofish		98713	IF	T	8	151	428	237	836
Menidia beryllina	Inland silverside		98728	IF		51	195	10		
Lepomis cyanellus	Green sunfish	sunfish	99094	P	T		3			
Lepomis gulosus	Warmouth	sunfish	99095	P	T			6	3	
Lepomis humilis	Orangespotted sunfish	sunfish	99096	IF			20	105	3	62
Lepomis macrochirus	Bluegill	sunfish	99097	IF	T	3	8		12	17
Lepomis megalotis	Longear sunfish	sunfish	99099	IF		3			14	43
Lepomis microlophus	Redear sunfish	sunfish	99100	IF				4	4	
Pomoxis annularis	White crappie	sunfish	99108	IF	T	4	5		6	
Aplodinotus grunniens	Freshwater drum		98958	IF	T	1	2			
					TOTAL TAXA	13	13	11	12	9
					TOTAL INDIVIDUALS	2270	3482	3018	2656	5455

* Five digit codes created by the USEPA to describe various parameters in their Storage and Retrieval database and are linked to descriptions of fish species.

**Trophic group designations are as follows: IF - invertivore; P - piscivore; O - omnivore; and H - herbivore

***Tolerance designations are: T - tolerant; I - intolerant. Those species without a tolerance designation are considered intermediate.

Table H-23.
Total Number of Fish Species Collected by Seine in May 2010

Species		Type	Parameter Code*	Trophic Group**	Tolerance Class***	Station 1 Hoggy Crossing 6 May 2010 Seine	Station 2 Flatlands Crossing 6 May 2010 Seine	Station 3 Boys Camp Crossing 7 May 2010 Seine	Station 4 Shelton Crossing 7 May 2010 Seine	Station 5 KRR Crossing 7 May 2010 Seine
Scientific Name	Common Name									
Lepisosteus osseus	Longnose gar		98341	P	T	5	4	7	25	15
Dorosoma cepedianum	Gizzard shad		98430	O	T	3			1	
Cyprinella lutrensis	Red shiner		98474	IF	T	1575	1063	3507	1946	2414
Notropis buchanani	Ghost shiner		98467	IF		64	119	4		22
Cyprinus carpio	Common carp		98437	O	T	4		1	2	
Pimephales vigilax	Bullhead minnow		98498	IF		138	77	50	15	106
Ictalurus punctatus	Channel catfish		98561	O	T	1		2		2
Pylodictis olivaris	Flathead catfish		98570	P		1	2			
Gambusia affinis	Western mosquitofish		98713	IF	T	24	57	31	43	10
Lepomis humilis	Orangespotted sunfish	sunfish	99096	IF		4	2	39	11	12
Lepomis macrochirus	Bluegill	sunfish	99097	IF	T	8	8	17	20	3
Lepomis megalotis	Longear sunfish	sunfish	99099	IF		4	9	7	5	3
Lepomis microlophus	Redear sunfish	sunfish	99100	IF			2			1
Aplodinotus grunniens	Freshwater drum		98958	IF	T		4		1	
					TOTAL TAXA	12	11	10	10	10
					TOTAL INDIVIDUALS	1831	1347	3665	2069	2588

* Five digit codes created by the USEPA to describe various parameters in their Storage and Retrieval database and are linked to descriptions of fish species.

**Trophic group designations are as follows: IF - invertivore; P - piscivore; O - omnivore; and H - herbivore

***Tolerance designations are: T - tolerant; I - intolerant. Those species without a tolerance designation are considered intermediate.

Table H-24.
Total Number of Fish Species Collected by Seine in July 2010

Species		Type	Parameter Code*	Trophic Group*	Tolerance Class**	Station 1 Hoggy Crossing July 2010 Seine	Station 2 Flatlands Crossing July 2010 Seine	Station 3 Boys Camp Crossing 20 July 2010 Seine	Station 4 Shelton Crossing 21July 2010 Seine	Station 5 KRR Crossing 21 July 2010 Seine
Scientific Name	Common Name									
Lepisosteus oculatus	Spotted gar		98340	P	T				1	
Lepisosteus osseus	Longnose gar		98341	P	T			5	7	4
Dorosoma cepedianum	Gizzard shad		98430	O	T			9		1
Cyprinella lutrensis	Red shiner		98474	IF	T	NO	NO	1299	1314	2306
Notropis buchanani	Ghost shiner		98467	IF				220	2	106
Cyprinus carpio	Common carp		98437	O	T	ACCESS	ACCESS			
Pimephales vigilax	Bullhead minnow		98498	IF				194	1	38
Ictalurus punctatus	Channel catfish		98561	O	T	NO	NO	1	5	27
Gambusia affinis	Western mosquitofish		98713	IF	T			396	45	144
Menidia beryllina	Inland silverside		98728	IF		SAMPLES	SAMPLES			1
Lepomis humilis	Orangespotted sunfish	sunfish	99096	IF				3		5
Lepomis macrochirus	Bluegill	sunfish	99097	IF	T	TAKEN	TAKEN	15	1	4
Lepomis megalotis	Longear sunfish	sunfish	99099	IF				2	4	11
Lepomis microlophus	Redear sunfish	sunfish	99100	IF					1	1
Micropterus salmoides	Largemouth bass	sunfish	99090	P				3	3	
Aplodinotus grunniens	Freshwater drum		98958	IF	T			2		
					TOTAL TAXA	–	--	12	11	12
					TOTAL INDIVIDUALS	–	--	2149	1384	2648

* Five digit codes created by the USEPA to describe various parameters in their Storage and Retrieval database and are linked to descriptions of fish species.
**Trophic group designations are as follows: IF - invertivore; P - piscivore; O - omnivore; and H - herbivore
***Tolerance designations are: T - tolerant; I - intolerant. Those species without a tolerance designation are considered intermediate.

Table H-25.
Metrics and Scoring Criteria for Fish Samples Based On Ecoregions 27, 29, and 32 Criteria 2009-2010 Index and Critical Periods[1]

Metric	Clear Fork Brazos River - 2009																			
	Station 1				Station 2				Station 3				Station 4				Station 5			
	Index		Critical		Index		Critical		Index		Critical		Index		Critical		Index		Critical	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
1. Total number of fish species	13	3	13	3	11	3	13	3	13	3	11	3	11	3	12	3	12	3	9	3
2. Number of native cyprinid species	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3
3. Number of benthic invertivore species	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
4. Number of sunfish species	3	3	3	3	3	3	4	5	4	5	3	3	3	3	6	5	4	5	3	3
5. Percentage of individuals as tolerant species[2]	86.7	1	93.7	1	91.3	1	32.5	3	95.3	1	68.3	1	97.4	1	79.7	1	91.6	1	51.4	1
6. Percentage of individuals as omnivores	0.4	5	3.7	5	6.2	5	1.1	5	0.4	5	0.1	5	0.4	5	0.1	5	2.0	5	0.1	5
7. Percentage of individuals as invertivores	99.2	5	96.0	5	93.4	5	98.7	5	99.3	5	99.8	5	99.3	5	99.3	5	98.0	5	99.8	5
8. Percentage of individuals as piscivores	0.5	1	0.3	1	0.4	1	0.3	1	0.3	1	0.1	1	0.3	1	0.6	1	0.0	1	0.1	1
9. Number of individuals in sample	1686	--	2270	--	1767	--	3482	--	4658	--	3018	--	3562	--	2656	--	6264	--	5455	--
9a. Number of individuals/seine haul	112	5	151	5	118	5	232	5	311	5	201	5	238	5	177	5	418	5	364	5
9b. Number of individuals/min electrofishing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. Percentage of individuals as Non-native species	0.1	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5
11. Percentage of individuals with disease anomalies	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5
Total Score	37		37		37		41		39		37		37		39		39		37	
Aquatic Life Use*	Intermediate		Intermediate		Intermediate		High		Intermediate		Intermediate		Intermediate		Intermediate		Intermediate		Intermediate	

[1]Index Period (15-17 June 2009 and 5-7 May 2010); Critical Period (10-12 August 2009 and 19-21 July 2010); *Excluding western mosquitofish
*Exceptional (≥49); High (41-48); Intermediate (35-40); Limited (< 35)

Table H-25.
Metrics and Scoring Criteria for Fish Samples Based On Ecoregions 27, 29, and 32 Criteria
2009-2010 Index and Critical Periods[1] (Concluded)

Metric	Clear Fork Brazos River - 2010																			
	Station 1				Station 2				Station 3				Station 4				Station 5			
	Index		Critical		Index		Critical		Index		Critical		Index		Critical		Index		Critical	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
1. Total number of fish species	12	3	--	--	11	3	--	--	10	3	12	3	10	3	11	3	10	3	12	3
2. Number of native cyprinid species	3	3	--	--	3	3	--	--	3	3	3	3	2	3	3	3	3	3	3	3
3. Number of benthic invertivore species	0	1	--	--	0	1	--	--	0	1	0	1	0	1	0	1	0	1	0	1
4. Number of sunfish species	3	3	--	--	4	5	--	--	3	3	3	3	3	3	3	3	4	5	4	5
5. Percentage of individuals as tolerant species[2]	87.2	1	--	--	80.3	1	--	--	96.4	1	61.9	1	96.4	1	98.9	1	94.0	1	68.4	1
6. Percentage of individuals as omnivores	0.4	5	--	--	0.1	5	--	--	0.1	5	0.5	5	0.1	5	3.3	5	0.1	5	1.1	5
7. Percentage of individuals as invertivores	99.2	5	--	--	99.6	5	--	--	99.7	5	99.2	5	98.6	5	95.9	5	99.3	5	98.8	5
8. Percentage of individuals as piscivores	0.3	1	--	--	0.3	1	--	--	0.2	1	0.4	1	1.2	1	0.8	1	0.6	1	0.2	1
9. Number of individuals in sample	1831	--	--	--	1347	--	--	--	3665	--	2149	--	2069	--	1364	--	2588	--	2648	--
9a. Number of individuals/seine haul	122	5	--	--	90.0	5	--	--	244	5	195	5	138	5	138	5	173	5	265	5
9b. Number of individuals/min electrofishing	N/A	N/A	--	--	N/A	N/A	--	--	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. Percentage of individuals as Non-native species	0.2	5	--	--	0.0	5	--	--	0.0	5	0.0	5	0.1	5	0.1	5	0.0	5	0.0	5
11. Percentage of individuals with disease anomalies	0.0	5	--	--	0.0	5	--	--	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5	0.0	5
Total Score	37		NOT		39		NOT		37		37		37		37		39		39	
Aquatic Life Use*	Intermediate		ASSESSED		Intermediate		ASSESSED		Intermediate		Intermediate		Intermediate		Intermediate		Intermediate		Intermediate	

[1]Index Period (15-17 June 2009); Critical Period (10-12 August 2009) [2]Excluding western mosquitofish
*Exceptional (≥49); High (41-48); Intermediate (35-40); Limited (< 35).

H.3.3.3.1 June 2009

During the June survey, a total of 17,937 individuals of fish representing 8 families and 18 species were collected from the five sites on the Clear Fork (Table H-21). Scattered localized rain fell in the area over the weekend prior to sampling. The major trophic categories present were invertivore, omnivore, and piscivore with nine species classified as tolerant. No intolerant species were represented in the collections. Six species were found throughout the stream survey area that included the gizzard shad (*Dorosoma cepedianum*), red shiner (*Cyprinella lutrensis*), ghost shiner (*Notropis buchanani*), bullhead minnow (*Pimephales vigilax*), western mosquitofish (*Gambusia affinis*), and inland silverside (*Menidia beryllina*).

The red shiner comprised 91% of the total June catch and dominated the seine collections taken at each location. The western mosquitofish was the second most common fish collected and accounted for approximately 3% of all fish taken. This species was present at all five stations with Station 5 producing the most individuals with 383. The third most abundant species was the ghost shiner with 262 individuals or approximately 1.5% of the total catch in June. The remaining 4.5% of the total catch in numerical order were the bullhead minnow, inland silverside, longear sunfish (*Lepomis megalotis*), bluegill (*Lepomis macrochirus*), white crappie (*Pomoxis annularis*), orangespotted sunfish (*Lepomis humilis*), longnose gar (*Lepisosteus osseus*), largemouth bass, channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), warmouth (*Lepomis gulosus*), flathead catfish (*Pylodictis olivaris*), green sunfish, and freshwater drum (*Aplodinotus grunniens*).

Station 5 ranked first in total numbers collected with 6,264 individuals representing 12 species. Station 3 ranked second with a total of 4,658 individuals and 13 species. Station 4 produced 3,561 individuals and 11 species. Station 2 yielded 1,767 individuals and 11 genera, and Station 1 was represented by 1,686 individuals and 13 species.

No intolerant or darter species were collected at Station 1, among the 13 fish species identified at this site (Table H-21). The IBI integrity value of 37 indicated a rating of an Intermediate rating score (Table H-25). Low species richness, the absence of intolerant species and benthic invertivores, a very high percentage of tolerant species, and a very low percentage of piscivores resulted in a less than High IBI rating. Approximately 99% of the community was comprised of invertivores; however, this category was dominated (86%) by a single species (red shiner).

No intolerant or darter species were collected at Station 2 among the 11 species identified at this site (Table H-21). The IBI value of 37 indicated a rating of Intermediate (Table H-25). Absence of intolerant species, a low number of invertebrate feeders, a high percentage of tolerant species, and low numbers of predators resulted in a less than High IBI rating for this study. This station also had the highest proportion of omnivorous individuals collected during the 2009 study.

Of the 13 fish species collected at Station 3 (Table H-21), no intolerant or darter species were collected at this site. The IBI value of 39 calculated for this section of river was higher than the previous upstream sites discussed, but the cumulative score still resulted in a rating of Intermediate (Table H-25). No benthic invertivore species, the absence of intolerant species, a high percentage of tolerant species, and a very low percentage of predatory species resulted in a less than High IBI rating.

A total of 11 species was collected at Station 4 (Table H-21). No intolerant or darter species were collected from this site. The IBI value of 37 calculated for this location resulted in a rating of Intermediate (Table H-25). No benthic invertivore species, no intolerant species, an elevated percentage of tolerant species, and a very low percentage of piscivores resulted in a less than High IBI rating.

No intolerant or darter species were collected at Station 5 among the 12 species taken (Table H-21). The IBI value of 39 indicated a rating of Intermediate and along with Station 3, was the highest index period value calculated at all locations (Table H-25). As was the case noted in all collections, the absence of intolerant species, a low number of invertebrate feeders, a high percentage of tolerant species, and low numbers of predators resulted in a less than High IBI rating during the June survey.

H.3.3.3.2 August 2009

Fish species collected from the Clear Fork at the five sites in August 2009 are listed in Table H-22. Scattered localized rain fell in the area during the week before sampling. There were a total of 16,881 fish captured by 20-ft seine representing 9 families and 18 species. Of the six species collected at every river location in June, only the gizzard shad, red shiner, bullhead minnow, and western mosquitofish were the most ubiquitous fish species collected in August. The three major trophic categories (invertivore, omnivore, and piscivore) were represented with

nine species classified as tolerant. Two new entries was added to the collection list as the first occurrence of the redear sunfish (*Lepomis microlophus*) was noted with four individuals each collected from Stations 3 and 4 and three juveniles (57–58 mm) of river carpsucker (*Carpiodes carpio*) captured at Station 2. This marked the last appearance of the green sunfish, the warmouth, and the river carpsucker in the study collections. The common carp and the largemouth bass, both collected in small numbers in May, were absent during the August survey.

Although not as dominant in terms of total numbers collected, the red shiner was again the most abundant species, accounting for approximately 59% of the total critical period catch. The lower numbers could be the result of less available flowing habitat encountered at each location. The second most dominant species was the bullhead minnow comprising almost 26% of the total catch with 4,364 individuals. Stations 3 and 5 produced the greatest number of this species with 1,990 and 1,675, respectively. The third most common fish was the western mosquitofish which comprised approximately 10% of the total August seine collection. This aggressive fish frequents shallow, marginal areas of standing warmer water. This was the most dominant habitat type observed at Stations 3 and 5 with 76% of this species being collected. The fourth most abundant, but not clearly a dominant, was the inland silverside which produced a total of 256 fish (1.5%) at three of the five stations.

The remaining 3.5% of the fish collected represented by less than 200 individuals each and listed in descending order of abundance included the ghost shiner, bluegill, gizzard shad, orangespotted sunfish, longear sunfish, channel catfish, longnose gar, white crappie, redear sunfish, warmouth, freshwater drum, river carpsucker, and flathead catfish. Station 5 again ranked first in total numbers collected with 5,455 individuals representing 9 species. Station 2 ranked second with a total of 3,482 individuals and 13 species. Station 3 produced 3,018 individuals and 11 species. Station 4 yielded 2,656 individuals and 12 species, while Station 1 was represented by 2,272 individuals and 13 species. Overall, the proportion of pollution tolerant individuals collected was lower at four of the five stations sampled in August.

No darter or intolerant species were among the 13 species collected at Station 1 (Table H-22). The IBI value of 37 calculated for this location in August was identical to the June score and within the range assigned as Intermediate (Table H-25). No differences were noted affecting the metric scoring between the two surveys, including slight variations in trophic composition and fish abundance and condition.

A total of 13 fish species were collected at Station 2 (Table H-22). The IBI score of 41 was the highest of all stations investigated during 2009–2010, resulting in a rating of High (Table H-25). The four-point increase was attributed to a higher number of sunfish species collected (four vs. three) and a much lower percentage of tolerant species collected (32.4 vs. 91.3). Other variations noted that did not affect the individual metric scoring between the two survey periods include the total number of species collected, total number of individuals collected, percentage of invertebrate feeding species, percentage of omnivore species, and number of native cyprinid species collected.

No intolerant or darter species were collected at Station 3 among the 11 species identified at this site (Table H-22). The IBI value of 37 calculated for this location in August was two points lower than June; however, both scores are within the range assigned as Intermediate (Table H-25). The lower score was due to a lower number of sunfish species collected in the August collection. Other comparative differences that did not affect individual metric scoring included a lower total number of individuals caught in the seine hauls that influenced the number of fish species collected, a lower percentage of tolerant species, and a lower percentage of omnivore and piscivore species.

A total of 12 fish species was collected at Station 4 (Table H-22). The IBI value of 39 calculated for this location increased two points over the computed score for June and was assigned an Intermediate ranking (Table H-25). The highest number of sunfish species (6), including the redear sunfish, were collected at this station, which was the one major difference between the two scores. Other variances not affecting individual metric values between sampling events included a slight increase in total species collected, a reduction in the percentage of tolerant species present, and a smaller percentage of omnivore species collected. This station also had the highest proportion, although slight, of piscivorous individuals collected during 2009.

The lowest species richness of the study occurred at Station 5 where 9 of the 18 total fish species in the critical period survey were collected (Table H-22). The IBI value of 37 was two points lower than the June total score, but both numbers are within the range assigned as Intermediate (Table H-25). The lower score was directly attributed to the metric scoring for the number of sunfish species collected. Other slight changes noted among the individual metrics not involving scoring changes included the total number of individuals caught and the percentages of tolerant, omnivore, and invertebrate feeding species collected.

H.3.3.3.3 May 2010

A total of 11,500 fish representing 7 families and 14 species were taken during HDR's survey in May. Scattered localized rain fell in the area during the week leading up to sampling. The decline in the relative abundance and total number of fish species collected, the lowest of the study, is attributed to the swift flowing condition of the stream. The higher flow regime affected the relative abundance and characteristics of representative microhabitat types. Shallow pools were less abundant, transitioning into run habitat with increased velocities. The fish community appeared to exhibit different responses to the rising and receding water related to their habitat affinities. Five species including the inland silverside, green sunfish, warmouth, largemouth bass, and white crappie were absent in the May collections. A total of seven species were present at all five stations investigated: longnose gar, red shiner, bullhead minnow, western mosquitofish, orangespotted sunfish, bluegill, and longear sunfish. The three major trophic categories (invertivore, omnivore, and piscivore) were represented with eight species classified as tolerant. The red shiner comprised almost 92% of the total spring catch with 10,505 individuals caught. This species was most abundant at Stations 3 and 5, with 3,507 and 2,414 individuals, respectively.

The second most dominant fish was the bullhead minnow with 386 individuals or approximately 3% of the total catch in spring. The third most common species was the ghost shiner comprising almost 2% of the species collected. The fourth abundant species was the western mosquitofish representing slightly over 1% of the total seine catch.

The remaining 10 species collected in small numbers included the orangespotted sunfish, longnose gar, bluegill, longear sunfish, common carp, channel catfish, freshwater drum, gizzard shad, flathead catfish, and redear sunfish. A total of five species collected during June 2009 did not appear in the May 2010 collections: inland silverside, green sunfish, warmouth, largemouth bass, and white crappie.

Station 3 ranked first in total numbers collected with 3,507 individuals representing 10 species. Station 5 ranked second with a total of 2,588 individuals and 10 species. Station 4 produced 2,069 individuals and 10 species. Station 1 yielded 1,831 individuals and 12 species, and Station 2 was represented by 1,347 individuals and 11 species.

No intolerant or darter species were collected at Station 1 among the 12 species identified (Table H-23). The IBI integrity value of 37 indicated an Intermediate rating score (Table H-25)

and was identical to each of the individual metric values calculated for the June 2009 collection and differed alike with the August 2009 results by a lower species richness, the absence of intolerant and benthic invertivore species, a high percentage of tolerant species, and a low predator population.

No intolerant or darter species were collected at Station 2 among the 11 species identified at this site (Table H-23). The IBI value of 39 indicated a rating of Intermediate (Table H-25). The 2009 IBI values varied from 37 in June and 41 in August. The increase in the total score with a consequent elevation to the High ALU subcategory in August was attributed to the collection of more sunfish species and less tolerant species composition. The difference in metric scoring between August and May was the increase in tolerant species collected by seine resulting in a less than High IBI rating. Several similarities noted that did not affect the individual metric scoring between the three survey periods include species richness, native cyprinids collected, percentage of tolerant species, percentage of invertebrate feeding species, percentage of omnivore species, and percentage of piscivore species collected. Of the 10 fish species collected at Station 3 (Table H-23), no intolerant or darter species were collected. The IBI value of 37 calculated for this section of river was identical to the August survey, although the flow regime was quite different. The cumulative score computed for all three fish collections resulted in an Intermediate IBI rating (Table H-25). The lower scores in August and May were directly related to the total number of sunfish species caught. A less than High IBI rating also resulted from the lack of benthic invertivore and intolerant species, a high percentage of tolerant species, and a very low percentage of predatory species.

A total of 11 species was collected at Station 4 (Table H-23). No intolerant or darter species were collected from this site. The ALU category calculated using the TPWD fish-based IBI for the fish data collected to date show that identical values (37) are indicative of an Intermediate rating (Table H-25). Scoring was consistent for all 11 metrics. No benthic invertivore species, no intolerant species, an elevated percentage of tolerant species, and a very low percentage of piscivores resulted in a less than High IBI rating.

No intolerant or darter species were collected at Station 5 among the 10 species taken (Table H-23). The IBI value of 39 indicated a rating of Intermediate which, along with Stations 2 and 3, was the highest index period value calculated at all locations during the two-year study

period (Table H-25). The two-point increase over the August survey was directly credited to the total number of sunfish species collected.

H.3.3.3.4 July 2010

A total of 6,181 fish was collected representing 8 families and 16 species (Table H-24) during the July 2010 survey. Stations 1 and 2 were not sampled. Swift-moving water as a result of thunderstorm activity in the area was again encountered during the July field effort, which is uncharacteristic of this time of year. The prior week was originally scheduled for the designated critical period aquatic life monitoring field effort but was delayed to allow the river water level and velocity to recede. The total number of fish (and possibly additional new species) would potentially have been higher had the upper two river sites been available for assessment. The three major trophic categories (invertivore, omnivore, and piscivore) were represented with nine species classified as tolerant. The red shiner, ubiquitous in all habitats sampled at every station visited, was the most abundant fish species collected, accounting for almost 80% of the total summer catch; followed by the western mosquitofish, representing almost 9.5% of the total; the ghost shiner representing 5.3% of the total; and the bullhead minnow, which comprised 3.8% of the individuals in the summer seine hauls. The other 12 fishes collected, accounting for 1.4% of the total catch, in descending order of abundance, included the channel catfish, bluegill, longear sunfish, longnose gar, gizzard shad, orangespotted sunfish, largemouth bass, redear sunfish, freshwater drum, spotted gar (*Lepisosteus oculatus*), common carp, and inland silverside. It was difficult to assess the relative abundance of the forage species populations as young-of-the-year juveniles were small enough to evade capture by the 0.32-cm mesh openings. Two fish species (river carpsucker and flathead catfish) not collected at the three downstream locations appear to utilize the habitats found only at the two uppermost river stations. The spotted gar made its only appearance at Station 4 with one individual netted in July.

Station 5 ranked first in total numbers collected with 2,648 individuals representing 12 species. Station 3 ranked second with a total of 2,149 individuals and 12 species. Station 4 was the third most productive station yielding 2,069 individuals and 11 species.

No samples were taken from Stations 1 and 2. Multi-metric scores for fish taken in 2009 and May 2010 at Station 1 yielded similar aquatic life use results although the total numbers of individuals did not differ significantly. An Intermediate rating was calculated for all three

collections; a value of 37 was calculated for the two index periods (June and May), and a value of 39 was computed for the fish sample taken in August. The two point increase was attributed to an increase in sunfish species collected. The ALU rating for fish at Station 2 fluctuated from Intermediate to High and back to Intermediate. The lack of fish data for August precluded comparison to determine if seasonality was a contributing factor to the higher score. A two point metric increase in the number of sunfish species collected and percent composition of tolerant species was credited for the four point difference between the two 2009 samples. The two point decrease between the final May and August survey values was caused by the decrease in score from 5 to 3 for the percentage of individuals as tolerant species metric.

No intolerant or darter species were collected at Station 3 among the 12 species identified at this site (Table H-24). The IBI value of 37 was calculated for this location in July. All station scores are found within the range assigned as Intermediate (Table H-25). The highest score (39) was due to a slightly greater number of sunfish species (4 vs. 3) collected in June. Other comparative differences that did not affect individual metric scoring included a lower total number of individuals caught in the seine hauls that influenced the number of fish species collected, a lower percentage of tolerant species, and a lower percentage of omnivore and piscivore species.

A total of 11 fish species was collected at Station 4 (Table H-24). The IBI value of 37 calculated for this location has remained fairly constant with a slight increase in score (39) observed in August. Low species richness; the absence of intolerant species; a low number of native minnows, sunfish, and invertebrate feeders; a high percentage of tolerant species; and low numbers of predators resulted in a less than High IBI rating during all surveys (Table H-25). The total number of individuals in each collection has progressively declined since June 2009. Proportions of piscivorous individuals for the two 2010 sample events were the highest of any station.

A total of 12 species was collected at Station 5 (Table H-24). No intolerant or darter species were collected from this site. The IBI value of 39 was consistent with both 2009 sampling event scores and two points higher than the August total score, but all numbers are found within the range assigned as Intermediate (Table H-25). As was continually noticed in the measure of the index and critical period fish biological conditions, scores calculated from the four evaluations for the Clear Fork maintained consistency and were fairly constant with each

other. Low individual metric scoring ranked sites similarly for the collection in the total number of fish species, the number of native cyprinid species, the number of benthic invertivore species, the percentage of tolerant species present, and the percent composition of individuals as carnivorous species. Consistently high scoring were the two trophic composition metrics (percentage of omnivorous and insectivorous species present) and all three fish abundance and condition metrics (number of individuals collected in each seine haul, low percentage of non-native species, and percentage of fish showing disease or anomalies). The capture of one additional sunfish species at each location would have increased the total score by two points. The absence of benthic invertivores (sucker and darter species) also was a key factor in limiting the total score in the range for Intermediate classification. Little or no improvement in biotic integrity was detected following each sampling event over the two year period.

H.3.3.3.5 Discussion

The geographic ranges of roughly 89 species of freshwater fish found in the Brazos River Basin (Linam and Kleinsasser, 1998) include the immediate and surrounding area, although, based on size and habitat suitability, not all of these species would occur in each area. Considerably less effort sampling the riverine fish community has been expended than in sampling fish found within the various reservoirs of the Clear Fork watershed.

No detailed ecological surveys have been conducted in recent years on the Clear Fork. However, the TPWD conducted a basic fisheries survey and a species inventory to gather fundamental data on the Clear Fork and its watershed (from April 16, 1958, through March 31, 1960) in Region 3-B in regard to the physical, chemical, and biological characteristics of the water.[30] The survey includes a determination of the distribution, the relative abundance, and the ecological factors influencing the distribution of the fish species present.

A total of 41 fish collections were made throughout the Wichita and Brazos river systems including the Double Mountain and Salt and Clear Forks portions from 1988 through 1992.[31] The presence of two imperiled minnow species, smalleye shiner and sharpnose shiner, currently classified by the U.S. Fish and Wildlife Service as candidate species for listing, was the primary

[30] Wilcox, J. Undated. *Basic Survey and Inventory of Species as Well as Their Distribution in the Clear Fork of the Brazos River in Region 3-B, Texas,* April 16, 1958 – March 31, 1960. Dingell-Johnson Project F-5-R-7, Texas Parks and Wildlife Department, Austin, Texas.

[31] Moss, R. W., and K. B. Mayes. 1993. Current status of *Notropis buccula* and *Notropis oxyrhynchus* in Texas. River studies report 8. Texas Parks and Wildlife Department, Austin.

focus of this study. The findings of this report agree with earlier surveys in the distribution of a depauperate "prairie stream community", consisting of only a few species that are characteristic of intermittent, shallow, sand bed streams with low habitat diversity, variable temperatures, and high levels of dissolved solids. The less saline Double Mountain Fork, Clear Fork, and the Brazos main stem, generally exhibited more diverse fish assemblages than did the Salt Fork and North Fork Double Mountain Fork sample locations. Information on life history information, habitat utilization, physical habitat characteristics, water quality parameters, spawning behavior, and diet were gathered specific to each species. No individuals of either species were collected at the two sampling points established on the Clear Fork at SH 6 near Lueders and U.S. 180 east of Roby.

TPWD also conducted fisheries studies on the area lakes to determine the need for changes in fish harvest regulations, stocking, population control, vegetation control, habitat improvement, and pollution control. A list of 37 fish species recorded from the aforementioned TPWD scientific collections taken from the river and area lakes including Fort Phantom Hill Reservoir[32], Hubbard Creek Reservoir[33], and Lake Stamford[34], along with a comparison of fish species occurrence during the two surveys at all five sampling locations investigated during the present study is presented in Table H-26. The species collected include species typical of riffle areas (certain minnow species and one darter species), pool habitats (sunfish species, several minnow species, shad, and silversides), and larger streams with relatively consistent flows. The latter includes river carpsucker, white bass (*Morone chrysops*), smallmouth buffalo (*Ictiobus bubalus*), and freshwater drum. The top predators in this watershed include the largemouth bass, channel catfish, flathead catfish, white bass, white crappie, black crappie (*Pomoxis nigromaculatus*), and several species of sunfish (*Lepomis* spp.).

A total of 52,499 fish representing 21 species from nine families were collected the study area in 2009–2010. The representative freshwater fauna found in the seine collections consists

[32]Texas Parks and Wildlife Department (TPWD). 1988. *Existing reservoir and stream management recommendations*. Federal Aid Project F-30-R-13, Fort Phantom Hill Reservoir, 1987. Statewide fishery management recommendations, District 1-B. Texas Parks and Wildlife Department, Inland Fisheries Department, Abilene, Texas

[33]Texas Parks and Wildlife Department (TPWD). 1994. *Statewide freshwater fisheries monitoring and management program*. Federal Aid Project F-30-R0. Survey report for Hubbard Creek Reservoir, 1993. Texas Parks and Wildlife Department, Inland Fisheries Division, District 1-B, Abilene, Texas.

[34]Texas Parks and Wildlife Department (TPWD). 1985. *Job A: Existing reservoir and stream management recommendations*. Federal Aid Project F-30-R-10, Lake Stamford, 1984. Statewide fishery management recommendations, District 1-B. Texas Parks and Wildlife Department, Inland Fisheries Department, Abilene, Texas.

of smaller forage fish populations that include the red shiner, inland silverside, ghost shiner, western mosquitofish, bullhead minnow, and gizzard shad. The sunfish family (Centrarchidae) was represented by eight species. Station 5 ranked first in total numbers collected with 16,955 individuals representing 13 species. Station 3 produced 13,490 individuals and 17 species. Station 4 yielded 9,671 individuals and 18 species. Although no collections were made in July 2010, Station 2 was represented by 6,596 individuals and 18 species, and 5,787 individuals and 17 species were caught at Station 1.

Table H-26.
Comparison of Present Survey Fish Collection Results with Historical River Collections and Area Reservoir Assemblages 15–17 June 2009, 10–12 August 2009, 5–7 May 2010 and 19–21 July 2010

Scientific Name	Common Name	Present Study Area	Fort Phantom Hill	Hubbard Creek Reservoir	Lake Abilene	Lake Stamford
Lepisosteus oculatus	Spotted gar	✓	✓	✓		✓
Lepisosteus osseus	Longnose gar	✓	✓	✓		✓
Dorosoma cepedianum	Gizzard shad	✓	✓	✓	✓	✓
Dorosoma petenense	Threadfin shad		✓	✓	✓	✓
Cyprinella lutrensis	Red shiner	✓	✓			✓
Cyprinus carpio	Common carp	✓	✓	✓	✓	✓
Notemigonus crysoleucas	Golden shiner		✓			✓
Notropis buchanani	Ghost shiner	✓				
Notropis volucellus	Mimic shiner					
Pimephales promelas	Fathead minnow		✓			
Pimephales vigilax	Bullhead minnow	✓	✓			✓
Carpiodes carpio	River carpsucker	✓		✓	✓	✓
Ictiobus bubalus	Smallmouth buffalo		✓	✓		✓
Ameiurus melas	Black bullhead					
Ameiurus natalis	Yellow bullhead					
Ictalurus punctatus	Channel catfish	✓	✓	✓	✓	✓
Ictalurus furcatus	Blue catfish		✓	✓	✓	✓
Pylodictis olivaris	Flathead catfish	✓	✓	✓	✓	✓
Fundulus zebrinus	Plains killifish					
Fundulus notatus	Blackstripe topminnow					
Cyprinodon rubrofluviatilis	Red River pupfish					
Gambusia affinis	Western mosquitofish	✓	✓			
Menidia beryllina	Inland silverside	✓	✓	✓	✓	✓
Morone chrysops	White bass		✓	✓		
M. saxatilis x M. chrysops	Hybrid striped bass			✓	✓	✓
Lepomis cyanellus	Green sunfish	✓	✓	✓	✓	✓
Lepomis gulosus	Warmouth	✓	✓	✓	✓	✓
Lepomis humilis	Orangespotted sunfish	✓	✓	✓	✓	✓
Lepomis macrochirus	Bluegill	✓	✓	✓	✓	✓
Lepomis megalotis	Longear sunfish	✓	✓	✓	✓	✓
Lepomis microlophus	Redear sunfish	✓	✓	✓		✓
Micropterus salmoides	Largemouth bass	✓	✓	✓	✓	✓
Pomoxis annularis	White crappie	✓	✓	✓	✓	✓
Pomoxis nigromaculatus	Black crappie					
Percina caprodes	Bigscale logperch		✓			✓
Stizostedion vitreum	Walleye		✓			
Aplodinotus grunniens	Freshwater drum	✓	✓	✓	✓	✓

Source: Wilcox (undated); Moss and Mayes (1993); TPWD (1985; 1988; 1994a, 1994b)

Pools were the most commonly encountered mesohabitat type in the project area (Figure H-2). Stations 1 and 2 had the highest percentage of pool coverage within the 500 m sample reach. The fish community appears to be restricted to less sensitive species (i.e., tolerant) which are able to withstand wide fluctuations in stream conditions. From 2009 to 2010, the data shows a slight decrease in species and also a decrease in absolute numbers, both for the overall community and to a lesser degree for the red shiner. The decrease in captures might be a joint effort of two different factors related with water level fluctuations: a community environmental response and an artifact of sampling activities. Long periods of constant water levels and flows provide stable fish rearing conditions and enable a stronger recruitment. Rising water creates highly productive and suitable habitats with abundant terrestrial vegetation providing shelter and food. The alternating rise and fall in water level over short periods of time created by frequent thunderstorms reduces spawning habitat stability and fish cover and feeding availability. The sampling artifact might be due to the frequent water level fluctuations resulting in more difficult fishing conditions. Flow is an abiotic habitat characteristic that may influence the presence or absence of certain fish species. As water temperatures warm, species tend to move to deeper water where they are less susceptible to the main collection gear used (seine). The larger pools also provide refuge from flooding effects and serve as reservoirs for recolonization and recruitment. Another factor may be the lack of a more powerful electrofishing apparatus efficient enough to sample the high conductivity waters of the river.

The most numerous species collected in order of decreasing relative abundance were the red shiner, bullhead minnow, western mosquitofish, ghost shiner, gizzard shad, and inland silverside. These six species comprised slightly over 98% of the total catch. The red shiner comprised slightly over 79% of the total catch with 41,752 individuals. This species was taken in large numbers from shallow pool and gravelly run habitat areas found at each of the five stations. Its extremely high tolerance to a wide range and sometimes harsh ecological conditions allows them to be highly competitive with other fishes. The bullhead minnow is another highly tolerant species that was prevalent in terms of numbers caught. This species was largely found in the slower water of the perennial pool habitat at each station, with Stations 2 and 5 producing almost 78% of the total study catch. The infrequent shallow backwater habitats mostly contained western mosquitofish, which were also abundant in the shallow water along the limited sandier portions of the river margins. Ghost shiners were collected almost exclusively in the shallower

pools of little to no velocity over coarse sand and small gravel near cutbank habitat areas at all five stations. The majority of inland silversides (93%) were found over hard substrates in open low to moderate velocity waters at Stations 1 and 2. Small numbers of eight sunfish species were mostly collected from mostly backwater areas in generally low velocity habitats having large woody debris, a critical element that is not abundant for the river fishery. Longnose gar observed in large numbers feeding amid the dense algal mats in the swift current of the riffle habitats were collected primarily in shallow pool habitats. Two common ictalurid species, the channel catfish and the flathead catfish, were collected in low numbers in the deeper pooled river sections of flowing water habitats over gravel and bedrock bottoms near structural features such as cutbanks and small debris piles.

The aquatic life use (ALU) scores calculated for the fish communities based on seine data only reflect the characteristics typical of an Intermediate to High Intermediate quality stream habitat based on the modified index of biotic integrity for Ecoregions 27, 29, and 32.[35] These scores generally were 2 to 4 points lower than the lower end of the designated High aquatic life use subcategory (41–48) assigned to Segment 1232. With the exception of the August collection at Station 2, all stations exhibited a qualitative biological score of either a 37 or 39 as species composition and feeding guilds among the five sites were quite similar. When figuring the species richness and composition, trophic composition, and fish abundance and condition, the stream reach at Station 1 exhibited a total identical IBI score of 37 for all three surveys. The overall aquatic life use scoring was the highest (41) at Station 2 in August while the cumulative point score for May was 37 and 39 in July. An identical value of 37 was calculated for the August, May, and July collections at Station 3 after an initial score of 39 was determined for the May collection. The IBI scoring for the fish community at Station 4 was similar with a 37 given to the June, May, and July sample events and a 39 for the August effort. Analysis of the fish assemblage data collected at Station 5 resulted in consistent metric values of 39 in June, May, and July and 37 in August.

Examination of individual metrics using the 5-3-1 scoring criteria suggests that a large number of the collections taken at the five sites had low species richness and composition (i.e., number of sunfish species and percentage of tolerant species) and trophic composition (i.e.,

[35] Linam, G.W., L.J. Kleinsasser, and K.B. Mayes. 2002. *Regionalization of the index of biotic integrity for Texas streams (River Studies Report No. 17)*. Texas Parks and Wildlife Department. Austin, Texas.

percentage of individuals as omnivores, invertivores, and piscivores). The generally low values (or high) for these parameter metrics for most site collections tended to result in consistent intermediate IBI values that only once scored in the range characterized as High (≥41). The combination of the watershed flow characteristics at the time of sampling and the ability of fish species to move throughout the river with relative ease in higher than normal flow regimes may be a contributing factor in the Intermediate IBI scores. Fourteen (14) tolerant species represented 96.5% of all fish captured in the river. Of the 37 documented species listed in Table H-25, only two species, the mimic shiner (*Notropis volucellus*) and the bigscale logperch (*Percina macrolepida*) are categorized as intolerant. Neither was present in the sample collections.

Normally the fish populations are also sampled by the electroshocking technique to accurately reflect the existing fish community, but the high water conductivities dictated the increased number of seine hauls to compensate for this geartype deficiency since the backpack electroshock unit was deemed unfeasible for sampling consistency, and a tow barge system was not readily available. A potential source of bias identified and observed in the river channel at every sample location limited the effectiveness of the seine. Physical obstructions such as the large particle substrates and rough, irregular channel bottoms interfered with seine maneuverability and prevented it from passing through the entire water column. The process of snagging and unsnagging the net from submergent and emergent stony obstructions provided a potential escape route for captured fish by rolling the lead line. Benthic fish species are more likely to evade capture than littoral fish occupying the water column near the surface. It should be noted that extra care was applied when working in these difficult conditions.

As described in Sections H.2.6.2 and H.2.6.3, the evaluation of biological criteria for the Clean Water Act (CWA) requirements in Texas uses two multi-metric indices of biological integrity (IBI), one based on fish communities and the other on benthic (bottom) communities of macroinvertebrates. The fish indices were developed from reference sites that consider regional differences in biological communities.[36] Reference sites are located in watersheds that are not likely to experience a change in anthropogenic disturbances over time.

[36] Linam, G.W., L.J. Kleinsasser, and K.B. Mayes. 2002. *Regionalization of the index of biotic integrity for Texas streams (River Studies Report No. 17)*. Texas Parks and Wildlife Department. Austin, Texas.

As previously mentioned, the seine-only data produced consistent individual Intermediate to High Intermediate IBI scores of 37 and 39 with one station exhibiting a High IBI score of 41 during August 2009 (Table H-24). Since the results of the fish assemblages suggest non-support of the designated condition category (High) for Segment 1232, State biologists from TCEQ and TPWD were contacted for guidance in assessment of the ALU category by establishing an interval around the unadjusted IBI scores with the coefficient of variation (CV=standard deviation/mean) developed by TPWD for Ecoregions 27, 29, and 32. Ecoregion specific CV values have been calculated for each condition category (i.e., Exceptional, High, Intermediate, Limited) from multiple data sets taken over many years for the different regions of the state, and a multiplier has been assigned to each.[37]

The variability of the five biomonitoring sites was examined by comparing the index and critical period IBI values for each individual site over a two-year monitoring period. The CV multiplier determined for the Ecoregions 27, 29, and 32 Intermediate ALU category (6.40%)[38] was used to compare the multiple fish IBI results since this normalizes the site variability to the mean site score. There were a total of three sites that had four events of IBI scores and two sites with three events of IBI scores or a total of 18 samples. Table H-27 presents the unadjusted and adjusted IBI results for all 18 fish collections taken in Segment 1232 during 2009 and 2010. The adjusted scoring was considerable, resulting in elevated individual station IBI scores to the high Intermediate and High subcategory. The overall mean of 37.88 for all sampling events increased to 40.3, or 0.7 from the High subcategory. The average coefficient of variation for 18 events represented by seine-only was slightly over 3% for the regionalized IBI. This value is less than the 6.4% ecoregion CV, thus indicating field collections were consistently conducted and the fish assemblage was very stable over this collection period. A CV greater than the ecoregion CV could have indicated inconsistent sampling or some factor (such as changes in water quality) that resulted in the larger than expected variation which would have likely led to the necessity of additional field collections to determine the reason for the large variability in results.

[37] TCEQ. DRAFT 2010 guidance for assessing and reporting surface water quality in Texas (June 6, 2009). In compliance with Section 305(b) and 303(d) of the Federal Clean Water Act. Texas Commission on Environmental Quality, Austin.
[38] Ibid

Table H-27
Application of Coefficient of Variation for Interpreting Multiple Fish Samples
Clear Fork Brazos River—Central Great Plains Ecoregion ((ER 27)
Segment 1232—Designated High Aquatic Life Use

Station	Sample Date	Regional Fish IBI Score
1	6/15/2009	37
1	8/10/2009	37
1	5/6/2010	37
Mean		37
Std. Deviation		0.0
Sample Coefficient of Variation		0.0
Intermediate Category Specific CV		0.064
CV Adjustment		2.368
CV Adjusted Mean		39.368
2	6/16/2009	37
2	8/10/2009	41
2	5/6/2010	39
Mean		39
Std. Deviation		2.0
Sample Coefficient of Variation		0.0513
Intermediate Category Specific CV		0.064
CV Adjustment		2.496
CV Adjusted Mean		41.496
3	6/16/2009	39
3	8/11/2009	37
3	5/7/2010	37
3	7/20/2010	37
Mean		37.5
Std. Deviation		1.0
Sample Coefficient of Variation		0.0266
Intermediate Category Specific CV		0.064
CV Adjustment		2.40
CV Adjusted Mean		39.9
4	6/16/2009	37
4	8/12/2009	39
4	5/7/2010	37
4	7/21/2010	37
Mean		37.5
Std. Deviation		1.0
Sample Coefficient of Variation		0.0266
Intermediate Category Specific CV		0.064
CV Adjustment		2.40
CV Adjusted Mean		39.9
5	6/17/2009	39
5	8/11/2009	37
5	5/7/2010	39
5	7/21/2010	39
Mean		38.5
Std. Deviation		1.0
Sample Coefficient of Variation		0.0259
Intermediate Category Specific CV		0.064
CV Adjustment		2.464
CV Adjusted Mean		40.964
Overall Mean		37.888
Std. Deviation		1.231
Sample Coefficient of Variation		0.0325
Intermediate Category Specific CV		0.064
CV Adjustment		2.425
CV Adjusted Mean		40.313

As part of the U.S. Environmental Protection Agency's (EPA's) National Rivers and Streams Assessment (NRSA), the TCEQ SWQM Team and the TPWD Stream Assessment Team collected chemical, physical, and biological information on 15 October 2009 to characterize and assess a section of the Clear Fork downstream of the Boys Camp Crossing (Station 3). This river site was randomly selected as part of a collaborative survey of the Nation's streams which, using a nationally consistent statistical survey approach, establishes a national baseline for ecological and water quality with the intent to use for comparison of results with future studies. All sampling data has been submitted to the EPA for analysis, and a report on the findings will be issued in 2011. Since assessment requires an accurate estimate of observed and expected ecological conditions, it is generally assumed that the expected regional conditions for this river segment will be formulated from the EPA results and referred to as the "reference stream". The identification of reference or baseline conditions (i.e., those expected to occur under the least impacted condition) will then serve as benchmarks for future evaluation against which sites of unknown status are compared.[39]

Rarely are there appropriate historical data to provide actual reference conditions for a specific site. A written request to the TCEQ was made to obtain the recent raw habitat and biological data, specifically the fisheries data collected by a tow-barge electroshock unit. Since the project's fish ALU assessment was based only from seine data, this recently collected electroshock information will be helpful in calculating the fish ALU rating for the "reference stream" using both collection methods. This will allow a direct determination of the degree of biological use support for the existing fish community supplied by the Clear Fork and serve as a guideline for future sampling activities.

The raw fisheries data has been received from the TCEQ after TPWD quality review. This unpublished information[40] was inserted into the regionalized IBI[41] and computed for comparison with the seine-only calculations derived from the Cedar Ridge Reservoir project's 2009 and 2010 data. An unofficial account of the fish community calculated by HDR from the

[39] Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R.Yant, and I.J. Schlosser. 1986. *Assessing biological integrity in running waters, a method and its rationale.* Special Publication 5. Illinois Natural History Survey, Champaign, Illinois. 28 pp.

[40] TCEQ, 2010. Seine and Electrofishing Data Collected on the Clear Fork Brazos River on October 15, 2009. Unpublished data not available to the public.

[41] Linam, G.W., L.J. Kleinsasser, and K.B. Mayes. 2002. *Regionalization of the Index of Biotic Integrity for Texas Streams (River Studies Report No. 17).* Texas Parks and Wildlife Department. Austin, Texas.

NRSA collection resulted in an unadjusted ALU score of 39 or High Intermediate. Only one additional species, the smallmouth buffalo (*Ictiobus bubalus*) was collected by electroshocking that was not represented in the HDR collections. Scoring agreement with the present study data does not necessarily mean the Clear Fork supports an Intermediate fish population but reinforces the fact that seine-only data, using twice the number of seine drags, can be considered for determination of fish population integrity as a valid starting point until more information is collected. It should also be noted that the NRSA data collection represents only one data point and reinforces the need for more sampling using both collection techniques to provide a more accurate assessment of the fish community.

Varying amounts of debris from terrestrial vegetation were present during each sampling event in 2009 and 2010. This debris not only constitutes the major base of the resident aquatic food chains, but also provides much of the habitat diversity. The absence of substantial amounts of aquatic vegetation observed at each sampling location resulted in a paucity of sheltered habitat (cover) and a small detrital food base entering the river channel contributed by the small amounts of submerged and floating rafts of leaf litter, twigs, branches, and logs that are usually present. River bank erosion undercuts many large trees along certain sections of the channel, causing them to fall and subsequently creating some additional habitat. However, standing timber was not very abundant throughout the entire length of the five selected ALM sample zones.

Habitat utilization by fish species varies seasonally with life stage and in response to local conditions. They can inhabit fast moving water or isolated pools. Their capture is dependant on the local conditions at the time of sampling. Few species collected were indicators of a particular mesohabitat type, as the study length of Clear Fork contains mostly generalist forage species that use a variety of habitats. Fluctuations of water level and abrupt changes in temperatures and dissolved oxygen concentrations due to the flashiness of the river may contribute to the dispersal of many individuals of fish, and it is apparent that the fish population in this section of the river has adjusted to these harsh conditions. Many of the species present are among the more common species for the state and are typical of perennial stream habitats and tolerant of impoundment. Nothing unusual was noted concerning condition of collected fish; no recognizable hybrid was captured. No alarming parasite or disease incidence was detected.

H.4 Aquatic Life Use Summary

The following summarizes the four ALM surveys conducted during 2009 and 2010:

- To clarify the stream nature to be inundated, site–specific baseline information on water quality, habitat quality, and biological integrity was collected to determine existing aquatic conditions at five locations along Segment 1232 of the Brazos River between SH 6 to a point approximately 5.0 miles downstream of the proposed dam location as a prerequisite for the construction of the proposed Cedar Ridge Reservoir.
- Land-use in the subwatershed is predominantly agricultural and rangeland with only one major urban area (Abilene). Nutrient enrichment is a concern in the Clear Fork Brazos River watershed due to runoff from agricultural and livestock areas.
- Field observations, habitat evaluations, and biological sampling efforts occurred during the index period (15-17 June 2009 and 5-7 May 2010) and the critical period (10-12 August 2009 and 19-21 July 2010). The study was undertaken through the guidelines of the TCEQ SWQM monitoring procedures. During each survey, water was continuous throughout the study reach, and swift flow conditions were experienced during 3 of the 4 survey periods when river streamflow was measured in excess of 25.0 cfs.
- The standard field parameters measured at the five monitoring locations showed water quality in this section of the Clear Fork Brazos River is suitable to sustain aquatic life: however, algal blooms may be particularly problematic to aquatic organisms (i.e., fluctuating D.O. and pH levels over a 24-hr period) during warm and hot months when the oxygen carrying capacity of the water is reduced, low stream flow conditions occur, and the lack of oxygen diffusion into the water from the atmosphere. Water quality of the Clear Fork of the Brazos River is represented by high conductivity levels. The results of the limited 24-hour monitoring suggest high pH values and low levels of DO during the 2010 sampling events. The elevated pH and periods of depressed DO concentrations are likely the result of high levels of photosynthetic activity occurring during weather conditions favorable for algal growth. Photosynthesis can cause a depletion of DO during the night and a rise of pH during the daylight hours by removing carbon dioxide from the water.
- Comparison of the HQI and macroinvertebrate scoring criteria showed that all statistical indices produced similar results and are in agreement with TCEQ's current assessment that Segment 1232 of the Brazos River (Clear Fork Brazos River) supports a High ALU.
- Transect data collected from five locations along the main channel was deemed adequate for habitat assessment. The river habitat quality observed at every location was very similar and can generally be characterized as shallow, fast flowing areas and slower, deeper pool areas. The resulting habitat quality metric score after summation of the habitat data taken for each site investigated indicated a predominately High aquatic habitat rating. No significant habitat changes were noted between each location other than slight differences in stream width and depth measurements. High water marks, sediment-stained vegetation on the banks and the lack of instream

woody debris accumulation indicate that the river carries a high volume of runoff during storm events.

- Macroinvertebrate collections were taken at all available microhabitats offered at each location. A total of 4,188 benthic invertebrates representing 64 taxa were collected during 2009-2010. Based on the 12 parameter evaluation developed by TCEQ, sixteen of the eighteen samples collected reflected a predominately High overall aquatic life use rating (Station 4 rated Exceptional in August and Station 3 rated Intermediate in June). Typical samples had high diversity, a balanced trophic structure and a community indicative of a complex and healthy ecosystem.
- Historical information on the stream fishes of this region is generally scarce. Considerably less effort sampling the fish community in the Clear Fork has been expended than in sampling fish in the various reservoirs within the watershed boundary. The intent of this study was to determine the current species composition of the fish community in this section of the Clear Fork Brazos River.
- Substrate size, depth, and reduced visibility of the aquatic habitats at the five sites limited the utility of seining as an effective fish abundance monitoring tool. Areas within the designated sample zone (usually 500 m in length) that could be effectively and safely sampled by seining were difficult to locate due to physical constraints. However, the sampling effort did result in the capture of a large number of a relatively low number of fish species at accessible locations.
- The varying water conductivities measured during the ALM surveys suggested influence from rainfall events; however, the potential for maintaining consistent use of electroshocking between events based on conductivity levels was questionable and was not utilized for fish sampling.
- A total of 52,499 individuals of fish represented by 9 families and 21 species were collected during the four sampling events. Approximately 57% of the 37 documented species were captured. The Family Cyprinidae was represented by four species numbering 92% of all fishes collected. Three native minnow species (red shiner, ghost shiner, and bullhead minnow) were the most numerous cyprinids and constituted slightly over 91% of the total catch. The red shiner, ubiquitous in all habitats at every sampling location, comprised more than 79% of the fish taken. The sample results show the river supports 8 species of centrachids. Although this family comprised a small percentage of the fish collections, the bluegill, longear sunfish and the orangespotted sunfish were the three most common species. The Clear Fork Brazos River exhibits an overall Intermediate fish aquatic life use based on the IBI criterion. Fish habitat in the study area includes a streambed of clay, silt, sand, gravel, cobbles, large rocks, and bedrock. Passage for mobile aquatic organisms was generally accessible during the survey, mostly reflecting the wet conditions which prevail on a daily basis. The two notable exceptions would be the section of river at Lueders Dam and a small low-head dam on private property near River Mile 148; these structures form a permanent barrier to upstream passage under most circumstances.
- The biological quality of the Clear Fork Brazos River as measured by a regionalized fish based IBI at five locations exhibits an Intermediate fish aquatic life use. Fish

occurrence (i.e., taxa richness), assemblage structure (i.e., relative proportions by families) and function (i.e., measured here as trophic structure) remained fairly intact within the drainage, despite a few changes in some populations through time. The lower than expected aquatic life use scores could be largely a consequence of sampling constraints (i.e., seine only). Large mobile species and benthic species are difficult to seine and can avoid seine hauls especially in less than suitable conditions. Since electrofishing was not used as part of the sample protocol in the 2009-2010 collections, this could be an explanation for lower species richness due to the absence of larger and more elusive fish species. However, it is worth noting that the results of the 15 seine hauls taken in all accessible habitats offered at each station for the present study included all but one fish species taken by electroshocking efforts as part of the NRSA sampling conducted by TCEQ and TPWD staff near Station 3. While not conclusive, the agreement in the studies using both techniques indicates the seining efforts employed in this study were effective.

- No federal or state protected species were found at the five locations. Neither the smalleye shiner nor the sharpnose shiner, both candidates for federal listing, was collected. The likelihood of these species inhabiting Clear Fork Brazos River is quite low due to the rocky nature of the riverine habitat that act as natural barriers prohibiting major migration runs. Additionally, no live or recently dead smooth pimpleback or Texas fawnsfoot were found in the project vicinity.
- Seasonal changes in stream flow, water temperature and biological activity are ordinarily reflected in cyclical changes in population sizes and relative abundance of fish and benthic macroinvertebrate species. Therefore, temporal and spatial variation in macroinvertebrate and fish communities suggest differences in seasonality, individual collection performance and chance rather than changes in species occurrence.

This page is intentionally left blank.

Appendix H
Attachment H-1
Stream Physical Characteristics Worksheets,
Physical Characteristics of Water Body Worksheets,
and Habitat Quality Index (HQI) Worksheets
2009 and 2010
(Provided on Compact Disc)

City of Abilene

Appendix H

Attachment H-1

Stream Physical Characteristics Worksheets, Physical Characteristics of Water Body Worksheets, and Habitat Quality Index (HQI) Worksheets

2009 and 2010

Available Upon Request

Contact

Mr. Chris Kozlowski

(512) 239-1801

Appendix H
Attachment H-2
Photographs
Aquatic Life Monitoring Locations
2009 and 2010
(Provided on Compact Disc)

City of Abilene

Appendix H

Attachment H-2

Photographs

Aquatic Life Monitoring Locations

2009 and 2010

Available Upon Request

Contact

Mr. Chris Kozlowski

(512) 239-1801

Appendix H
Attachment H-3
24-Hour Monitoring at Three Locations
May and July 2010

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Lueders City Park Downstream of S.H. 6
24-hour Field Data, 5-6 May 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
5/5/2010	15:45:40	24.15	2.408	12.16	8.74
5/5/2010	16:00:40	24.28	2.405	12.1	8.78
5/5/2010	16:15:40	24.43	2.402	11.92	8.83
5/5/2010	16:30:40	24.6	2.402	11.82	8.89
5/5/2010	16:45:40	24.76	2.401	11.65	8.92
5/5/2010	17:00:40	24.89	2.4	11.54	8.95
5/5/2010	17:15:40	24.97	2.405	11.42	8.98
5/5/2010	17:30:40	24.99	2.407	11.22	9
5/5/2010	17:45:40	25.01	2.408	11.03	9.02
5/5/2010	18:00:40	24.97	2.41	10.68	9.03
5/5/2010	18:15:40	24.97	2.411	10.55	9.05
5/5/2010	18:30:40	24.92	2.416	10.23	9.06
5/5/2010	18:45:40	24.9	2.416	10.01	9.07
5/5/2010	19:00:40	24.84	2.415	9.81	9.08
5/5/2010	19:15:40	24.75	2.415	9.7	9.09
5/5/2010	19:30:40	24.64	2.414	9.55	9.09
5/5/2010	19:45:40	24.5	2.414	9.41	9.09
5/5/2010	20:00:40	24.34	2.413	9.21	9.08
5/5/2010	20:15:40	24.15	2.413	8.91	9.08
5/5/2010	20:30:40	23.94	2.413	8.65	9.07
5/5/2010	20:45:40	23.72	2.413	8.38	9.05
5/5/2010	21:00:40	23.47	2.414	8.28	9.04
5/5/2010	21:15:40	23.24	2.415	8.04	9.03
5/5/2010	21:30:40	23.01	2.416	7.94	9.01
5/5/2010	21:45:40	22.8	2.417	7.82	8.99
5/5/2010	22:00:40	22.57	2.419	7.62	8.97
5/5/2010	22:15:40	22.37	2.42	7.5	8.95
5/5/2010	22:30:40	22.22	2.421	7.38	8.94
5/5/2010	22:45:40	22.07	2.422	7.29	8.93
5/5/2010	23:00:40	21.94	2.423	7.24	8.92
5/5/2010	23:15:40	21.85	2.423	7.16	8.91
5/5/2010	23:30:40	21.77	2.424	7.1	8.91
5/5/2010	23:45:40	21.7	2.424	7.1	8.89
5/6/2010	0:00:40	21.61	2.424	6.97	8.89
5/6/2010	0:15:40	21.54	2.425	6.97	8.89
5/6/2010	0:30:40	21.5	2.426	6.9	8.89
5/6/2010	0:45:40	21.46	2.426	6.82	8.89
5/6/2010	1:00:40	21.45	2.426	6.89	8.89
5/6/2010	1:15:40	21.43	2.427	6.9	8.9
5/6/2010	1:30:40	21.42	2.429	6.8	8.91
5/6/2010	1:45:40	21.42	2.429	6.8	8.92
5/6/2010	2:00:40	21.42	2.429	6.78	8.93
5/6/2010	2:15:40	21.4	2.43	6.77	8.93
5/6/2010	2:30:40	21.38	2.431	6.82	8.92
5/6/2010	2:45:40	21.36	2.432	6.77	8.93
5/6/2010	3:00:40	21.34	2.432	6.83	8.93
5/6/2010	3:15:40	21.31	2.433	6.84	8.93
5/6/2010	3:30:40	21.28	2.424	6.75	8.93
5/6/2010	3:45:40	21.26	2.434	6.8	8.93
5/6/2010	4:00:40	21.23	2.434	6.73	8.93
5/6/2010	4:15:40	21.2	2.434	6.78	8.93

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Lueders City Park Downstream of S.H. 6
24-hour Field Data, 5-6 May 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
5/6/2010	4:30:40	21.17	2.434	6.69	8.93
5/6/2010	4:45:40	21.15	2.435	6.78	8.94
5/6/2010	5:00:40	21.11	2.435	6.67	8.94
5/6/2010	5:15:40	21.08	2.435	6.71	8.95
5/6/2010	5:30:40	21.05	2.435	6.72	8.95
5/6/2010	5:45:40	21.03	2.435	6.63	8.95
5/6/2010	6:00:40	20.99	2.436	6.62	8.96
5/6/2010	6:15:40	20.96	2.436	6.59	8.96
5/6/2010	6:30:40	20.94	2.436	6.67	8.96
5/6/2010	6:45:40	20.91	2.436	6.67	8.97
5/6/2010	7:00:40	20.89	2.436	6.59	8.97
5/6/2010	7:15:40	20.88	2.436	6.57	8.98
5/6/2010	7:30:40	20.86	2.436	6.56	8.98
5/6/2010	7:45:40	20.84	2.436	6.54	8.99
5/6/2010	8:00:40	20.85	2.436	6.65	8.99
5/6/2010	8:15:40	20.87	2.437	6.59	8.99
5/6/2010	8:30:40	20.93	2.437	6.64	9
5/6/2010	8:45:40	21	2.437	6.7	9.01
5/6/2010	9:00:40	21.08	2.437	6.86	9.01
5/6/2010	9:15:40	21.2	2.438	6.99	9.02
5/6/2010	9:30:40	21.29	2.439	7	9.03
5/6/2010	9:45:40	21.38	2.439	7.16	9.03
5/6/2010	10:00:40	21.41	2.439	7.13	9.03
5/6/2010	10:15:40	21.52	2.439	7.23	9.04
5/6/2010	10:30:40	21.69	2.44	7.39	9.05
5/6/2010	10:45:40	21.8	2.44	7.58	9.06
5/6/2010	11:00:40	21.98	2.44	7.75	9.08
5/6/2010	11:15:40	22.15	2.441	7.94	9.09
5/6/2010	11:30:40	22.3	2.441	8.07	9.11
5/6/2010	11:45:40	22.36	2.44	8.27	9.12
5/6/2010	12:00:40	22.53	2.441	8.37	9.13
5/6/2010	12:15:40	22.66	2.441	8.56	9.15
5/6/2010	12:30:40	22.84	2.441	8.61	9.17
5/6/2010	12:45:40	23.04	2.442	8.84	9.18
5/6/2010	13:00:40	23.14	2.442	8.82	9.19
5/6/2010	13:15:40	23.34	2.442	8.95	9.22
5/6/2010	13:30:40	23.48	2.442	9.06	9.23
5/6/2010	13:45:40	23.7	2.442	9.27	9.25
5/6/2010	14:00:40	23.82	2.443	9.3	9.27
5/6/2010	14:15:40	23.97	2.443	9.37	9.29
5/6/2010	14:30:40	24.14	2.443	9.5	9.31
5/6/2010	14:45:40	24.28	2.443	9.58	9.33
5/6/2010	15:00:40	24.44	2.443	9.67	9.35
5/6/2010	15:15:40	24.53	2.443	9.75	9.37
5/6/2010	15:30:40	24.69	2.443	9.85	9.39
Start Date/Time	5/5/2010 15:45				
End Date/Time	5/6/2010 15:30				
Mean		22.53	2.428	9.85	9.02
Minimum		20.84	2.400	6.54	8.74
Maximum		25.01	2.443	12.16	9.39
# Samples Taken	96				

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Boys Camp Crossing (Station 5)
24-hour Field Data, 5-6 May 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
5/5/2010	19:01:28	22.34	1.929	12.74	9
5/5/2010	19:16:28	22.32	1.931	12.38	8.98
5/5/2010	19:31:28	22.39	1.919	12.51	9
5/5/2010	19:46:28	22.46	1.925	12.33	9
5/5/2010	20:01:28	22.47	1.913	12.42	9.01
5/5/2010	20:16:28	22.46	1.918	12.63	9.01
5/5/2010	20:31:28	22.53	1.927	13.14	9.02
5/5/2010	20:46:28	22.56	1.943	13.27	9.03
5/5/2010	21:01:28	22.59	1.937	13.52	9.05
5/5/2010	21:16:28	22.6	1.96	13.52	9.05
5/5/2010	21:31:28	22.65	1.954	13.72	9.07
5/5/2010	21:46:28	22.64	1.97	13.59	9.08
5/5/2010	22:01:28	22.62	1.963	13.44	9.08
5/5/2010	22:16:28	22.63	1.973	13.43	9.07
5/5/2010	22:31:28	22.59	1.973	13.24	9.06
5/5/2010	22:46:28	22.54	1.975	13.02	9.05
5/5/2010	23:01:28	22.51	1.975	12.72	9.03
5/5/2010	23:16:28	22.5	1.982	12.48	9.01
5/5/2010	23:31:28	22.51	1.984	12.39	9.01
5/5/2010	23:46:28	22.58	1.985	12.24	9
5/6/2010	0:01:28	22.64	1.984	12.37	9
5/6/2010	0:16:28	22.68	1.985	12.18	8.99
5/6/2010	0:31:28	22.73	1.984	12.09	8.99
5/6/2010	0:46:28	22.74	1.984	11.91	8.98
5/6/2010	1:01:28	22.74	1.983	12.14	8.98
5/6/2010	1:16:28	22.72	1.983	12.04	8.98
5/6/2010	1:31:28	22.7	1.982	11.77	8.97
5/6/2010	1:46:28	22.7	1.983	11.63	8.97
5/6/2010	2:01:28	22.65	1.981	11.56	8.96
5/6/2010	2:16:28	22.6	1.982	11.51	8.96
5/6/2010	2:31:28	22.54	1.981	11.46	8.95
5/6/2010	2:46:28	22.52	1.979	11.26	8.94
5/6/2010	3:01:28	22.44	1.997	11.12	8.93
5/6/2010	3:16:28	22.42	1.996	10.97	8.92
5/6/2010	3:31:28	22.37	1.996	10.92	8.92
5/6/2010	3:46:28	22.29	1.996	10.72	8.91
5/6/2010	4:01:28	22.26	1.998	10.59	8.9
5/6/2010	4:16:28	22.19	2	10.4	8.89
5/6/2010	4:31:28	22.14	1.999	10.28	8.88
5/6/2010	4:46:28	22.09	2	10.15	8.87
5/6/2010	5:01:28	22.07	2.001	10.02	8.86
5/6/2010	5:16:28	22.02	2.003	9.92	8.85
5/6/2010	5:31:28	21.96	2.004	9.73	8.85
5/6/2010	5:46:28	21.91	2.005	9.59	8.84
5/6/2010	6:01:28	21.85	2.005	9.44	8.83
5/6/2010	6:16:28	21.81	2.006	9.32	8.82
5/6/2010	6:31:28	21.76	2.005	9.16	8.81
5/6/2010	6:46:28	21.71	2.007	9.1	8.8
5/6/2010	7:01:28	21.68	2.007	8.92	8.79
5/6/2010	7:16:28	21.63	2.007	8.86	8.79
5/6/2010	7:31:28	21.59	2.008	8.81	8.79

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Boys Camp Crossing (Station 5)
24-hour Field Data, 5-6 May 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
5/6/2010	7:46:28	21.59	2.008	8.73	8.78
5/6/2010	8:01:28	21.58	2.009	8.76	8.78
5/6/2010	8:16:28	21.61	2.009	8.78	8.78
5/6/2010	8:31:28	21.72	2.01	9.01	8.79
5/6/2010	8:46:28	21.78	2.01	9.16	8.8
5/6/2010	9:01:28	21.82	2.01	9.22	8.8
5/6/2010	9:16:28	21.87	2.011	9.15	8.79
5/6/2010	9:31:28	21.93	2.011	9.19	8.79
5/6/2010	9:46:28	22.06	2.012	9.31	8.8
5/6/2010	10:01:28	22.06	2.014	9.49	8.8
5/6/2010	10:16:28	22.06	2.014	9.37	8.8
5/6/2010	10:31:28	22.15	2.014	9.52	8.81
5/6/2010	10:46:28	22.06	2.014	9.56	8.81
5/6/2010	11:01:28	22.33	2.014	9.91	8.83
5/6/2010	11:16:28	22.44	2.014	10.18	8.84
5/6/2010	11:31:28	22.53	2.013	10.47	8.85
5/6/2010	11:46:28	22.69	2.013	10.85	8.87
5/6/2010	12:01:28	22.81	2.013	11.43	8.89
5/6/2010	12:16:28	22.93	2.012	11.7	8.91
5/6/2010	12:31:28	22.87	2.015	11.22	8.87
5/6/2010	12:46:28	23.15	2.029	11.19	8.88
5/6/2010	13:01:28	23.15	2.029	11.05	8.86
5/6/2010	13:16:28	23.23	2.03	11.06	8.86
5/6/2010	13:31:28	23.44	2.032	10.97	8.86
5/6/2010	13:46:28	23.53	2.033	10.98	8.86
5/6/2010	14:01:28	23.62	2.034	11.07	8.86
5/6/2010	14:16:28	23.87	2.034	11.01	8.87
5/6/2010	14:31:28	24.01	2.035	11.02	8.87
5/6/2010	14:46:28	24.11	2.036	11.04	8.87
5/6/2010	15:01:28	24.21	2.035	11.09	8.87
5/6/2010	15:16:28	24.26	2.035	11.32	8.89
5/6/2010	15:31:28	24.31	2.035	12.06	8.89
5/6/2010	15:46:28	24.31	2.034	12.02	8.89
5/6/2010	16:01:28	24.41	2.034	12.03	8.9
5/6/2010	16:16:28	24.51	2.034	11.72	8.88
5/6/2010	16:31:28	24.48	2.035	11.53	8.88
5/6/2010	16:46:28	24.61	2.04	11.44	8.86
5/6/2010	17:01:28	24.68	2.041	11.21	8.84
5/6/2010	17:16:28	24.65	2.04	11.07	8.84
5/6/2010	17:31:28	24.44	2.034	11.16	8.86
5/6/2010	17:46:28	24.45	2.042	11.19	8.86
5/6/2010	18:01:28	24.39	2.043	11.13	8.85
5/6/2010	18:16:28	24.4	2.049	10.97	8.84
5/6/2010	18:31:28	24.19	2.043	10.96	8.83
5/6/2010	18:46:28	24.09	2.042	10.87	8.84
Start Date/Time	5/5/2010 19:01				
End Date/Time	5/6/2010 18:46				
Mean		22.77	2000	11.09	8.90
Minimum		21.58	1913	8.73	8.78
Maximum		24.68	2049	13.72	9.08
# Samples Taken	96				

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Krooked River Ranch Crossing (Station 5)
24-hour Field Data, 5-6 May 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
5/5/2010	17:31:28	23.39	1.739	*	9.39
5/5/2010	17:46:28	23.45	1.735	*	9.39
5/5/2010	18:01:28	23.52	1.73	*	9.39
5/5/2010	18:16:28	23.52	1.717	*	9.39
5/5/2010	18:31:28	23.59	1.71	*	9.39
5/5/2010	18:46:28	23.64	1.699	*	9.39
5/5/2010	19:01:28	23.73	1.723	*	9.4
5/5/2010	19:16:28	23.8	1.713	*	9.39
5/5/2010	19:31:28	23.82	1.708	*	9.4
5/5/2010	19:46:28	23.84	1.717	*	9.4
5/5/2010	20:01:28	23.92	1.709	*	9.39
5/5/2010	20:16:28	23.96	1.712	*	9.39
5/5/2010	20:31:28	24.03	1.726	*	9.4
5/5/2010	20:46:28	24.04	1.722	*	9.39
5/5/2010	21:01:28	24.03	1.73	*	9.39
5/5/2010	21:16:28	24.01	1.725	*	9.39
5/5/2010	21:31:28	24.01	1.721	*	9.38
5/5/2010	21:46:28	23.99	1.721	*	9.37
5/5/2010	22:01:28	23.96	1.723	*	9.36
5/5/2010	22:16:28	23.92	1.719	*	9.36
5/5/2010	22:31:28	23.87	1.716	*	9.35
5/5/2010	22:46:28	23.81	1.734	*	9.35
5/5/2010	23:01:28	23.73	1.752	*	9.34
5/5/2010	23:16:28	23.67	1.75	*	9.34
5/5/2010	23:31:28	23.61	1.748	*	9.34
5/5/2010	23:46:28	23.56	1.745	*	9.33
5/5/2010	0:01:28	23.49	1.745	*	9.33
5/5/2010	0:16:28	23.42	1.746	*	9.32
5/5/2010	0:31:28	23.35	1.743	*	9.32
5/5/2010	0:46:28	23.29	1.745	*	9.31
5/5/2010	1:01:28	23.22	1.743	*	9.31
5/5/2010	1:16:28	23.16	1.741	*	9.31
5/5/2010	1:31:28	23.1	1.739	*	9.3
5/6/2010	1:46:28	23.03	1.737	*	9.3
5/6/2010	2:01:28	22.96	1.737	*	9.29
5/6/2010	2:16:28	22.88	1.735	*	9.29
5/6/2010	2:31:28	22.83	1.734	*	9.28
5/6/2010	2:46:28	22.74	1.733	*	9.28
5/6/2010	3:01:28	22.67	1.736	*	9.27
5/6/2010	3:16:28	22.59	1.737	*	9.25
5/6/2010	3:31:28	22.52	1.737	*	9.23
5/6/2010	3:46:28	22.46	1.738	*	9.22
5/6/2010	4:01:28	22.39	1.739	*	9.2
5/6/2010	4:16:28	22.33	1.739	*	9.19
5/6/2010	4:31:28	22.27	1.741	*	9.18
5/6/2010	4:46:28	22.21	1.745	*	9.17
5/6/2010	5:01:28	22.17	1.746	*	9.17
5/6/2010	5:16:28	22.1	1.747	*	9.15
5/6/2010	5:31:28	22.06	1.749	*	9.15
5/6/2010	5:46:28	21.98	1.751	*	9.13
5/6/2010	6:01:28	21.92	1.753	*	9.12

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Krooked River Ranch Crossing (Station 5)
24-hour Field Data, 5-6 May 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
5/6/2010	6:16:28	21.86	1.754	*	9.12
5/6/2010	6:31:28	21.8	1.755	*	9.11
5/6/2010	6:46:28	21.74	1.756	*	9.1
5/6/2010	7:01:28	21.68	1.758	*	9.09
5/6/2010	7:16:28	21.63	1.745	*	9.08
5/6/2010	7:31:28	21.58	1.761	*	9.08
5/6/2010	7:46:28	21.57	1.744	*	9.08
5/6/2010	8:01:28	21.57	1.755	*	9.08
5/6/2010	8:16:28	21.61	1.76	*	9.09
5/6/2010	8:31:28	21.67	1.753	*	9.1
5/6/2010	8:46:28	21.75	1.769	*	9.1
5/6/2010	9:01:28	21.84	1.75	*	9.11
5/6/2010	9:16:28	21.91	1.77	*	9.12
5/6/2010	9:31:28	22	1.759	*	9.13
5/6/2010	9:46:28	22.12	1.775	*	9.14
5/6/2010	10:01:28	22.25	1.775	*	9.16
5/6/2010	10:16:28	22.43	1.775	*	9.18
5/6/2010	10:31:28	22.57	1.775	*	9.19
5/6/2010	10:46:28	22.6	1.775	*	9.19
5/6/2010	11:01:28	22.71	1.775	*	9.18
5/6/2010	11:16:28	22.94	1.775	*	9.2
5/6/2010	11:31:28	22.98	1.776	*	9.2
5/6/2010	11:46:28	23.25	1.776	*	9.2
5/6/2010	12:01:28	23.48	1.775	*	9.23
5/6/2010	12:16:28	23.52	1.774	*	9.23
5/6/2010	12:31:28	23.41	1.773	*	9.23
5/6/2010	12:46:28	23.54	1.769	*	9.24
5/6/2010	13:01:28	23.78	1.767	*	9.25
5/6/2010	13:16:28	23.91	1.765	*	9.26
5/6/2010	13:31:28	24.09	1.764	*	9.26
5/6/2010	13:46:28	24.31	1.761	*	9.27
5/6/2010	14:01:28	24.52	1.759	*	9.28
5/6/2010	14:16:28	24.72	1.767	*	9.29
5/6/2010	14:31:28	24.89	1.763	*	9.3
5/6/2010	14:46:28	25.05	1.77	*	9.31
5/6/2010	15:01:28	25.19	1.77	*	9.32
5/6/2010	15:16:28	25.27	1.767	*	9.33
5/6/2010	15:31:28	25.31	1.764	*	9.33
5/6/2010	15:46:28	25.43	1.758	*	9.35
5/6/2010	16:01:28	25.54	1.752	*	9.36
5/6/2010	16:16:28	25.6	1.748	*	9.36
5/6/2010	16:31:28	25.72	1.754	*	9.38
5/6/2010	16:46:28	25.78	1.747	*	9.4
5/6/2010	17:01:28	25.77	1.741	*	9.41
5/6/2010	17:16:28	25.83	1.749	*	9.41
Start Date/Time	5/5/2010 17:31				
End Date/Time	5/6/2010 17:16				
Mean		23.32	1747	--	9.27
Minimum		21.57	1699	--	9.08
Maximum		25.83	1776	--	9.41
# Samples Taken	96				

*Not reported; failed post-calibration requirements

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Lueders City Park Downstream of S.H. 6
24-hour Field Data, 19-20 July 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
7/19/2010	14:00:40	32.02	1.456	7.05	*
7/19/2010	14:15:40	32.16	1.457	7.3	*
7/19/2010	14:30:40	32.4	1.457	7.61	*
7/19/2010	15:00:40	32.51	1.459	7.59	*
7/19/2010	15:15:40	32.53	1.461	7.62	*
7/19/2010	15:30:40	32.69	1.462	7.42	*
7/19/2010	15:45:40	32.81	1.464	7.54	*
7/19/2010	16:00:40	32.84	1.466	7.55	*
7/19/2010	16:15:40	32.88	1.467	7.49	*
7/19/2010	16:30:40	32.88	1.469	7.13	*
7/19/2010	16:45:40	32.9	1.47	7.11	*
7/19/2010	17:00:40	32.92	1.471	6.98	*
7/19/2010	17:15:40	32.96	1.473	7.03	*
7/19/2010	17:30:40	32.95	1.474	6.63	*
7/19/2010	17:45:40	32.92	1.476	6.52	*
7/19/2010	18:00:40	32.89	1.477	6.42	*
7/19/2010	18:15:40	32.85	1.479	6.24	*
7/19/2010	18:30:40	32.78	1.48	6.19	*
7/19/2010	18:45:40	32.69	1.481	5.95	*
7/19/2010	19:00:40	32.61	1.482	5.81	*
7/19/2010	19:15:40	32.53	1.483	5.68	*
7/19/2010	19:30:40	32.45	1.485	5.75	*
7/19/2010	19:45:40	32.38	1.486	5.41	*
7/19/2010	20:00:40	32.31	1.487	5.25	*
7/19/2010	20:15:40	32.24	1.488	--	*
7/19/2010	20:30:40	32.17	1.489	4.86	*
7/19/2010	20:45:40	32.08	1.49	4.78	*
7/19/2010	21:00:40	31.99	1.491	4.69	*
7/19/2010	21:15:40	31.89	1.492	4.61	*
7/19/2010	21:30:40	31.79	1.493	4.56	*
7/19/2010	21:45:40	31.7	1.495	4.46	*
7/19/2010	22:00:40	31.61	1.496	4.4	*
7/19/2010	22:15:40	31.53	1.498	4.34	*
7/19/2010	22:30:40	31.46	1.5	4.3	*
7/19/2010	22:45:40	31.4	1.502	4.36	*
7/19/2010	23:00:40	31.34	1.505	4.36	*
7/19/2010	23:15:40	31.3	1.507	4.33	*
7/19/2010	23:30:40	31.26	1.509	4.34	*
7/19/2010	23:45:40	31.22	1.512	4.33	*
7/20/2010	0:00:40	31.18	1.514	4.34	*
7/20/2010	0:15:40	31.14	1.517	4.36	*
7/20/2010	0:30:40	31.1	1.519	4.36	*
7/20/2010	0:45:40	31.05	1.521	4.38	*
7/20/2010	1:00:40	31	1.522	4.35	*
7/20/2010	1:15:40	30.97	1.524	4.39	*
7/20/2010	1:30:40	30.93	1.526	4.39	*
7/20/2010	1:45:40	30.89	1.527	4.41	*
7/20/2010	2:00:40	30.86	1.528	4.39	*
7/20/2010	2:15:40	30.81	1.529	4.42	*
7/20/2010	2:30:40	30.76	1.53	4.42	*
7/20/2010	2:45:40	30.73	1.53	4.43	*

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Lueders City Park Downstream of S.H. 6
24-hour Field Data, 19-20 July 2010

Date	Time	Temp	SpCond	DO Conc	pH*
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
7/20/2010	3:00:40	30.64	1.532	4.49	*
7/20/2010	3:15:40	30.6	1.532	4.51	*
7/20/2010	3:30:40	30.57	1.533	4.52	*
7/20/2010	3:45:40	30.53	1.533	4.56	*
7/20/2010	4:00:40	30.48	1.533	4.55	*
7/20/2010	4:15:40	30.42	1.533	4.55	*
7/20/2010	4:30:40	30.38	1.533	4.58	*
7/20/2010	4:45:40	30.33	1.533	4.6	*
7/20/2010	5:00:40	30.27	1.533	4.63	*
7/20/2010	5:15:40	30.22	1.533	4.64	*
7/20/2010	5:30:40	30.16	1.534	4.6	*
7/20/2010	5:45:40	30.1	1.535	4.62	*
7/20/2010	6:00:40	30.06	1.536	4.66	*
7/20/2010	6:15:40	30.01	1.536	4.64	*
7/20/2010	6:30:40	29.96	1.536	4.68	*
7/20/2010	6:45:40	29.93	1.536	4.66	*
7/20/2010	7:00:40	29.87	1.536	4.66	*
7/20/2010	7:15:40	29.83	1.536	4.66	*
7/20/2010	7:30:40	29.79	1.536	4.63	*
7/20/2010	7:45:40	29.76	1.536	4.68	*
7/20/2010	8:00:40	29.73	1.536	4.66	*
7/20/2010	8:15:40	29.72	1.537	4.71	*
7/20/2010	8:30:40	29.72	1.537	4.77	*
7/20/2010	8:45:40	29.74	1.539	4.88	*
7/20/2010	9:00:40	29.79	1.54	4.93	*
7/20/2010	9:15:40	29.84	1.542	5.05	*
7/20/2010	9:30:40	29.86	1.543	5.13	*
7/20/2010	9:45:40	29.82	1.545	5.12	*
7/20/2010	10:00:40	29.82	1.546	5.19	*
7/20/2010	10:15:40	29.87	1.548	5.29	*
7/20/2010	10:30:40	29.94	1.549	5.31	*
7/20/2010	10:45:40	30.01	1.55	5.46	*
7/20/2010	11:00:40	30.15	1.551	5.61	*
7/20/2010	11:15:40	30.29	1.552	5.67	*
7/20/2010	11:30:40	30.41	1.553	5.84	*
7/20/2010	12:00:40	30.54	1.554	5.94	*
7/20/2010	12:15:40	30.67	1.556	6.03	*
7/20/2010	12:30:40	30.8	1.556	6.16	*
7/20/2010	12:45:40	30.95	1.557	6.12	*
7/20/2010	13:00:40	31.09	1.557	6.24	*
7/20/2010	13:15:40	31.2	1.558	6.21	*
7/20/2010	13:30:40	31.3	1.56	6.16	*
7/20/2010	13:45:40	31.4	1.559	6.23	*
Start Date/Time	7/19/2010 14:00				
End Date/Time	7/20/2010 13:45				
Mean		31.18	1515	5.33	--
Minimum		29.72	1456	4.3	--
Maximum		32.96	1560	7.62	--
# Samples Taken					

*Not reported; failed post-calibration requirements

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Boys Camp Crossing (Station 3)
24-hour Field Data, 19-20 July 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
7/19/2010	17:01:28	31.97	1.177	9.97	8.49
7/19/2010	17:16:28	31.98	1.173	10	8.49
7/19/2010	17:31:28	31.83	1.168	9.88	8.48
7/19/2010	17:46:28	31.82	1.17	9.89	8.49
7/19/2010	18:01:28	31.92	1.168	10.04	8.5
7/19/2010	18:16:28	31.76	1.171	9.89	8.48
7/19/2010	18:31:28	31.86	1.166	10.35	8.51
7/19/2010	18:46:28	31.82	1.152	10.42	8.52
7/19/2010	19:01:28	31.79	1.151	10.34	8.51
7/19/2010	19:16:28	31.7	1.142	10.06	8.5
7/19/2010	19:31:28	31.67	1.14	10	8.49
7/19/2010	19:46:28	31.6	1.17	9.68	8.46
7/19/2010	20:01:28	31.59	1.173	9.62	8.46
7/19/2010	20:16:28	31.65	1.178	9.72	8.47
7/19/2010	20:31:28	31.65	1.189	9.66	8.46
7/19/2010	20:46:28	31.64	1.193	9.66	8.46
7/19/2010	21:01:28	31.57	1.192	9.54	8.45
7/19/2010	21:16:28	31.49	1.201	9.42	8.43
7/19/2010	21:31:28	31.43	1.201	9.27	8.42
7/19/2010	21:46:28	31.36	1.201	9.13	8.41
7/19/2010	22:01:28	31.32	1.201	8.93	8.4
7/19/2010	22:16:28	31.28	1.201	8.81	8.39
7/19/2010	22:31:28	31.25	1.201	8.72	8.38
7/19/2010	22:46:28	31.2	1.201	8.66	8.37
7/19/2010	23:01:28	31.17	1.201	8.59	8.37
7/19/2010	23:16:28	31.14	1.201	8.6	8.37
7/19/2010	23:31:28	31.11	1.201	8.57	8.37
7/19/2010	23:46:28	31.07	1.201	8.4	8.35
7/20/2010	0:01:28	31.01	1.202	8.28	8.34
7/20/2010	0:16:28	30.97	1.202	8.18	8.33
7/20/2010	0:31:28	30.94	1.203	8.06	8.32
7/20/2010	0:46:28	30.89	1.203	8.02	8.31
7/20/2010	1:01:28	30.85	1.203	7.88	8.3
7/20/2010	1:16:28	30.84	1.203	7.79	8.29
7/20/2010	1:31:28	30.8	1.204	7.77	8.29
7/20/2010	1:46:28	30.78	1.205	7.68	8.27
7/20/2010	2:01:28	30.73	1.205	7.57	8.26
7/20/2010	2:16:28	30.72	1.205	7.53	8.26
7/20/2010	2:31:28	30.67	1.206	7.47	8.25
7/20/2010	2:46:28	30.62	1.207	7.33	8.24
7/20/2010	3:01:28	30.55	1.207	7.26	8.23
7/20/2010	3:16:28	30.5	1.208	7.1	8.21
7/20/2010	3:31:28	30.46	1.208	7.05	8.21
7/20/2010	3:46:28	30.42	1.208	6.97	8.2
7/20/2010	4:01:28	30.38	1.208	6.93	8.2
7/20/2010	4:16:28	30.33	1.208	6.83	8.19
7/20/2010	4:31:28	30.28	1.209	6.69	8.18
7/20/2010	4:46:28	30.24	1.209	6.59	8.16
7/20/2010	5:01:28	30.21	1.21	6.45	8.15
7/20/2010	5:16:28	30.16	1.21	6.33	8.14
7/20/2010	5:31:28	30.13	1.21	6.28	8.13

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Boys Camp Crossing (Station 3)
24-hour Field Data, 19-20 July 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
7/20/2010	5:46:28	30.09	1.21	6.22	8.13
7/20/2010	6:01:28	30.05	1.211	6.16	8.12
7/20/2010	6:16:28	30.03	1.211	6.11	8.11
7/20/2010	6:31:28	29.98	1.211	6	8.1
7/20/2010	6:46:28	29.97	1.211	5.95	8.1
7/20/2010	7:01:28	29.94	1.211	5.92	8.09
7/20/2010	7:16:28	29.91	1.211	5.88	8.09
7/20/2010	7:31:28	29.86	1.212	5.86	8.08
7/20/2010	7:46:28	29.84	1.212	5.81	8.08
7/20/2010	8:01:28	29.79	1.212	5.74	8.07
7/20/2010	8:16:28	29.78	1.213	5.73	8.07
7/20/2010	8:31:28	29.8	1.213	5.8	8.07
7/20/2010	8:46:28	29.82	1.214	5.79	8.07
7/20/2010	9:01:28	29.76	1.214	5.71	8.06
7/20/2010	9:16:28	29.75	1.215	5.64	8.05
7/20/2010	9:31:28	29.84	1.215	5.73	8.06
7/20/2010	9:46:28	29.83	1.215	5.69	8.06
7/20/2010	10:01:28	29.83	1.215	5.67	8.05
7/20/2010	10:16:28	29.86	1.215	5.65	8.05
7/20/2010	10:31:28	30.03	1.215	5.85	8.07
7/20/2010	10:46:28	30.08	1.215	5.94	8.08
7/20/2010	11:01:28	30.13	1.216	6.13	8.1
7/20/2010	11:16:28	30.22	1.216	6.37	8.12
7/20/2010	11:31:28	30.35	1.215	6.55	8.13
7/20/2010	11:46:28	30.53	1.216	6.78	8.16
7/20/2010	12:01:28	30.65	1.216	7.01	8.17
7/20/2010	12:16:28	30.78	1.218	7.22	8.2
7/20/2010	12:31:28	30.9	1.217	7.3	8.21
7/20/2010	12:46:28	30.99	1.217	7.46	8.22
7/20/2010	13:01:28	31.07	1.217	7.39	8.22
7/20/2010	13:16:28	31.07	1.217	7.39	8.23
7/20/2010	13:31:28	31.15	1.217	7.6	8.25
7/20/2010	13:46:28	31.29	1.217	7.9	8.27
7/20/2010	14:01:28	31.49	1.217	8.37	8.32
7/20/2010	14:16:28	31.3	1.217	8.14	8.3
7/20/2010	14:31:28	31.41	1.217	8.28	8.32
7/20/2010	14:46:28	31.53	1.217	8.45	8.33
7/20/2010	15:01:28	31.52	1.218	8.35	8.34
7/20/2010	15:16:28	31.66	1.218	8.7	8.36
7/20/2010	15:31:28	31.63	1.218	8.88	8.38
7/20/2010	15:46:28	31.61	1.217	9.19	8.41
7/20/2010	16:01:28	31.64	1.216	9.5	8.42
7/20/2010	16:16:28	31.45	1.217	9.32	8.41
7/20/2010	16:31:28	31.69	1.22	9.35	8.42
7/20/2010	16:46:28	31.61	1.216	9.36	8.43
Start Date/Time	7/19/2010 17:01				
End Date/Time	7/20/2010 16:46				
Mean		30.86	1203	7.79	8.27
Minimum		29.75	1140	5.64	8.05
Maximum		31.98	1220	10.42	8.52
# Samples Taken	96				

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Krooked River Ranch Crossing (Station 5)
24-hour Field Data, 19-20 July 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
7/19/2010	16:01:28	33.01	1.343	*	9.34
7/19/2010	16:16:28	32.91	1.337	*	9.34
7/19/2010	16:31:28	32.82	1.336	*	9.35
7/19/2010	16:46:28	32.88	1.339	*	9.35
7/19/2010	17:01:28	32.96	1.342	*	9.35
7/19/2010	17:16:28	32.96	1.339	*	9.35
7/19/2010	17:31:28	32.93	1.337	*	9.35
7/19/2010	17:46:28	32.9	1.334	*	9.35
7/19/2010	18:01:28	32.83	1.333	*	9.36
7/19/2010	18:16:28	32.78	1.34	*	9.36
7/19/2010	18:31:28	32.79	1.337	*	9.37
7/19/2010	18:46:28	32.79	1.333	*	9.39
7/19/2010	19:01:28	32.75	1.327	*	9.39
7/19/2010	19:16:28	32.69	1.33	*	9.4
7/19/2010	19:31:28	32.63	1.327	*	9.39
7/19/2010	19:46:28	32.56	1.325	*	9.38
7/19/2010	20:01:28	32.44	1.329	*	9.36
7/19/2010	20:16:28	32.36	1.334	*	9.34
7/19/2010	20:31:28	32.26	1.334	*	9.32
7/19/2010	20:46:28	32.2	1.332	*	9.31
7/19/2010	21:01:28	32.11	1.332	*	9.29
7/19/2010	21:16:28	32.02	1.332	*	9.27
7/19/2010	21:31:28	31.94	1.332	*	9.25
7/19/2010	21:46:28	31.86	1.332	*	9.24
7/19/2010	22:01:28	31.79	1.335	*	9.22
7/19/2010	22:16:28	31.72	1.338	*	9.21
7/19/2010	22:31:28	31.65	1.338	*	9.2
7/19/2010	22:46:28	31.58	1.338	*	9.18
7/19/2010	23:01:28	31.52	1.337	*	9.17
7/19/2010	23:16:28	31.47	1.337	*	9.16
7/19/2010	23:31:28	31.41	1.337	*	9.15
7/19/2010	23:46:28	31.35	1.337	*	9.14
7/20/2010	0:01:28	31.3	1.337	*	9.13
7/20/2010	0:16:28	31.25	1.337	*	9.12
7/20/2010	0:31:28	31.22	1.336	*	9.12
7/20/2010	0:46:28	31.17	1.337	*	9.11
7/20/2010	1:01:28	31.13	1.336	*	9.11
7/20/2010	1:16:28	31.08	1.336	*	9.1
7/20/2010	1:31:28	31.03	1.336	*	9.09
7/20/2010	1:46:28	30.99	1.336	*	9.09
7/20/2010	2:01:28	30.94	1.336	*	9.08
7/20/2010	2:16:28	30.89	1.336	*	9.07
7/20/2010	2:31:28	30.84	1.335	*	9.07
7/20/2010	2:46:28	30.81	1.335	*	9.07
7/20/2010	3:01:28	30.78	1.335	*	9.06
7/20/2010	3:16:28	30.74	1.335	*	9.07
7/20/2010	3:31:28	30.71	1.334	*	9.06
7/20/2010	3:46:28	30.67	1.333	*	9.07
7/20/2010	4:01:28	30.62	1.332	*	9.07
7/20/2010	4:16:28	30.57	1.332	*	9.07
7/20/2010	4:31:28	30.54	1.331	*	9.07

Cedar Ridge Reservoir Project - Clear Fork Brazos River
Krooked River Ranch Crossing (Station 5)
24-hour Field Data, 19-20 July 2010

Date	Time	Temp	SpCond	DO Conc	pH
M/D/Y	hh:mm:ss	C	mS/cm	mg/L	
7/20/2010	4:46:28	30.49	1.331	*	9.07
7/20/2010	5:01:28	30.46	1.33	*	9.06
7/20/2010	5:16:28	30.42	1.329	*	9.06
7/20/2010	5:31:28	30.4	1.329	*	9.06
7/20/2010	5:46:28	30.36	1.328	*	9.05
7/20/2010	6:01:28	30.34	1.328	*	9.05
7/20/2010	6:16:28	30.32	1.327	*	9.05
7/20/2010	6:31:28	30.29	1.327	*	9.04
7/20/2010	6:46:28	30.27	1.326	*	9.04
7/20/2010	7:01:28	30.25	1.326	*	9.04
7/20/2010	7:16:28	30.22	1.325	*	9.04
7/20/2010	7:31:28	30.21	1.325	*	9.04
7/20/2010	7:46:28	30.19	1.324	*	9.05
7/20/2010	8:01:28	30.19	1.323	*	9.06
7/20/2010	8:16:28	30.2	1.322	*	9.07
7/20/2010	8:31:28	30.26	1.322	*	9.08
7/20/2010	8:46:28	30.3	1.32	*	9.1
7/20/2010	9:01:28	30.37	1.32	*	9.11
7/20/2010	9:16:28	30.41	1.319	*	9.12
7/20/2010	9:31:28	30.45	1.318	*	9.13
7/20/2010	9:46:28	30.55	1.317	*	9.14
7/20/2010	10:01:28	30.65	1.316	*	9.16
7/20/2010	10:16:28	30.77	1.315	*	9.17
7/20/2010	10:31:28	30.87	1.314	*	9.19
7/20/2010	10:46:28	30.99	1.313	*	9.2
7/20/2010	11:01:28	31.11	1.312	*	9.21
7/20/2010	11:16:28	31.26	1.311	*	9.23
7/20/2010	11:31:28	31.38	1.311	*	9.24
7/20/2010	11:46:28	31.5	1.31	*	9.25
7/20/2010	12:01:28	31.65	1.308	*	9.26
7/20/2010	12:16:28	31.73	1.308	*	9.26
7/20/2010	12:31:28	31.8	1.307	*	9.26
7/20/2010	12:46:28	31.89	1.306	*	9.27
7/20/2010	13:01:28	32.05	1.306	*	9.29
7/20/2010	13:16:28	32.1	1.305	*	9.29
7/20/2010	13:31:28	32.11	1.304	*	9.3
7/20/2010	13:46:28	32.14	1.303	*	9.31
7/20/2010	14:01:28	32.17	1.302	*	9.3
7/20/2010	14:16:28	32.33	1.302	*	9.31
7/20/2010	14:31:28	32.55	1.301	*	9.32
7/20/2010	14:46:28	32.64	1.299	*	9.33
7/20/2010	15:01:28	32.71	1.298	*	9.35
7/20/2010	15:16:28	32.75	1.297	*	9.36
7/20/2010	15:31:28	32.79	1.296	*	9.36
7/20/2010	15:46:28	32.8	1.294	*	9.37
Start Date/Time	7/19/2010 16:01				
End Date/Time	7/20/2010 15:46				
Mean		31.50	1325	--	9.20
Minimum		30.19	1294	--	9.04
Maximum		33.01	1343	--	9.4
# Samples Taken	96				

*Not reported; failed post-calibration requirements

Appendix I
Freshwater Mussels of the Clear Fork Brazos River Cedar Ridge Reservoir Project

FRESHWATER MUSSELS OF THE CLEAR FORK BRAZOS RIVER: CEDAR RIDGE RESERVOIR PROJECT



Robert G. Howells
BioStudies
160 Bearskin Trail
Kerrville, Texas 78028
biostudies@hctc.net

Prepared: September 2009
for HDR Engineering, Inc.

FRESHWATER MUSSELS OF THE CLEAR FORK BRAZOS RIVER: CEDAR RIDGE RESERVOIR PROJECT

Robert G. Howells
BioStudies
160 Bearskin Trail
Kerrville, Texas 78028
biostudies@hctc.net

Prepared: September 2009
for HDR Engineering, Inc.
Austin, Texas

INTRODUCTORY OVERVIEW

Freshwater mussels (Family Unionidae) are members of one of several families of freshwater bivalve mollusks that occur in fresh waters, with over 50 species reported in Texas (Howells et al. 1996). They are important elements of aquatic ecosystems where they may be the major biomass component of some waters (Negus 1966), contribute to nutrient storage and release (Nedeau et al., undated), impact water quality by their water-filtering activities (Strayer et al. 1999, 2004; Nedeau et al. 2000; Lyons et al. 2007), contribute to substrate turn-over, support numerous associated commensal and parasitic organisms, and provide a forage base for other mollusk-eating predators (Howells et al. 1996).

Freshwater Mussel Biology

Basic freshwater mussel biology (see summaries in Howells et al. 1996; Parmalee and Bogan 1998; Williams et al. 2008; and others) has a number of rather complex elements. Unlike marine mussels (Mytilidae) or zebra mussels (Dreissenidae), older juvenile and adult freshwater mussels do not produce adhesive byssal threads to attach to solid objects (though some recently transformed juveniles do have byssal threads for a brief period). Freshwater mussels may occur in streams, rivers, reservoirs, lakes, ponds, and canals. Some accept an array of habitat types, but others may have very limited requirements. Some species prefer ponds and backwaters, but other require flowing waters and cannot endure impoundment. Unionids typically dig into substrates of mud, sand, gravel, lighter cobble, or mixtures of these. They avoid deep-shifting sand, deep-soft silt, scored cobble and bedrock, areas with collapsing banks, unstable substrates that change frequently, bottoms covered with algae and organic materials (sticks, leaves, etc.), areas without sufficient dissolved oxygen, and polluted waters. Sexes are usually separate (some species are hermaphrodites) and some are strongly sexually dimorphic. Males release sperm into the water column, females pull it in during feeding and respiration. Fertilized eggs and larvae (glochidia) are retained in marsupia on female gills until sufficiently developed for release. Females release glochidia singly or in groups (conglutinates). Glochidia are parasites on fishes and must find the appropriate fish species and attach in the correct area (fins, gills) within hours or they will die. Glochidia that fail to find a host, attach to the wrong fish species, incorrect place on the host fish, or attach to a fish with immunity (from prior glochidial infections) will die. Some unionids accept a wide range of host fishes, but others may only use a single species. Transformation to the juvenile stage occurs in several weeks or months depending on mussel and fish species and season. Transformed juveniles drop from the host fish to begin life on the bottom; those that fall on unacceptable substrates will die. Mussels are filter feeders and remove algae, bacteria, protozoa, and organics from the water column (and possibly from the substrate).

Harvest of Freshwater Mussels

Native Americans regularly harvested freshwater mussels for food and pearls and also used their shells for ornamentation and tools (Howells 1996a; Howells et al. 1996; Parmalee and Bogan 1998; Williams et al. 2008). In the 1890s, a major commercial fishery developed to use species with hard, white-nacred shells to produce buttons; however, by the mid-1900s with the development of plastics and decline of mussel stocks this fishery largely ended (Howells et al.

1996; Parmalee and Bogan 1998; Williams et al. 2008). Due to long distances from button factories in the upper Mississippi River Valley, Texas experienced only minimal shell harvest for use in small, local button production facilities (Howells et al. 1996). Texas has also supported mussel harvest for gem-quality pearls that began in Spanish colonial times and extended into the present (Howells 1996a). Harvest has also included use of soft tissues for trotline bait and shells for arts and crafts work, but only to a limited extent (Howells et al. 1996). Some of the most significant commercial shell harvest in Texas occurred in the late 1900s when resident and non-resident musselers took certain species for shells used to produce implant nuclei to create cultured pearls (Howells 1993; Howells et al. 1996); however, this fishery declined dramatically by the late 1990s with the reductions of mussel stocks, tightening of harvest regulations, and losses of pearl-culture oysters in Japan used to produce most of the world's cultured pearls.

Conservations Status of Freshwater Mussels

Freshwater mussels are sensitive barometers of environmental quality. When terrestrial or aquatic ecological conditions degrade or are modified, unionid mussels are often the first organisms to decline or vanish. Subsequently, unionids are the most rapidly declining faunal group in North America (Bogan 1996; Strayer et al. 2004), with estimates of 50-80% of the U.S. species being extinct, endangered, threatened, or that will be very soon. Among the approximately 300 North American species, 25% have already been federally listed as threatened or endangered, with another 50% of special concern (Williams et al. 1993; Williams et al 2008). In Texas, only one species is currently listed as endangered at the federal and state level, but another 15 species are currently being considered for additional state or federal listing. Howells (2009) listed conservation status concerns for 27 Texas species (about half of the total number of species reported from Texas waters).

As a result of the catastrophic declines in freshwater mussel assemblages seen throughout North America, including Texas, potential influences on their continued secure survival have become subject to greater attention in recent decades. Dam and bridge building activities, water management practices, and general construction projects may need to evaluate their impacts, if any, on local mussel populations. Although some such activities may have significant impacts on unionid survival, others may have little or no influence, and still others may occur in areas where mussel populations have already declined.

FRESHWATER MUSSEL STUDIES IN TEXAS

Despite the ecological and economic importance of freshwater mussels, the group drew rather limited attention until relatively recently. Early boundary water and other survey efforts sometimes included collections of freshwater mussels in the 1800s. Strecker (1931) prepared a review of collection records from Texas waters available at that time and several university manuscripts 1939-1940 addressed eastern Texas mussels (Parks 1939; Bachtel 1940; Parks and Bachtel 1940) and several others examined sites in the upper Trinity River basin (Read and Oliver 1953; Read 1954; Flook and Ubelaker 1972; Mauldin 1972). More recently, in the 1960s and 1970s, H.D. Murray (Trinity University, San Antonio) made collections statewide and produced several publications on Texas unionids. In the 1970s and 1980s, R.W. Neck (Houston

Museum of Natural Science, HMNS) and A. Metcalf (University of Texas at El Paso) also initiated mussel collections and surveys, with several resulting publications. From the late 1960s though the 1990s, C.M. Mather (University of Science and Arts of Oklahoma, USAO, Chickasha) and J.A.M. Bergmann (U.S. Department of Defense, San Antonio) made extensive collections of freshwater mussels throughout Texas. Also, in recent decades, W.H. McCullagh (Jacksonville, Florida) collected information on Texas unionid distribution.

A price war among shell buyers of pearl-implant-nuclei shells in 1991 prompted hundreds of resident and non-resident musselers to begin harvesting in Texas waters where few regulations were in place (Howells 1993). In response to this rapidly expanding fishery, Texas Parks and Wildlife Department's (TPWD) Inland Fisheries Division instructed R.G. Howells at its Heart of the Hills Fisheries Science Center (HOH; then, Heart of the Hills Research Station) to initiate studies of this resource in 1992. The HOH staff began statewide surveys of mussel distribution and abundance, research on mussel biology and taxonomic genetic studies, and development of an array of written materials, including technical reports, scientific journal articles, and educational publications. Collaboration with Neck and Murray produced the book "Freshwater Mussels of Texas" (Howells et al. 1996; but sent to press in 1994) and with Mather and Bergmann to produce a 1995 symposium proceeding presentation on rare Texas unionids (Howells et al. 1997) and a journal article on eastern Texas taxa (Howells et al. 2000). These publications were able to combine collection records from the Houston Museum of Natural Science (HMNS), Trinity University collection (TUC), University of Science and Arts of Oklahoma (USAO), and personal data relating to Texas mussel surveys.

From 1992 though 2006, HOH produced annual mussel survey reports to document ongoing data development in Texas, with particularly noteworthy efforts in 1994, 1995, and 1996 (note that some publications predated these reports). Although the TPWD administration dramatically reduced HOH mussel research in 1997, some work continued through HOH and other individuals within and outside TPWD provided additional information on the status of Texas unionids. In 2004, State Wildlife Grant (SWG) funding became available to support new surveys of locations around Texas previously found to support either particularly diverse and abundant populations, very rare mussel species, or both. Field research in 2005 and 2006 conducted by staff of Stephen F. Austin State University (performed by A.Y. Karatayev and L.E. Burlakova) and Laredo Community College (conducted by T. Miller) were summarized and compared to previous data (Howells 2006). In subsequent years, Karatayev and Burlakova conducted additional SWG-funded and other studies at selected sites in Texas (Karatayev and Burlakova 2007; Burlakova and Karatayev 2008).

In 1998, HOH and TPWD Wildlife Diversity Division personnel created a volunteer Mussel Watch program with the goal of having trained volunteers provide additional field data on Texas freshwater mussels. However, by mid-2000, HOH withdrew from the program due to concerns about some Mussel Watch generated information. Some initial data were included in annual HOH reports, but although the Mussel Watch program has continued, most such volunteer information was not incorporated in subsequent HOH reports and publications.

Following retirement from TPWD in 2006, R.G. Howells continued field work, writing, consulting, and collaboration with others on issues related to freshwater mussels. In response to

questions about species status from TPWD, USFWS, Wild Earth Guardians, and others, Howells released a biological opinion to address the conservation status of rare mussels in Texas, including generally rare taxa, those under consideration for federal listing, and TPWD's no-harvest mussel sanctuaries (Howells 2009). He is currently one of a group of researchers working through the AFS on the taxonomy and conservation status of U.S., Canadian, and Mexican unionids to update the previous Williams et al. (1993) paper on conservation status and distribution (Williams et al.; in preparation). More recently, Howells began creation of a database related to unionids survey and collection records from Texas waters and important data from adjacent states. This includes the TPWD Management Data Series (MDS) annual survey reports and other MDS reports, SWG reports, unpublished databases of (Mather, Bergmann, McCullagh, and others), journal articles and technical reports, M.S. theses, and available museum and university collection records. This growing database includes ca 13,000 entries to date and was used to develop information in this report. Additionally, TPWD staff in conjunction with Karatayev and Burlakova (Buffalo State College, NY) also report developing a mussel database for Texas waters as well (not reviewed for use in this report).

Among the various mussel studies and collections made in Texas, relatively few focused on the Brazos River and none were directed specifically at the Clear Fork Brazos River. Most information from the Clear Fork Brazos River drainage is from the TPWD surveys conducted by R.G. Howells, with additional specimens in collections of the University of Michigan Museum of Zoology and University of Science and Arts of Oklahoma and personal observations of J.A.M Bergmann and W.H. McCullagh (Table 1). The Cedar Ridge Reservoir Project area of the Clear Fork Brazos River appears not to have any freshwater mussel survey activities prior to HDR efforts initiated in 2009.

PRESENT STUDY EFFORTS

On 12 and 13 August 2009, Robert G. Howells (BioStudies, Kerrville, Texas), David J. Thomas (HDR Engineering, Inc., Austin, Texas), and Dr. Roy Darville (East Texas Baptist University, Marshall, Texas) initiated mussel survey activities in the Cedar Ridge area of the Clear Fork Brazos River in Haskell, Shackelford, and Throckmorton counties, Texas. Sites examined include the river stretch between M1 and M4 crossings and examination of the river up- and downstream from access points at Perry Camp, Lodge, Picnic, and Boys Home crossings (Fig. 1). Kayaks were used to float the M1-M4 area and crossings were accessed by vehicle and ranch roads. Survey efforts included wading and substrate examination by hand and foot as well as visual examination of shallows, riffles, and bar areas. No timed or area searches, quadrate samples, or transect surveys were employed due to a failure to locate living or very recently dead unionids to justify such activities. Shells and valves found and observed were noted and representative specimens were retained. Shell condition (time since death) approximations followed those of Howells (2003) were used to evaluate whether shell remains found were those of mussels that died very recently (within only a few weeks) or were more likely produced many months, years, or even centuries earlier.

Literature and collection records related to unionids species documented in the Clear Fork Brazos River were reviewed and summarized in Table 1. Additionally, a list of mussels

previously documented by HDR (D.J. Thomas, HDR Engineering, Inc.; pers. comm.) in the Clear Fork Brazos River in the Cedar Ridge area was obtained and presented in Table 2. Species found during the present survey effort (12-13 August 2009) and those from other selected regional water bodies are presented in Table 3. Representative shells and valves recovered from the study site and comparative images of these same species from prior collections (living or recently dead when taken) at other locations are presented in Figures 2-27.

SURVEY FINDINGS

Mussel Species

Among the 14-15 unionid mussel species reported from the Clear Fork Brazos River (Table 1), shells and valves of five unionids and the introduced exotic Asian clam (*Corbicula fluminea*) were found in surveys conducted on 12-13 August 2009 in the Cedar Ridge Reservoir Project study area (Table 3). An additional unionid species was found by HDR prior to BioStudies sampling (Table 2). Unionids found included Tampico pearlymussel (*Cyrtonaias tampicoensis*), yellow sandshell (*Lampsilis teres*), fragile papershells (*Letpodea fragilis*), pink papershell (*Potamilus ohiensis*), bleufer (*P. purpuratus*), and pistolgrip (*Quadrula verrucosa*; previously *Tritogonia verrucosa,* Serb et al. 2003).

The unionid species taken in the present study area (Tables 2-3) are consistent with those found at other area locations (Table 1) and are typical of the region and flowing-water environments (Howells et al. 1996; Howells 2006).

No living unionids or Asian clams were found during the 12-13 August survey efforts. Most shells and valves were relatively long dead to subfossil, having died months, years, or decades earlier. Two yellow sandshell specimens found between the M1 and M4 crossings (Figure 1) and another from Perry Camp Crossing were relatively recently dead. One Asian clam from Perry Camp Crossing was very recently dead (soft tissue in adductor muscle scars).

The freshwater mussel species found are known to tolerate a range of substrate types, water temperatures, flow rates, and water body types. Though present in flowing river waters at the Cedar Ridge Reservoir Project site, all tolerate impoundment well and occur in other reservoirs in Texas (Table 3). Host fishes reported for these mussel species (Howells et al. 1996; Parmalee and Bogan 1998; Williams et al. 2008) occur in the study area and also adapt to impoundments.

Asian clam is a highly invasive introduced exotic species that invaded Texas in the 1950s and 1960s (Howells et al. 2004) and has been documented in over 180 counties (Karatayev et al. 2005), with two additional counties found during this present study. It is highly adaptable to many types of habitat and is particularly advantaged by disturbed habitats (Howells et al. 1996). It is interesting that despite its invasive nature and presence at sites throughout the study area, including collection of shells of 0+ through 3+ age classes, living specimens were not found and even shells and valves were not abundant.

Mussel species currently under consideration for threatened or endangered listing by TPWD, U.S. Fish and Wildlife Service (USFWS), or both, that have been reported from the Clear Fork Brazos River area include smooth pimpleback (*Quadrula houstonensis*) and Texas fawnsfoot (*Truncilla macrodon*). On 26 August 2009, the Texas Parks and Wildlife Commission meeting in Fort Worth authorized TPWD to publish a list of 15 freshwater mussel species, including smooth pimpleback and Texas fawnsfoot, to be added to the state Threatened List (http://www.tpwd.state.tx.us/business/feedback/meetings/2009/0827/agenda/regulations). The USFWS is also moving to publish a 90-day comment period in the Federal Register in September 2009 relative to federal listing of these two species and seven others (C.L. Stevens; USFWS, pers. comm., September 2009). Neither mussel species was found within the Cedar Ridge Reservoir Project study area in 2009 and no previous records for this site were located during preparation of this report.

The only record of smooth pimpleback in the region is from a Pleistocene-dated road cut downstream of the study area and, if dated correctly, would be 10,000 years old or more (Table 3). No recent records of shells or living specimens elsewhere in the Clear Fork Brazos River have been located. Smooth pimpleback also tolerates impoundment (Howells et al. 1996; Howells 2002).

Very recently dead Texas fawnsfoot specimens were reported at two sites downstream of the study area in 1995 (Table 1). These locations were ca 45 miles (72.0 km) and ca 55 miles (88.0 km) downstream of Perry Camp Crossing. Neither site appears to have been reexamined since and these represent the farthest upstream the species has been found within the Brazos River basin. In August 2009, two recently dead specimens were reported at RR 1974, Young County, Texas, ca 70 miles (112.0 km) downstream of Perry Camp Crossing (D. Johnson, Houston, Texas; pers. comm.). Other collection records exist for sites downstream of Possum Kingdom and Granbury reservoirs on the main channel of the Brazos River (Howells 2009). These include living to recently dead specimens found below Possum Kingdom Reservoir ca 37 miles (59.2 km; 1996; Howells 1997), ca 69 miles (110.4 km; 1980 and 1990; R.G. Howells database), and ca 82 miles (131.2 km; 1996; Howells 1997) downstream of that impoundment. Another site ca 31 miles (49.6 km; 1996; Howells 1997) downstream from Granbury Reservoir produced similar specimens. Texas fawnsfoot is not known to occur in impoundments and appears to be restricted to flowing waters. However, Possum Kingdom and Granbury reservoirs were impounded in 1941 (Simmons 1986) and 1969 (www.granbury.org), respectively. This suggests Texas fawnsfoot is able to survive in flowing waters downstream of reservoirs. Collection records of Texas fawnsfoot in the lower Clear Fork Brazos River are similar distances below the Cedar Creek Reservoir site as other populations that have been found downriver of Possum Kingdom and Granbury reservoirs in the same drainage basin.

CLARIFICATION ON CONSERVATION STATUS DESIGNATIONS: It should be noted that there are several levels of meaning relative to terms like "endangered" and "threatened". Organisms can be biologically or ecologically endangered or threatened without being legally listed by U.S. Fish and Wildlife Service or Texas Parks and Wildlife Department as endangered or threatened. Both state and federal literature may refer to a species as being endangered or threatened without that species being legally listed as such. Other organizations (e.g., The Nature Conservancy, American Fisheries Society) may also designate plants or animals as endangered or threatened without inherent legal implications.

Mussel Habitat:

Desirable mussel habitat (mud, sand, fine to moderate gravels) was present at numerous sites, but no living unionids or Asian clams were found at any of the sites examined. At nearly all locations, however, even acceptable mussel substrates were found to show black, organic coloration below the immediate surface. Surveys conducted by HOH throughout Texas have generally found few to no mussels, and certainly no abundant and diverse assemblages, in substrates displaying this trait (R.G. Howells, personal observation). The sources and timing of this organic input to the system are undetermined. Given that unionid mussels act much like earthworms in mixing and de-compacting substrates in aquatic ecosystems, the presence of black organic materials in the substrate subsurface areas suggests large numbers of active mussels are unlikely to be present. Sediment turn-over and mixing would be expected to be more significant due to activities of crawling and digging mussels if significant numbers existed in the area.

Nutrient supported filamentous algae was also present in the study area. Although not desirable in high-quality mussel habitats, algal growths at the sites examined in the present study were not deemed sufficiently heavy as to preclude freshwater mussel survival.

In 2006 and 2007, TPWD revised its protective no-harvest mussel sanctuaries to designate sites that contained either abundant and diverse assemblages or particularly rare species. No locations on the Clear Fork Brazos River were designated as no-harvest mussel sanctuaries.

CONCLUSIONS

No living freshwater mussels or Asian clams were found during the 12-13 August survey of the Cedar Ridge Reservoir Project site area of the Clear Fork Brazos River.

Very few very recently dead or relatively recently dead shells were found and shells, valves, and fragments ranging from relatively long dead to subfossil were present only in limited abundance. Few shells were found along the shoreline with evidence of having been killed and deposited by predators though tracks from raccoon (*Procyon lotor*) and other potential predators were present. Collectively, this suggests a limited likelihood that large mussel populations were present but overlooked.

Yellow sandshell, and possibly other unionid species, and Asian clams likely do persist in the area in limited numbers, but no evidence of dense or diverse unionid populations was apparent.

Unionid species currently recognized in the Cedar Ridge Reservoir Project area are known to exist in both flowing water systems, like the Clear Fork Brazos River, and within reservoirs. All would be expected to tolerate impoundment.

Substrates of acceptable mud, sand, and gravel mussel habitat were present in the study area, but black organic materials in the substrate, filamentous algal growths, and general lack of numbers of living Asian clams suggests challenges to freshwater mussel survival in the Cedar Ridge Reservoir Project area.

None of the rare unionid species currently proposed for listing by either TPWD or USFWS are known to occur in the Cedar Ridge Reservoir Project area and those present in the Brazos River drainage would be expected to occur in more downstream areas. Among the proposed species know from historic or downstream sites in the Clear Fork Brazos River, smooth pimpleback (*Quadrula houstonensis*) is only known from the fossil record and tolerates impoundment and Texas fawnsfoot (*Truncilla macrodon*) has been reported to occur downstream of other impoundments in the Brazos River.

Given the absence of living unionids or Asian clams, paucity of recent or older shell and valves, lack of records of rare mussel species, and apparent organic inputs to the system, no labor-intensive sampling efforts (e.g., quadrats, transects, etc.) were deemed justifiable during the 12-13 August survey and none would appear to be warranted unless and until confirmation of abundant or diverse mussel assemblages in the Cedar Ridge Reservoir Project study area is produced.

RECOMMENDATION: No labor-intensive, quantitative unionid program in the Cedar Ridge Reservoir Project area appears necessary at this time. Rather, ongoing ecological, chemical, and engineering work and studies should continue to monitor the presence of unionids in the study area on a qualitative basis as these efforts are conducted. If at some point, dense or diverse mussel assemblages or rare species are actually located, mussel sampling protocols can be reevaluated at that time. If minimal flows are maintained and construction-related silts and other materials are managed during construction, reservoir filling, and subsequent operation, mussel populations that exist downstream of the Cedar Ridge Reservoir should be able to endure.

ACKNOWLEDGMENTS

Opinions presented herein are those of the author. Photographs from the Clear Fork Brazos River at the Cedar Ridge Reservoir Project area were prepared for this report. Other mussel photographs are those of the author, were prepared previously for other purposes, and should not be reused elsewhere without written permission from BioStudies. Special thanks go to D.J. Thomas and Dr. R. Darville for their contributions and assistance with the 12-13 August 2009 survey efforts.

LITERATURE CITED

Bachtel, H.J. 1940. Freshwater mussels of East Texas. M.A. Thesis, Stephen F. Austin State Teachers College, Nacogdoches, Texas.

Bogan, A.E. 1996. Decline and decimation: the extirpation of unionids freshwater bivalves in North America. Journal of Shellfish Research 15:484.

Burlakova, L.E., and A.Y. Karatayev. 2008. State-wide assessment of unionid diversity in Texas. Performance Report. State Wildlife Grant report to Texas Parks and Wildlife Department, Austin.

Flook, S.L.H., and J.E. Ubelaker. 1972. A survey of metazoan parasites in unionid bivalves of the Garza-Little Elm Reservoir, Dallas County, Texas. The Texas Journal of Science 23:281-392.

Howells, R.G. 1993. Preliminary survey of freshwater mussel harvest in Texas. Texas Parks and Wildlife Department, MDS 100, Austin.

Howells, R.G. 1996a. Tampico pearlymussel (*Cyrtonaias tampicoensis*): shades of the Old West. American Conchologist 24(2):24-26.

Howells, R.G. 1996b. Distributional surveys of freshwater bivalves in Texas: progress report for 1994. Texas Parks and Wildlife Department, MDS 120, Austin.

Howells, R.G. 1997. Distributional surveys of freshwater bivalves in Texas: progress report for 1996. Texas Parks and Wildlife Department, MDS 144, Austin.

Howells, R.G. 1999. Distributional surveys of freshwater bivalves in Texas: progress report for 1998. Texas Parks and Wildlife Department, MDS 161, Austin.

Howells, R.G. 2000. Distributional surveys of freshwater bivalves in Texas: progress report for 1999. Texas Parks and Wildlife Department, MDS 170, Austin.

Howells, R.G. 2002. Freshwater mussels (Unionidae) of the pimpleback-complex (*Quadrula* spp.) in Texas. Texas Parks and Wildlife Department, MDS 197, Austin.

Howells, R.G. 2004. Distributional surveys of freshwater bivalves in Texas: progress report for 2003. Texas Parks and Wildlife Department, MDS 222, Austin.

Howells, R.G. 2006. Statewide freshwater mussel survey. Final Report. State Wildlife Grant Report T-15-P, Texas Parks and Wildlife Department, Austin.

Howells, R.G. 2009. Biological opinion: Conservation status of selected freshwater mussels in Texas. BioStudies, Kerrville, Texas.

Howells, R.G., C.M. Mather, and J.A.M. Bergmann. 1997. Conservation status of selected freshwater mussels in Texas. Pages 117-128 *in* K.S. Cummings et al. Symposium on the Conservation and Management of Freshwater Mussels II: Initiatives for the Future. UMRCC, Rock Island, Illinois.

Howells, R.G., R.W. Neck, and H.D. Murray. 1996. Freshwater mussels of Texas. Texas Parks and Wildlife Press, Austin.

Howells, R.G., J.B. Wise, A.Y. Karatayev, and L.E. Burlakova. 2004. New "old records" of Asian clam *Corbicula fluminea* in Texas. Ellipsaria 6(3):11.

Karatayev, A.Y., and L.E. Burlakova. 2007. East Texas mussel survey. State Wildlife Grant report to Texas Parks and Wildlife Department, Austin.

Karatayev, A.Y., R.G. Howells, L.E. Burlakova, and B.D. Sewell. 2005. History of spread and current distribution of *Corbicula fluminea* (Muller) in Texas. Journal of Shellfish Research 24(2):553-559.

Lyons, M.S., R.A. Krebs, J.P. Holt, L.J. Rundo, and W. Zawisik. 2007. Assessing causes of change in the freshwater mussels (Bivalvia: Unionidae) in the Black River, Ohio. American Midland Naturalist 158(1):1-15.

Mauldin, V.L. 1972. The bivalve mollusca of selected Tarrant County, Texas reservoirs. M.S. Thesis, Texas Christian University, Fort Worth.

Neck, R.W., and R.G. Howells. 1994. Status survey of Texas heelsplitter, *Potamilus amphichaenus* (Frierson, 1898). Texas Parks and Wildlife Department, Special Report, Austin.

Nedeau, E.J., M.A. McCollough, and B. I. Schwartz. 2000. The freshwater mussels of Maine. Maine Department of Inland Fisheries and Wildlife, Augusta.

Nedeau, E., A.K. Smith, and J. Stone. Undated. Freshwater mussels of the Pacific Northwest. U.S. Fish and Wildlife Service.

Negus, C. 1966. A quantitative study of growth and reproduction of unionids mussels in the river Thames at Reading. Journal of Animal Ecology 35:513-532.

Parks, H.B. 1939. The Mollusca of the East Texas Pine Belt. Technical Bulletin of Stephen F. Austin State Teachers College 1(7): no pagination.

Parks, H.B., and H. Bachtel. 1940. Fresh water mussels of the East Texas rivers and streams. Technical Bulletin of Stephen F. Austin State Teachers College 2(3): no pagination.

Parmalee, P.W., and A.E. Bogan. 1998. The freshwater mussels of Tennessee. The University of Tennessee Press, Knoxville.

Read, L.B. 1954. The pelecypoda of Dallas County. Field and Laboratory 22:35-51.

Read, L.B., and K.H. Oliver. 1953. Notes on the ecology of the fresh-water mussels of Dallas County. Field and Laboratory 221(2):75-80.

Serb, J.M., J.E. Buhay, and C. Lydeard. 2003. Molecular systematics of the North American freshwater bivalve genus *Quadrula* (Unionidae: Ambleminae) based on mitochondrial ND1 sequences. Molecular Phylogenetics and Evolution 28(2003):1-11.

Simmons, E.G. 1986. Public waters of Texas. Texas Parks and Wildlife Department, PWD-BK-3200-244-11/86, Austin.

Strayer, D.L., N.F. Caraco, J.J. Cole, S. Findlay, and M.L. Pace. 1999. Transformation of freshwater ecosystems by bivalves. BioScience 49(1):19-27.

Strayer, D.L., J.A. Downing, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton, and S.J. Nichols. 2004. Changing perspectives on pearlymussels: North America's most imperiled animals. BioScience 54(5):429-439.

Williams, J.D., A.E. Bogan, and J.T. Garner. 2008. Freshwater mussels of Alabama & the Mobile Basin in Georgia, Mississippi & Tennessee. The University of Alabama Press, Tuscaloosa.

Williams, J.D., M.L. Warren, Jr., K.S. Cummings, J.L. Harris, and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries (Bethesda) 18(9):6-22.

Table 1. Freshwater mussels reported from the Clear Fork Brazos River drainage prior to 2009 and associated information sources.

Species	County	Location	Source[a]
Tampico pearlymussel	Jones	Fort Phantom Hill Reservoir	Howells 1996b, 1999, 2000
Cyrtonaias tampicoensis	Jones	South (Old) Anson Lake	Howells 1996b
	Shackelford	Clear Fork Brazos R., US 283	Howells 2000
	Shackelford	Clear Fork Brazos R., Ft. Griffin	Howells 1996b
	Stephens	Lake Daniel	Howells 1996b
	Stephens	Hubbard Creek Reservoir	Howells 2000, 2004
	Stephens	Clear Fork Brazos R., US 183	Howells 1996b
	Taylor	Lake Kirby	Howells 1996b, 2000
	Taylor	Clear Fork Brazos R., near Hawley	UMMZ 130485
Yellow sandshell	Shackelford	Clear Fork Brazos R., US 283	Howells 1996b, 2000
Lampsilis teres	Stephens	Hubbard Creek below reservoir	Howells 1996b
	Stephens	Clear Fork Brazos R., US 183	Howells 1996b
Fragile papershell	Jones	Fort Phantom Hill Reservoir	Howells 2000
Leptodea fragilis	Stephens	Hubbard Creek Reservoir	Howells 2004
	Stephens	Clear Fork Brazos R., US 183	Howells 1996b
Pink papershell	Shackelford	Clear Fork Brazos R., Ft. Griffin	Howells 1996b
Potamilus ohiensis	Stephens	Hubbard Creek Reservoir	Howells 2004
	Stephens	Clear Fork Brazos R., US 183	Howells 1996b
Bleufer	Haskell	Stamford Reservoir	Howells 2001
Potamilus purpuratus	Jones	Fort Phantom Hill Reservoir	Howells 1996b, 2000
	Stephens	Hubbard Creek below reservoir	Howells 1996b
	Stephens	Clear Fork Brazos R., US 183	Howells 1996b
Giant floater	Haskell	Stamford Reservoir	Howells 2001
Pyganodon grandis	Jones	Fort Phantom Hill Reservoir	Howells 1996b, 1999, 2000
	Nolan	Lake Trammel	Howells 1997, 2001
	Nolan	Nelson Park L., Abilene	Howells 1999
	Stephens	Lake Daniel	Howells 1996b
	Stephens	Hubbard Creek below reservoir	Howells 1996b
	Stephens	Hubbard Creek Reservoir	Howells 2000, 2004
	Taylor	Lake Kirby	Howells 1996b, 2000
Southern mapleleaf	Jones	Fort Phantom Hill Reservoir	Howells 1996b, 1999, 2000
Quadrula apiculata	Shackelford	Road cut, US 283 N of Albany	USAO 8177
	Stephens	Hubbard Creek Reservoir	Howells 2000, 2004
	Stephens	Clear Fork Brazos R., US 183	Howells 1996b
	Taylor	Lake Kirby	Howells 1996b, 2000
	Taylor	Lake Kirby	J.H. McCullagh database
Smooth pimpleback	Shackelford	Road cut, US 283 N of Albany	USAO 8176
Quadrula houstonensis		(Pleistocene)	
Pistolgrip	Jones	Fort Phantom Hill Reservoir	Howells 1999, 2000
Quadrula verrucosa			

Table 1. Continued.

Species	County	Location	Source
Lilliput	Stephens	Lake Daniel	Howells 1996b
Toxolasma parvus	Stephens	Hubbard Creek below reservoir	Howells 1996b
Texas lilliput	Taylor	Lake Kirby	Howells 2000
Toxolasma texasiensis			
Texas fawnsfoot[b]	Stephens	Clear Fork Brazos R., US 183	Howells 1996b
Truncilla macrodon	Stephens	Clear Fork Brazos R., RR 578	Howells 1996b, JAMB TX 0274
Pondhorn	Shackelford	Clear Fork Brazos R., US 283	Howells 2000
Uniomerus tetralasmus	Stephens	Stream at US 180 E Breckenridge	USAO 8167
Pondhorn spp.	Taylor	Lake Kirby	Howells 2000
Uniomerus spp.			
Paper pondshell	Jones	Fort Phantom Hill Reservoir	Howells 1996b
Utterbackia imbecillis	Shackelford	Clear Fork Brazos R., Ft. Griffin	Howells 1996b
	Stephens	Lake Daniel	Howells 1996b
	Stephens	Hubbard Creek below reservoir	Howells 1996b

[a] UMMZ = University of Michigan Museum of Zoology collection
USAO = University of Science and Arts of Oklahoma collection
JAMB = J.A.M. Bergmann collection and notes

[b] Dan Johnson (Houston, Texas; pers. comm.) reported finding two recently dead Texas fawnsfoot specimens in the Clear Fork Brazos River at RR 1974, Young County, Texas, in August 2009.

Table 2. Freshwater bivalves documented in the Cedar Ridge study area of the Clear Fork Brazos River, Texas, March – August 2009, by HDR Engineering, Inc. (D.J. Thomas, HDR Engineering, Inc.; pers. comm.).

Species	HDR Site Designation
	Freshwater Mussels (Unionidae)
Tampico pearlymussel *Cyrtonaias tampicoensis*	M6, M7, M10, M11, 33, 36, 79, 82, 116, 220, 232, 239
Yellow sandshell *Lampsilis teres*	M1, M2, M3, M4, M6, M7, M8, M9, M10, M11, 33, 36, 44, 78, 82, 95, 98, 109, 122, 133, 146, 154, 169, 178, 205, 220, 226, 232, 251
Fragile papershell *Leptodea fragilis*	M1, M3, M4, M6, M8, M10, M11, 33, 44, 82, 122, 133, 169
Pink papershell *Potamilus ohiensis*	M2, M5, M7, M10, 36, 109, 239
Bleufer *Potamilus purpuratus*	M1, M2, M4, M5, M10, 44, 89, 205, 220, 226, 239, 251
Pistolgrip *Quadrula verrucosa*	M9
	Asian Clams (Corbiculidae)
Asian clam *Corbicula fluminea*	M2, M5, M7, 44, 86, 89, 98, 206, 233, 251

Table 3. Freshwater mussels found in the Cedar Ridge Reservoir study area of the Clear Fork Brazos River, 12-13 August 2009, in the present study and species previously documented in other selected reservoirs in the Brazos and Trinity basins.

Waterbody	Study Area	Fort Phantom Hill Reservoir	Stamford Reservoir	Hubbard Creek Reservoir	Belton Reservoir	Stillhouse Hollow Reservoir	Somerville Reservoir	Lewisville Reservoir
Drainage	Brazos	Brazos	Brazos	Brazos	Brazos	Brazos	Brazos	Trinity
Date	2009	1999	2000	1999	1996	1996	1996	1999
Source	Present study	Howells 2000	Howells 2001	Howells 2000	Howells 1997	Howells 1997	Howells 1997	Howells 2000
Threeridge *Amblema plicata*	-	-	-	-	X	X	X	X
Tampico pearlymussel *Cyrtonaias tampicoensis*	X	X	X	X	X	X	X	-
Rock-pocketbook *Arcidens confragosus*	-	-	-	-	-	-	-	X
Louisiana fatmucket *Lampsilis hydiana*	-	-	-	-	X	X	-	X
Yellow sandshell *Lampsilis teres*	X	-	-	-	X	X	X	X
Fragile papershell *Leptodea fragilis*	X	X	-	X	X	-	-	X
Pink papershell *Potamilus ohiensis*	X	-	-	X	-	-	-	X
Bleufer *Potamilus purpuratus*	-	X	X	-	X	-	X	X
Giant floater *Pyganodon grandis*	-	X	X	X	X	X	X	X
Southern mapleleaf *Quadrula apiculata*	-	X	-	X	X	X	X	X
Western pimpleback *Quadrula mortoni*	-	-	-	-	-	-	-	X
Pistolgrip *Quadrula verrucosa*	X	X	-	-	-	X	-	X
Lilliput *Toxolasma parvus*	-	-	-	-	-	-	-	X
Texas lilliput *Toxolasma texasiensis*	-	-	-	-	-	-	X	-
Tapered pondhorn *Uniomerus declivis*	-	-	-	-	-	-	X	-
Paper pondshell *Utterbackia imbecillis*	-	-	-	-	X	-	X	X

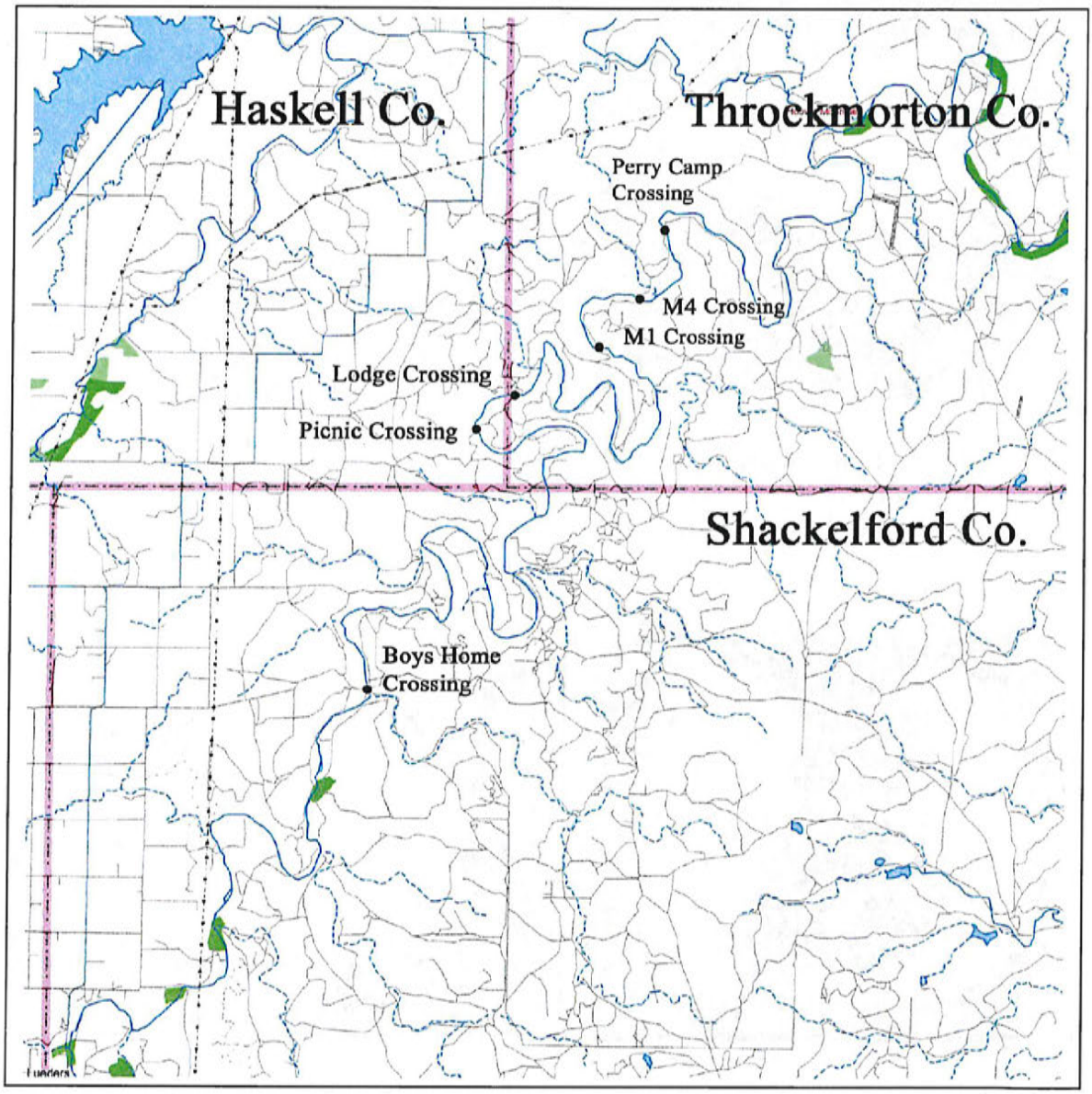
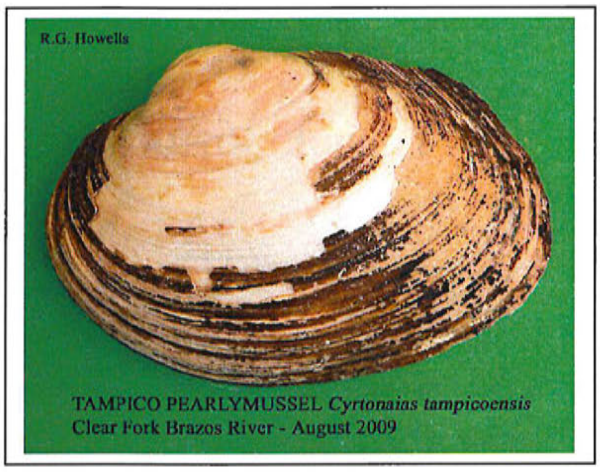


Figure 1. Locations on the Clear Fork Brazos River in Haskell, Shackelford, and Throckmorton counties, Texas, surveyed for freshwater mussels 12-13 August 2009.



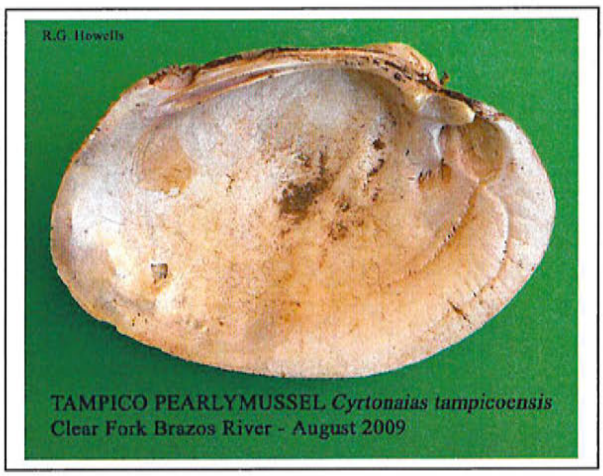


Figure 2 & 3. Tampico pearlymussel (*Cyrtonaias tampicoensis*) specimen, Clear Fork Brazos River, Texas, Cedar Ridge Reservoir Project area, collected August 2009, considered relatively long dead.



Figure 4. Tampico pearlymussel (*Cyrtonaias tampicoensis*) specimen, Clear Fork Brazos River, Texas, Cedar Ridge Reservoir Project area, collected August 2009, considered relatively long dead.

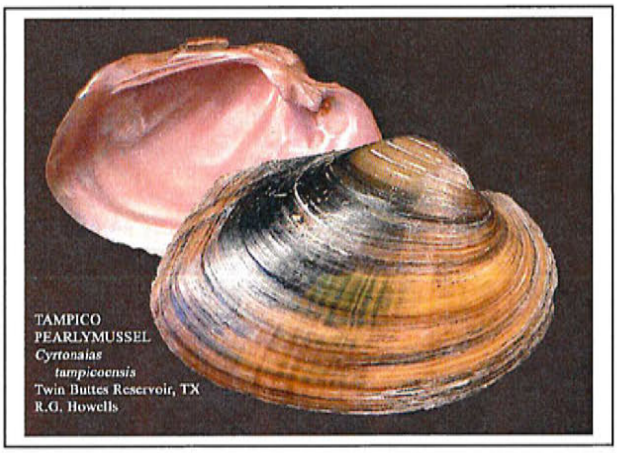


Figure 5. Tampico pearlymussel (*Cyrtonaias tampicoensis*) specimen, Concho River drainage, Texas, condition was very recently dead when collected.



Figure 6. Yellow sandshell (*Lampsilis teres*), Clear Fork Brazos River, Cedar Ridge Reservoir Project area, collected August 2009, considered long dead.



Figures 7 & 8. Yellow sandshell (*Lampsilis teres*), Clear Fork Brazos River, Cedar Ridge Reservoir Project area, collected August 2009, relatively recently dead.

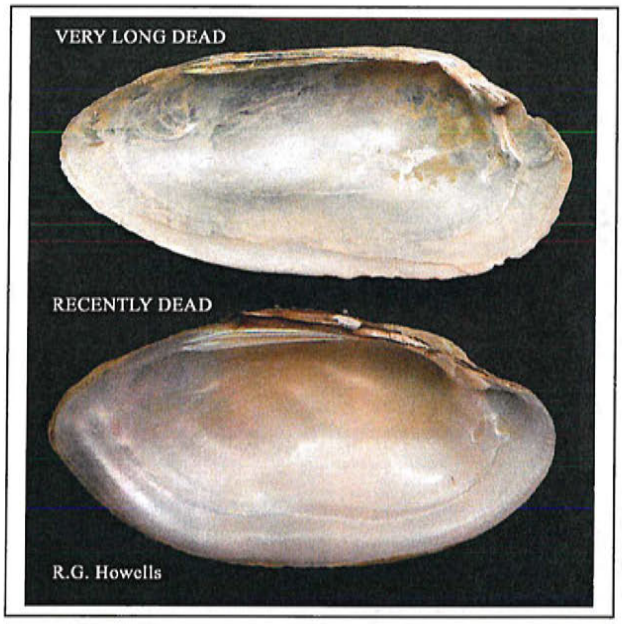


Figure 9. Yellow sandshell (*Lampsilis teres*). Top: very long dead specimen from the Clear Fork Brazos River, Cedar Ridge Reservoir Project area, August 2009. Bottom: very recently dead specimen when collected in Lake Corpus Christi, Texas.

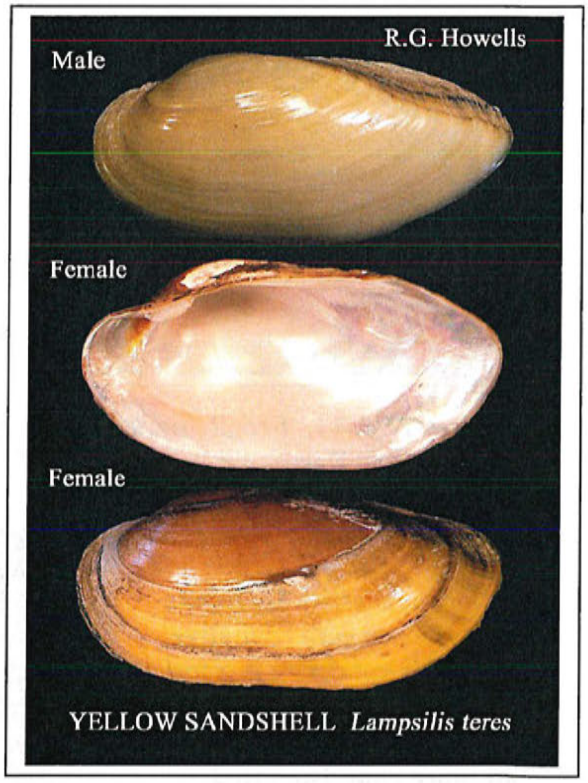


Figure 10. Yellow sandshell (*Lampsilis teres*), several Texas locations, recently dead at collection.

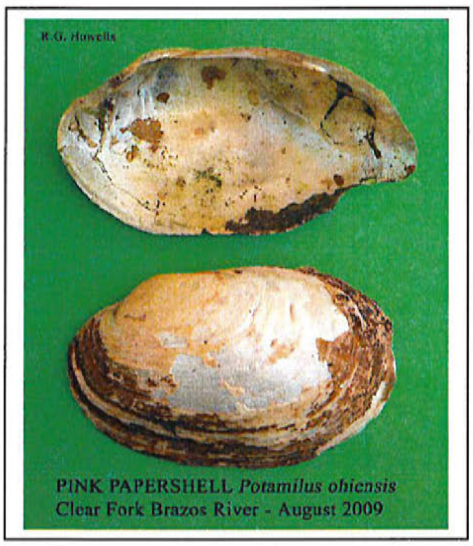
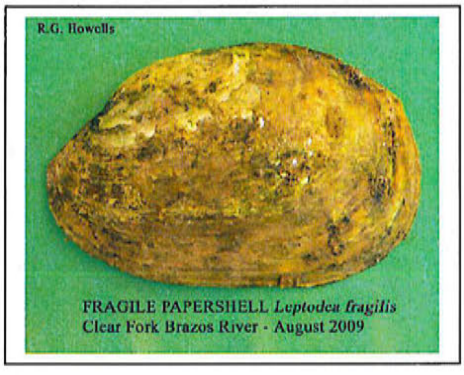


Figure 11. Pink papershell (*Potamilus ohiensis*), Clear Fork Brazos River, Cedar Ridge Reservoir Project area, Texas, August 2009, considered long dead.



Figure 12. Pink papershell (*Potamilus ohiensis*), Lake Arrowhead, Texas, collected alive. Note: anterior and posterior wings (ala) shown are often broken or eroded and therefore missing in many specimens.





Figures 13 & 14. Fragile papershell (*Leptodea fragilis*), Clear Fork Brazos River, Cedar Ridge Reservoir Project area, Texas, August 2009, considered long dead.

Figure 15. Fragile papershell (*Leptodea fragilis*), Colorado River, Texas, collected alive. Note: This specimen is a female with a blunt posterior margin; males are often less deep bodies and more round-pointed posteriorly. Like pink papershell, the dorsal wings are often lacking due to erosion or breakage.

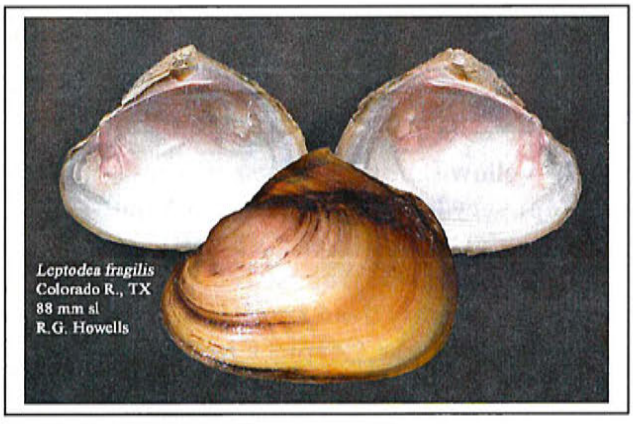
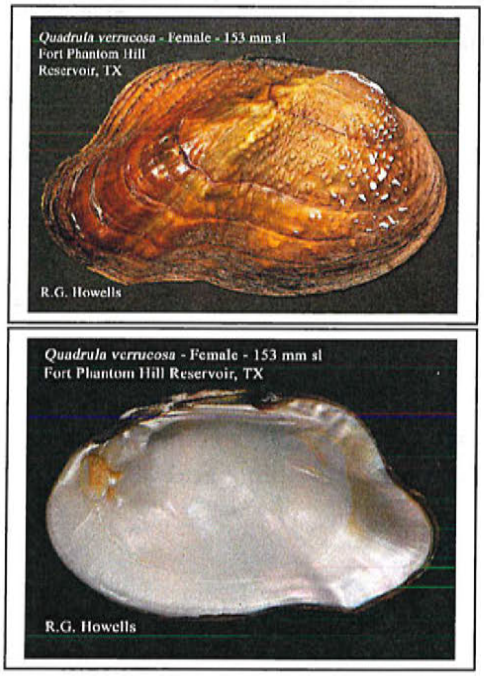




Figure 16. Pistolgrip (*Quadrula verrucosa*), Clear Fork Brazos River, Cedar Ridge Reservoir Project area, Texas, August 2009, considered very long dead.



Figure 17. Pistolgrip (*Quadrula verrucosa*) right pseudocardinal tooth, Clear Fork Brazos River, Cedar Ridge Reservoir Project area, Texas, August 2009, considered subfossil. Fragments of large pistolgrip specimens from this area can be confused with other species like washboard (*Megalonaias nervosa*) that has a far larger and deeper beak cavity.



Figures 17 & 18. Pistolgrip (*Quadrula verrucosa*) female, Fort Phantom Hill Reservoir, Texas, collected alive.

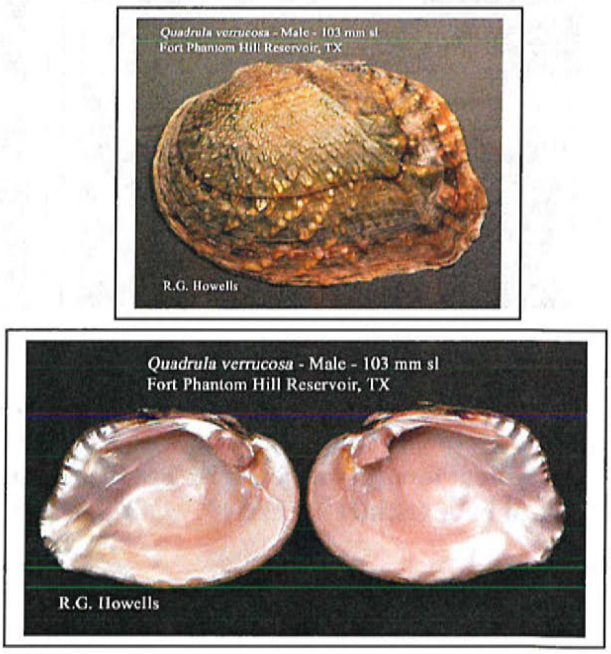


Figure 19. Pistolgrip (*Quadrula verrucosa*) male, Fort Phantom Hill Reservoir, Texas, collected alive.



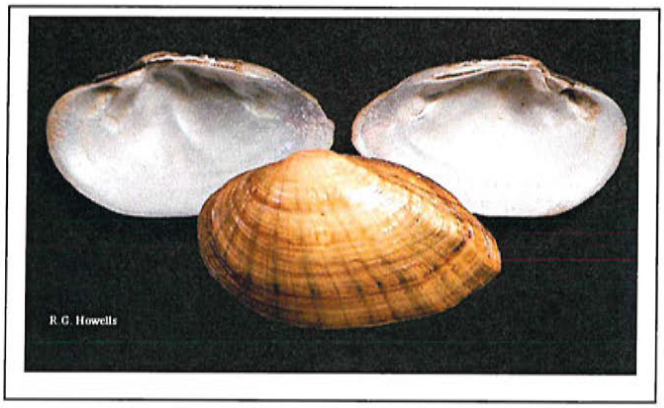


Figures 21 & 21. Bleufer (*Potamilus purpuratus*), Clear Fork Brazos River, Cedar Ridge Reservoir Project area, Texas, 2009. This right valve of a male bleufer was considered relatively long dead. This specimen was collected by the HDR staff prior to the 12-13 August 2009 survey.





Figures 22 & 23. Bleufer (*Potamilus purpuratus*), Concho River, Texas, collected alive. Note: Specimens from the Brazos and Colorado drainages in Texas differ somewhat from typical forms from eastern Texas and the Mississippi River drainage and may prove to be a distinct species (*P. coloradoensis*).





Figures 24 & 25. Texas fawnsfoot (*Truncilla macrodon*) specimens from the Central Brazos River drainage, Texas. This species is endemic to the Brazos and Colorado drainage basins of Texas. It has been reported in the lower Clear Fork Brazos River as recently as August 2009, but is not known in or near the Cedar Ridge Reservoir Project area.

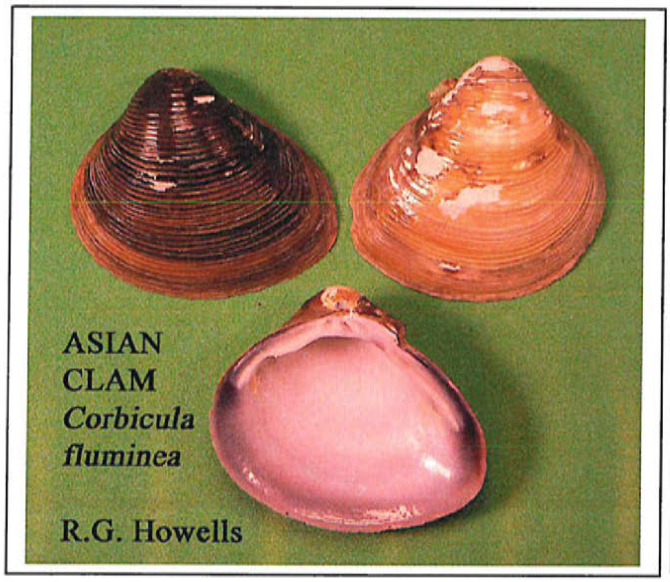


Figure 26. Asian clam (*Corbicula fluminea*), from several locations in Texas, collected alive. Classification of this invasive exotic species remains unresolved, with some suggestions of multiple species involvement.

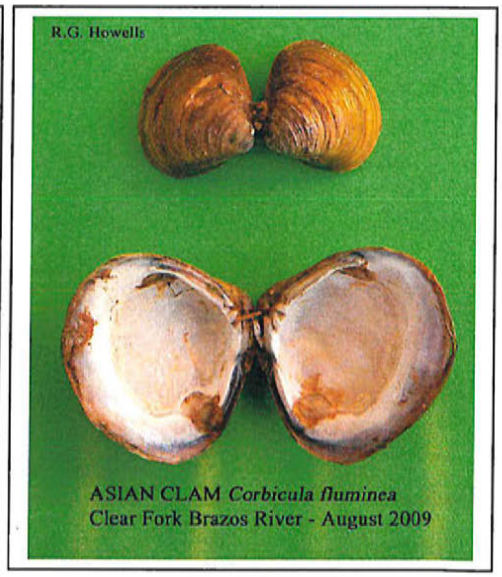


Figure 27. Asian clam (*Corbicula fluminea*), Clear Fork Brazos River, Cedar Ridge Reservoir Project area, Texas, August 2009. Lower specimen is very recently dead (soft tissue remains on adductor muscle scars), but displays atypical nacre.

Appendix J
Cedar Ridge Reservoir Project
Freshwater Mussel Surveys
2010

Appendix J
Cedar Ridge Reservoir Project
Freshwater Mussel Surveys
2010

Prepared for:

City of Abilene

Prepared by:

HDR Engineering, Inc.
Texas Registered Engineering Firm No. F-754

July 2011

Table of Contents

Section		Page
J-1	Introduction	J-1
J-2	Study Objectives	J-3
J-3	Methods and Materials	J-3
	J-3.1 Study Area	J-3
	J-3.2 Sampling Methodology	J-5
J-4	Results	J-7
J-5	Discussion	J-20
J-6	Recommendations	J-21
J-7	Literature Cited	J-24

List of Figures

Figure		Page
J-1	2010 Mussel Survey Locations	J-2
J-2	Mussel Survey Locations Proposed for 2011	J-23

List of Tables

Table		Page
J-1	Mussel Survey Locations, Clear Fork Brazos River Watershed, July and October 2010	J-4
J-2	Mussel Shell Condition Terminology	J-6
J-3	Freshwater Mussel Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality, Clear Fork Brazos River, 19–21 July 2010	J-8
J-4	Freshwater Mussel Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality, Clear Fork Brazos River, 4–8 October 2010	J-10
J-5	Freshwater Mussel Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality, Clear Fork Brazos River, 19–21 July 2010 and 4–8 October 2010	J-14
J-6	Mussel Survey Locations Proposed for 2011	J-22

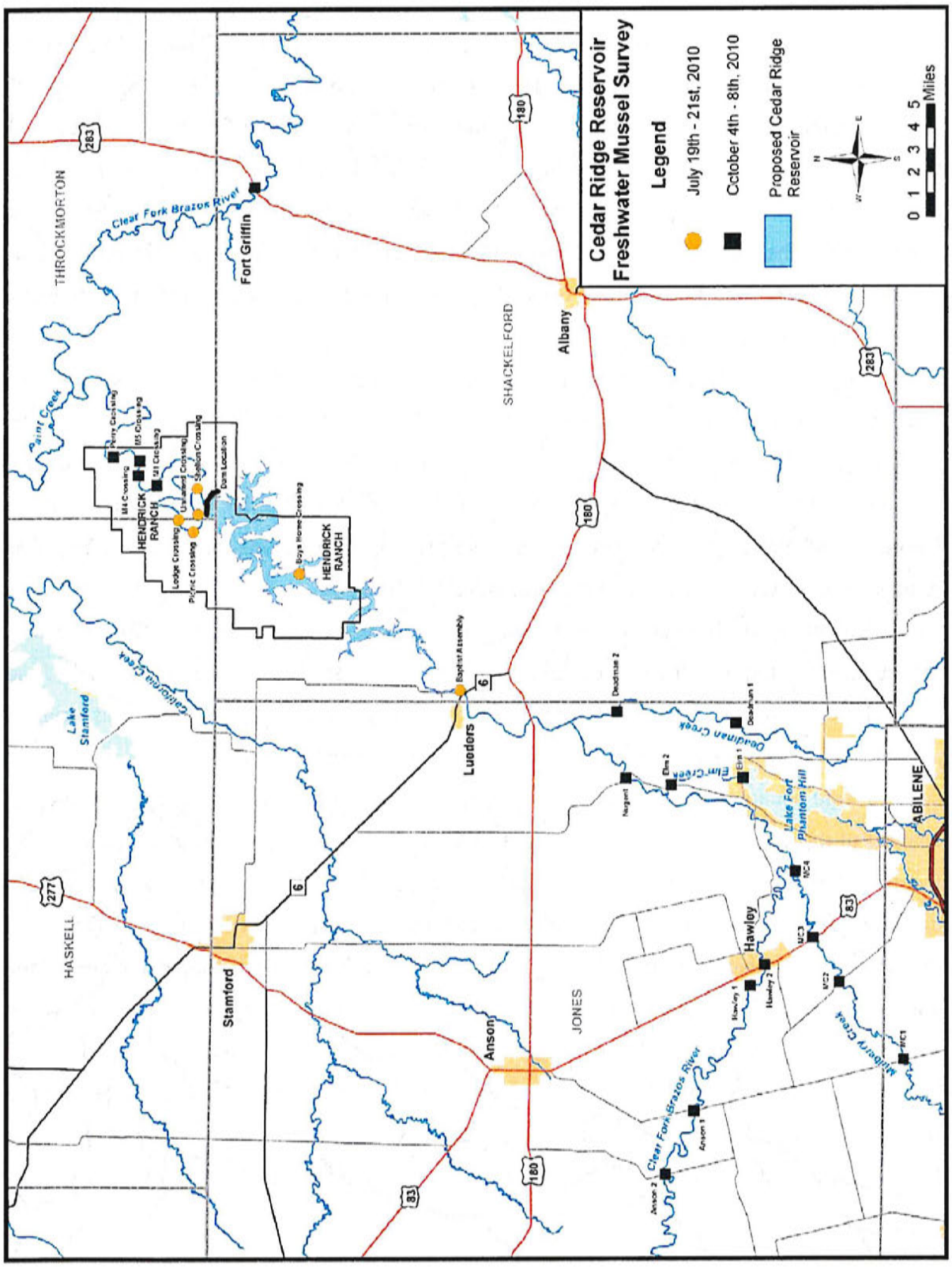
J-1 Introduction

There have been increased concerns over the conservation status of freshwater mussels in response to the decline of the once-diverse unionid populations in the United States during the last 100 years. Recognized to be one of the most critically imperiled freshwater groups in the United States, 15 of the 52 freshwater mussel species known in Texas were placed on the State protection list as threatened in December 2009 (Texas Register, 2010). Knowledge of mussel populations in the Clear Fork Brazos River (Clear Fork) system is scant, and this information is necessary for assessing the potential effects of the proposed Cedar Ridge Reservoir Project on existing mussel communities.

There is a shortage of current information due to the lack of comprehensive surveys. The small numbers of records of freshwater mussels in the Clear Fork Basin date back to 1994 (Howells, 2009). A review of the existing freshwater mussel data by Howells (2009) determined that no freshwater mussel survey activities have occurred within the project study area in Haskell, Shackelford, and Throckmorton counties prior to HDR Engineering, Inc. (HDR) efforts initiated in August 2009 with assistance from Mr. Bob Howells.

Following the 2009 survey, two mussel surveys were conducted during 2010 to evaluate the abundance and distribution of unionid mussels in the Clear Fork in Haskell, Jones, Shackelford, Taylor, and Throckmorton counties. Public access along the river is primarily private; however, there are some "pull-outs" along the public roads crossing the river. These surveys were conducted at accessible river crossings with a concentration of effort in the main channel of the Clear Fork at several locations within the reservoir footprint and downstream of the proposed dam location (Figure J-1). The 19–21 July 2010 survey was conducted at numerous river crossings concurrent with the critical period ALM survey with a concentration of effort in the main channel of the Clear Fork downstream of the proposed dam and at one location within the reservoir footprint. The areal coverage of the second field survey conducted 4–8 October 2010 was expanded to include numerous collection locations in the Clear Fork watershed situated upstream and downstream of the reservoir footprint. The principal investigator was Mr. Joe Bergmann, a qualified mussel surveyor (Cibolo Creek Enterprises, LLC.) experienced with state-wide mussel sampling and familiar with the regional fauna.

Figure J-1. 2010 Mussel Survey Locations



There were ample opportunities for HDR aquatic biologists to encounter live mussels or mussel beds outside of structured sampling. Shoreline and mid-channel areas were inspected for unionid species during each of the other biota-specific surveys. However, no incidental finds of dead shell or live individuals/beds were found during the Aquatic Life Monitoring (ALM) surveys conducted in 2009 and 2010.

J-2 Study Objectives

Due to the lack of historical data in this region of Texas, the study objectives were to 1) collect data on mussel distribution, habitat utilization, and other related factors critical for the evaluation of the current status of freshwater mussels in the Clear Fork; 2) identify suitable habitat for two recently state-listed threatened freshwater mussel species proposed for federal protection—the Texas fawnsfoot (*Truncilla macrodon*) and smooth pimpleback (*Quadrula houstonensis)* and; 3) provide supplementary information to a previous freshwater mussel survey in the Clear Fork conducted by Mr. Bob Howells on 12–13 August 2009. This study serves to address the lack of mussel population information for the Clear Fork.

J-3 Methods and Materials

J-3.1 Study Area

For the 2010 sampling efforts, a total of 24 locations were established for investigation in the Clear Fork watershed including three major tributaries (i.e., Mulberry Creek, Elm Creek, and Deadman Creek). As shown on Figure J-1, representative reaches and areas most likely to support mussel species were chosen based on topographic maps, aerial photography, field reconnaissance, and best professional judgment. Six locations were surveyed during 19–21 July 2010 and 19 locations were examined during 4–8 October 2010 (Table J-1). The length of the Clear Fork adjacent to the Big Country Baptist Assembly on FM 142 north of the State Highway (SH) 6 river crossing near Lueders in Shackelford County was visited during both surveys.

Table J-1
Mussel Survey Locations
Clear Fork Brazos River Watershed
July and October 2010

Site Name	Survey Location	Stream	County	Collection Date
Hawley 1	County Road (CR) 509	Clear Fork	Jones	10/4/2010
Hawley 2	US 83/277	Clear Fork	Jones	10/4/2010
Elm 1	FM 1082	Elm Creek	Jones	10/4/2010
Elm 2	W. Lake Road	Elm Creek	Jones	10/4/2010
Deadman 1	CR 310	Deadman Creek	Jones	10/4/2010
Deadman 2	CR 303	Deadman Creek	Jones	10/4/2010
Nugent	W. Lake Road	Clear Fork	Jones	10/4/2010
Anson 1	FM 707	Clear Fork	Jones	10/8/2010
Anson 2	FM 3116	Clear Fork	Jones	10/8/2010
MC1	FM 707	Mulberry Creek	Taylor	10/4/2010
MC2	FM 2404	Mulberry Creek	Jones	10/4/2010
MC3	US 83/277	Mulberry Creek	Jones	10/4/2010
MC4	CR 341	Mulberry Creek	Jones	10/4/2010
Baptist Assembly	FM 142	Clear Fork	Shackelford	7/21/2010 10/5/2010
Boys Camp	Hendrick Ranch	Clear Fork	Shackelford	7/20/2010
Shelton Crossing	Hendrick Ranch	Clear Fork	Throckmorton	7/20/2010
Unnamed Crossing	Hendrick Ranch	Clear Fork	Throckmorton	7/21/2010
Picnic Crossing	Hendrick Ranch	Clear Fork	Haskell	7/21/2010
Lodge Crossing	Hendrick Ranch	Clear Fork	Throckmorton	7/19/2010
M1 Crossing	Hendrick Ranch	Clear Fork	Throckmorton	10/6/2010
M4 Crossing	Hendrick Ranch	Clear Fork	Throckmorton	10/6/2010
M5 Crossing	Hendrick Ranch	Clear Fork	Throckmorton	10/6/2010
Perry Camp	Hendrick Ranch	Clear Fork	Throckmorton	10/6/2010
Fort Griffin	US 283/CR188	Clear Fork	Shackelford	10/5/2010

J-3.2 Sampling Methodology

A thorough search was conducted at each location, and coverage was dependant on the amount of bank stability, adequate substrate, canopy shading, and sufficient flow. A minimum of 400 to 500 m longitudinal length at each river location was inspected. Approximate search areas in the smaller creeks were dependant on the presence of water, suitable substrate, and water quality conditions. Mr. Bergmann searched all representative habitats at each survey site, concentrating at mid-channel and along the river edges so that shorelines could also be inspected for empty shells. Sampling adequacy was determined by best professional judgment and typically became obvious when a minimum search time of 30 minutes failed to increase the number of live or dead mussel (shell) species present.

All searches involved visual and tactile searches for live mussels while wading within the river channel. Sightings of empty mussel shells along the river edges helped identify key areas of the creek where live mussels were likely to be discovered. Mussels exposed at the surface were located by sight and by disturbing and fanning gravel substrates and moving cobble and larger rock by hand. Searches for live mussels were also conducted by feeling with feet in the deeper wade-able areas. These techniques were necessary to increase the collection of juveniles, and other small species and individuals that were buried in the substrate. Live mussels were identified, examined, and recorded as they were found. Underwater observations in the deeper portions of the river were restricted by high turbidity and low water clarity, thereby reducing the ability to view the channel bottom and in turn the effectiveness in the use of a snorkel and mask.

When each station survey period ended, the number and species of live mussels and mussel shells were tabulated. All live specimens found were measured, photographed, and returned to their collecting locations in the orientation they were found. All dead shells found at each site—not represented by living species—were collected, and a few select individuals were kept for voucher purposes and stored in the possession of Cibolo Creek Enterprises, LLC. Dead specimens of mussel species not represented by live individuals were classified by terminology relating to the time scale of shell conditions (i.e., how long a given specimen has been dead) provided by Howells (1996a, 1996b, 2004) in Table J-2.

Although a very few (11) live specimens were collected in 2010, an established quantitative mussel sampling protocol was prepared with guidelines to follow in the event live mussels or a concentration of mussels ("bed") were encountered (Strayer and Smith, 2003).

Table J-2.
Mussel Shell Condition Terminology

Term	Definition
Very recently dead	Soft tissue remains attached to the shell or valve; shell is in good condition, essentially as it would be in a living specimen; internal and external colors are not faded.
Recently dead	No soft tissue remains, but shell otherwise in good condition (looking like a living specimen that had been killed and cleaned); internally nacre is glossy and without evidence of algal or other staining, calcium deposition, or external erosive effects; internal and external colors are not significantly faded.
Relatively-recently dead	Shell is in good condition, but internally nacre is losing its glossy nature; algal or other staining, calcium deposition, or external erosive effects (or some combination of these) are evident on the nacre; internal and external colors are often somewhat faded.
Relatively-long dead	Similar to above, but more pronounced; shell epidermis often has sections beginning to flake.
Long dead	Shell shows signs of internal and external erosion, staining, calcium deposition, or some combination of these; most or all of the internal coloration and glossy nature of the nacre has faded (especially in species with colored nacre); shell epidermis often has major sections absent, or if present, clearly aged and flaking.
Very-long dead	Shell shows significant signs of internal and external erosion, staining, and calcium deposition more widely pronounced than above; coloration is often faded white or nearly so; often with relatively little epidermis remaining; for specimens in particularly erosive environments (scoured substrates, low pH waters, etc.), internal (e.g. shell teeth) and external features (e.g. pustules, ridges) are often weathered and smoothed, or otherwise exfoliated; shells are often chalky, brittle, and crumbling.
Subfossil	Shells have little or no epidermis remaining; nacre is faded white, and entire shell is often bleached white; shell sometimes shows signs of erosion, staining, or calcium deposition of recent origin; shells are typically chalky and powdery to the touch, and often brittle and crumbling.

Source: Howells (1996a, 1996b, 2004)

J-4 Results

All stream systems surveyed, except Deadman Creek and Elm Creek, showed evidence of unionid life, whether in the form of live individuals or shells. A total of 184 complete unionid shells, single valves, or identifiable fragments representative of 10 species including one live specimen were enumerated from 6 locations during the 19–21 July survey (Table J-3). A large number of empty shells of the ubiquitous exotic Asian clam species (*Corbicula fluminae*) were abundant at each station examined.

Evidence of 13 species of mussels from 214 examples of unionid material collected was found during the 4–8 October 2010 survey (Table J-4), and of these, ten individuals representing four species were found alive: two Tampico pearlymussel (*Cyrtonaias tampicoensis*), two yellow sand shell (*Lampsilis teres*), one fragile papershell (*Leptodea fragilis*), and five giant floater (*Pyganodon grandis*).

A total of 398 complete unionid shells, single valves, or identifiable fragments representative of 14 species including eleven live specimens were enumerated from 24 locations during the July and October surveys (Table J-5). Live mussels were found only at two locations. The one live fragile papershell (*Leptodea fragilis*) specimen found at the Baptist Assembly in August and the ten living non-protected individuals collected at the Fort Griffin location in October were pulled from the water for identification and immediately returned carefully back to the substrate alive.

The shell assemblages collected during 2010 included the two threatened endemic species. A total of 10 smooth pimpleback (10 valves) were recorded from five sites during 2010. A total of 16 (1 whole; 15 valves) Texas fawnsfoot were identified at four locations. A whole, relatively recent dead Texas fawnsfoot was documented in October at Fort Griffin. Additionally, a single valve (or shell) of a long-dead Texas fawnsfoot was found in the spring of 2010 by HDR biologists approximately 48 river-miles downstream of the proposed project during a snake survey.

Table J-3
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Clear Fork Brazos River
19-21 July 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
Total 6 Stations			N=184	N=3	N=180	N=1	N=0	N=1	N=17	N=18	N=59	N=59	N=29
Amblema plicata	Threeridge	1	3		3								3
Cyrtonaias tampicoensis	Tampico pearlymussel	6	55	1	54				5	3	19	13	15
Lampsilis teres	Yellow sand shell	6	73		73				8	10	33	15	7
Leptodea fragilis	Fragile papershell	4	41	1	39	1		1	2	5	5	25	2
Potamilus ohiensis	Pink papershell	1	1		1							1	
Quadrula houstonensis	Smooth pimpleback	2	4		4							3	1
Quadrula verrucosa	Pistolgrip	2	3	1	2				1			2	
Toxolasma parvus	Lilliput	1	1		1						1		
Truncilla macrodon	Texas fawnsfoot	2	2		2						1		1
Utterbackia imbecilis	Paper pondshell	1	1		1				1				
CLEAR FORK BRAZOS RIVER	SHACKLEFORD COUNTY												
Baptist Assembly FM 142[3]	21 July 2010		N=6										
Cyrtonaias tampicoensis	Tampico pearlymussel		2	1	1					1		1	
Lampsilis teres	Yellow sand shell		2		2					1	1		
Leptodea fragilis	Fragile papershell		2	1		1		1					
ALM Site 3 - Boys Home	20 July 2010		N=7										
Cyrtonaias tampicoensis	Tampico pearlymussel		2		2				1			1	
Lampsilis teres	Yellow sand shell		2		2				1	1			
Toxolasma parvus	Lilliput		1		1						1		
Truncilla macrodon	Texas fawnsfoot		1		1						1		
Utterbackia imbecilis	Paper pondshell		1		1				1				
CLEAR FORK BRAZOS RIVER	THROCKMORTON COUNTY												
ALM Site 4 - Shelton	20 July 2010		N=51										
Cyrtonaias tampicoensis	Tampico pearlymussel		12		12				2			7	3
Lampsilis teres	Yellow sand shell		28		28				4	3	15	5	1
Leptodea fragilis	Fragile papershell		10		10					3	3	4	
Quadrula verrucosa	Pistolgrip		1		1							1	

Table J-3 (concluded)
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Cedar Ridge Reservoir Project - Clear Fork Brazos River
19-21 July 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
CLEAR FORK BRAZOS RIVER	**THROCKMORTON COUNTY**												
Unnamed Crossing	21 July 2010		N=79										
Cyrtonaias tampicoensis	Tampico pearlymussel		23		23					1	13	2	7
Lampsilis teres	Yellow sand shell		32		32					4	12	10	6
Leptodea fragilis	Fragile papershell		18		18				1	2		13	2
Potamilus ohiensis	Pink papershell		1		1							1	
Quadrula verrucosa	Pistolgrip		2	1	1				1			1	
Quadrula houstonensis	Smooth pimpleback		3		3							3	
CLEAR FORK BRAZOS RIVER	**HASKELL COUNTY**												
Picnic Crossing	21 July 2010		N=39										
Amblema plicata	Threeridge		3		3								3
Cyrtonaias tampicoensis	Tampico pearlymussel		15		15				2		6	2	5
Lampsilis teres	Yellow sand shell		8		8				3		5		
Leptodea fragilis	Fragile papershell		11		11				1		2	8	
Quadrula houstonensis	Smooth pimpleback		1		1								1
Truncilla macrodon	Texas fawnsfoot		1		1								1
CLEAR FORK BRAZOS RIVER	**THROCKMORTON COUNTY**												
ALM Site 5 - KRR Lodge	19 July 2010		N=2										
Cyrtonaias tampicoensis	Tampico pearlymussel		1		1					1			
Lampsilis teres	Yellow sand shell		1		1					1			

[1]Based on shell condition terminology found in Howells (1995, 1996, 2004). See Table J-2.
[2]Relative mortality estimates are gross approximations based only on shell condition.
[3]Circumstances at the Baptist Assembly (high traffic at canoe landing) did not allow a complete search of this location. Only 30 minutes was expended in the search for mussels.

Table J-4
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Clear Fork Brazos River
4-8 October 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
Total 19 Stations			N=214	N=47	N=157	N=10	N=3	N=15	N=48	N=18	N=58	N=56	N=6
Cyrtonaias tampicoensis	Tampico pearlymussel	11	53	6	45	2		2	5		23	21	
Lampsilis teres	Yellow sand shell	8	64	15	47	2		7	18	2	15	20	
Leptodea fragilis	Fragile papershell	4	35	12	22	1		4	19	3	2	6	
Potamilus ohiensis	Pink papershell	2	7	1	6				2	2	2	1	
Potamilus purpuratus	Bleufer	2	10	5	5			1		3		6	
Pyganodon grandis	Giant floater	1	11	5	1	5	2			2	2		
Quadrula apiculata	Southern mapleleaf	1	4	1	3				4				
Quadrula houstonensis	Smooth pimpleback	3	6		6								6
Quadrula verrucosa	Pistolgrip	2	5	1	4					4	1		
Toxolasma parvus	Lilliput	1	1		1							1	
Truncilla macrodon	Texas fawnsfoot	2	14	1	13		1			2	10	1	
Uniomerus tetralasmus	Pondhorn	3	3		3			1			2		
Utterbackia imbecilis	Paper pondshell	1	1		1						1		
CLEAR FORK BRAZOS RIVER	JONES COUNTY												
Anson FM 3116	8 October 2010		N=1										
Cyrtonaias tampicoensis	Tampico pearlymussel		1		1						1		
Anson FM 707	8 October 2010		N=3										
Cyrtonaias tampicoensis	Tampico pearlymussel		1		1						1		
Uniomerus tetralasmus	Pondhorn		1		1						1		
Utterbackia imbecilis	Paper pondshell		1		1						1		
Hawley CR 509	4 October 2010		N=4										
Cyrtonaias tampicoensis	Tampico pearlymussel		2		2			1			1		
Lampsilis teres	Yellow sand shell		1		1						1		
Uniomerus tetralasmus	Pondhorn		1		1			1					

Table J-4 (cont'd)
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Cedar Ridge Reservoir Project - Clear Fork Brazos River
4-8 October 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
CLEAR FORK BRAZOS RIVER	**JONES COUNTY**												
Hawley US 83/277	4 October 2010		N=6										
Cyrtonaias tampicoensis	Tampico pearlymussel		1		1						1		
Lampsilis teres	Yellow sand shell		2		2						2		
Quadrula houstonensis	Smooth pimpleback		1		1								1
Quadrula verrucosa	Pistolgrip		1		1						1		
Uniomerus tetralasmus	Pondhorn		1		1						1		
MULBERRY CREEK	**TAYLOR COUNTY**												
MC-1 FM 707	4 October 2010		N=0										
MULBERRY CREEK	**JONES COUNTY**												
MC-2 FM 2404	4 October 2010		N=0										
MC-3 US 83/277	4 October 2010		N=1										
Cyrtonaias tampicoensis	Tampico pearlymussel		1		1				1				
MC-4 CR 341	4 October 2010		N=0										
ELM CREEK	**JONES COUNTY**												
EC-1 FM 1082	4 October 2010		N=0										
EC-2 W. Lake Road	4 October 2010		N=0										
DEADMAN CREEK	**JONES COUNTY**												
DC-1 CR 310	4 October 2010		N=0										
DC-2 CR303	4 October 2010		N=0										

Table J-4 (cont'd)
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Cedar Ridge Reservoir Project - Clear Fork Brazos River
4-8 October 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
CLEAR FORK BRAZOS RIVER	**JONES COUNTY**												
Nugent at W. Lake Road	4 October 2010		N=0										
CLEAR FORK BRAZOS RIVER	**SHACKLEFORD COUNTY**												
Baptist Assembly FM 142	5 October 2010		N=30										
Cyrtonaias tampicoensis	Tampico pearlymussel		6	3	3							6	
Lampsilis teres	Yellow sand shell		9	3	6				1	1		7	
Leptodea fragilis	Fragile papershell		8	4	4			1	1	2		4	
Potamilus purpuratus	Bleufer		6	4	2							6	
Truncilla macrodon	Texas fawnsfoot		1		1							1	
CLEAR FORK BRAZOS RIVER	**THROCKMORTON COUNTY**												
M1 on Hendrick Ranch	6 October 2010		N=8										
Cyrtonaias tampicoensis	Tampico pearlymussel		2		2							2	
Lampsilis teres	Yellow sand shell		3		3						1	2	
Leptodea fragilis	Fragile papershell		3	1	2					1		2	
M4 on Hendrick Ranch	6 October 2010		N=8										
Cyrtonaias tampicoensis	Tampico pearlymussel		4		4						1	3	
Lampsilis teres	Yellow sand shell		3	1	2					1		2	
Potamilus ohiensis	Pink papershell		1		1							1	
M5 on Hendrick Ranch	6 October 2010		N=4										
Cyrtonaias tampicoensis	Tampico pearlymussel		3		3						1	2	
Lampsilis teres	Yellow sand shell		1		1							1	

Table J-4 (concluded)
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Cedar Ridge Reservoir Project - Clear Fork Brazos River
4-8 October 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
CLEAR FORK BRAZOS RIVER	**THROCKMORTON COUNTY**												
Perry Camp	6 October 2010		N=6										
Cyrtonaias tampicoensis	Tampico pearlymussel		2		2				1			1	
Lampsilis teres	Yellow sand shell		2		2				1		1		
Leptodea fragilis	Fragile papershell		1		1				1				
Quadrula houstonensis	Smooth pimpleback		1		1								1
CLEAR FORK BRAZOS RIVER	**SHACKLEFORD COUNTY**												
Ft. Griffin US 283 to CR 188	5 October 2010		N=143										
Cyrtonaias tampicoensis	Tampico pearlymussel		30	3	25	2		1	3		17	7	
Lampsilis teres	Yellow sand shell		43	11	30	2		7	16		10	8	
Leptodea fragilis	Fragile papershell		23	7	15	1		3	17		2		
Potamilus ohiensis	Pink papershell		6	1	5				2	2	2		
Potamilus purpuratus	Bleufer		4	1	3			1		3			
Pyganodon grandis	Giant floater		11	5	1	5	2			2	2		
Quadrula apicula	Southern mapleleaf		4	1	3				4				
Quadrula houstonensis	Smooth pimpleback		4		4								4
Quadrula verrucosa	Pistolgrip		4	1	3					4			
Toxolasma parvus	Lilliput		1		1							1	
Truncilla macrodon	Texas fawnsfoot		13	1	12		1			2	10		

[1]Based on shell condition terminology found in Howells (1995, 1996, 2004). See Table J-2.
[2]Relative mortality estimates are gross approximations based only on shell condition.

Table J-5
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Clear Fork Brazos River
19-21 July 2010 and 4-8 October 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
Total 24 Stations			N=398	N=50	N=337	N=11	N=3	N=16	N=65	N=36	N=117	N=115	N=35
Amblema plicata	Threeridge	1	3		3								3
Cyrtonaias tampicoensis	Tampico pearlymussel	17	108	7	99	2		2	10	3	42	34	15
Lampsilis teres	Yellow sand shell	14	137	15	120	2		7	26	12	48	35	7
Leptodea fragilis	Fragile papershell	8	76	13	61	2		5	21	8	7	31	2
Potamilus ohiensis	Pink papershell	3	8	1	7				2	2	2	2	
Potamilus purpuratus	Bleufer	2	10	5	5			1		3		6	
Pyganodon grandis	Giant floater	1	11	5	1	5	2			2	2		
Quadrula apiculata	Southern mapleleaf	1	4	1	3				4				
Quadrula houstonensis	Smooth pimpleback	5	10		10							3	7
Quadrula verrucosa	Pistolgrip	4	8	2	6				1	4	1	2	
Toxolasma parvus	Lilliput	2	2		2						1	1	
Truncilla macrodon	Texas fawnsfoot	4	16	1	15		1			2	11	1	1
Uniomerus tetralasmus	Pondhorn	3	3		3			1			2		
Utterbackia imbecilis	Paper pondshell	2	2		2				1		1		
CLEAR FORK BRAZOS RIVER	JONES COUNTY												
Anson FM 3116	8 October 2010		N=1										
Cyrtonaias tampicoensis	Tampico pearlymussel		1		1						1		
Anson FM 707	8 October 2010		N=3										
Cyrtonaias tampicoensis	Tampico pearlymussel		1		1						1		
Uniomerus tetralasmus	Pondhorn		1		1						1		
Utterbackia imbecilis	Paper pondshell		1		1						1		
Hawley CR 509	4 October 2010		N=4										
Cyrtonaias tampicoensis	Tampico pearlymussel		2		2			1			1		
Lampsilis teres	Yellow sand shell		1		1						1		
Uniomerus tetralasmus	Pondhorn		1		1			1					

Table J-5 (cont'd)
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Cedar Ridge Reservoir Project - Clear Fork Brazos River
19-21 July 2010 and 4-8 October 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
CLEAR FORK BRAZOS RIVER	**JONES COUNTY**												
Hawley US 83/277	4 October 2010		N=6										
Cyrtonaias tampicoensis	Tampico pearlymussel		1		1						1		
Lampsilis teres	Yellow sand shell		2		2						2		
Quadrula houstonensis	Smooth pimpleback		1		1								1
Quadrula verrucosa	Pistolgrip		1		1						1		
Uniomerus tetralasmus	Pondhorn		1		1						1		
MULBERRY CREEK	**TAYLOR COUNTY**												
MC-1 FM 707	4 October 2010		N=0										
MULBERRY CREEK	**JONES COUNTY**												
MC-2 FM 2404	4 October 2010		N=0										
MC-3 US 83/277	4 October 2010		N=1										
Cyrtonaias tampicoensis	Tampico pearlymussel		1		1				1				
MC-4 CR 341	4 October 2010		N=0										
ELM CREEK	**JONES COUNTY**												
EC-1 FM 1082	4 October 2010		N=0										
EC-2 W. Lake Road	4 October 2010		N=0										
DEADMAN CREEK	**JONES COUNTY**												
DC-1 CR 310	4 October 2010		N=0										
DC-2 CR303	4 October 2010		N=0										

Table J-5 (cont'd)
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Cedar Ridge Reservoir Project - Clear Fork Brazos River
19-21 July 2010 and 4-8 October 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
CLEAR FORK BRAZOS RIVER	**JONES COUNTY**												
Nugent at W. Lake Road	4 October 2010		N=0										
CLEAR FORK BRAZOS RIVER	**SHACKLEFORD COUNTY**												
Baptist Assembly FM 142[3]	21 July 2010		N=6										
Cyrtonaias tampicoensis	Tampico pearlymussel		2	1	1					1		1	
Lampsilis teres	Yellow sand shell		2		2					1	1		
Leptodea fragilis	Fragile papershell		2	1		1		1					
Baptist Assembly FM 142	5 October 2010		N=30										
Cyrtonaias tampicoensis	Tampico pearlymussel		6	3	3							6	
Lampsilis teres	Yellow sand shell		9	3	6				1	1		7	
Leptodea fragilis	Fragile papershell		8	4	4			1	1	2		4	
Potamilus purpuratus	Bleufer		6	4	2							6	
Truncilla macrodon	Texas fawnsfoot		1		1							1	
ALM Site 3 - Boys Home	20 July 2010		N=7										
Cyrtonaias tampicoensis	Tampico pearlymussel		2		2				1			1	
Lampsilis teres	Yellow sand shell		2		2				1	1			
Toxolasma parvus	Lilliput		1		1						1		
Truncilla macrodon	Texas fawnsfoot		1		1						1		
Utterbackia imbecilis	Paper pondshell		1		1				1				
CLEAR FORK BRAZOS RIVER	**THROCKMORTON COUNTY**												
ALM Site 4 - Shelton	20 July 2010		N=51										
Cyrtonaias tampicoensis	Tampico pearlymussel		12		12				2			7	3
Lampsilis teres	Yellow sand shell		28		28				4	3	15	5	1
Leptodea fragilis	Fragile papershell		10		10					3	3	4	
Quadrula verrucosa	Pistolgrip		1		1							1	

Table J-5 (cont'd)
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Cedar Ridge Reservoir Project - Clear Fork Brazos River
19-21 July 2010 and 4-8 October 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
CLEAR FORK BRAZOS RIVER	**THROCKMORTON COUNTY**												
Unnamed Crossing	21 July 2010		N=79										
Cyrtonaias tampicoensis	Tampico pearlymussel		23		23					1	13	2	7
Lampsilis teres	Yellow sand shell		32		32					4	12	10	6
Leptodea fragilis	Fragile papershell		18		18				1	2		13	2
Potamilus ohiensis	Pink papershell		1		1							1	
Quadrula verrucosa	Pistolgrip		2	1	1				1			1	
Quadrula houstonensis	Smooth pimpleback		3		3							3	
CLEAR FORK BRAZOS RIVER	**HASKELL COUNTY**												
Picnic Crossing	21 July 2010		N=39										
Amblema plicata	Threeridge		3		3								3
Cyrtonaias tampicoensis	Tampico pearlymussel		15		15				2		6	2	5
Lampsilis teres	Yellow sand shell		8		8				3		5		
Leptodea fragilis	Fragile papershell		11		11				1		2	8	
Quadrula houstonensis	Smooth pimpleback		1		1								1
Truncilla macrodon	Texas fawnsfoot		1		1								1
CLEAR FORK BRAZOS RIVER	**THROCKMORTON COUNTY**												
ALM Site 5 - KRR Lodge	19 July 2010		N=2										
Cyrtonaias tampicoensis	Tampico pearlymussel		1		1					1			
Lampsilis teres	Yellow sand shell		1		1					1			
M1 on Hendrick Ranch	6 October 2010		N=8										
Cyrtonaias tampicoensis	Tampico pearlymussel		2		2							2	
Lampsilis teres	Yellow sand shell		3		3						1	2	
Leptodea fragilis	Fragile papershell		3	1	2					1		2	

Table J-5 (cont'd)
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Cedar Ridge Reservoir Project - Clear Fork Brazos River
19-21 July 2010 and 4-8 October 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
CLEAR FORK BRAZOS RIVER	**THROCKMORTON COUNTY**												
M4 on Hendrick Ranch	6 October 2010		N=8										
Cyrtonaias tampicoensis	Tampico pearlymussel		4		4						1	3	
Lampsilis teres	Yellow sand shell		3	1	2					1		2	
Potamilus ohiensis	Pink papershell		1		1							1	
M5 on Hendrick Ranch	6 October 2010		N=4										
Cyrtonaias tampicoensis	Tampico pearlymussel		3		3						1	2	
Lampsilis teres	Yellow sand shell		1		1							1	
Perry Camp	6 October 2010		N=6										
Cyrtonaias tampicoensis	Tampico pearlymussel		2		2				1			1	
Lampsilis teres	Yellow sand shell		2		2				1		1		
Leptodea fragilis	Fragile papershell		1		1				1				
Quadrula houstonensis	Smooth pimpleback		1		1								1
CLEAR FORK BRAZOS RIVER	**SHACKLEFORD COUNTY**												
Ft. Griffin US 283 to CR 188	5 October 2010		N=143										
Cyrtonaias tampicoensis	Tampico pearlymussel		30	3	25	2		1	3		17	7	
Lampsilis teres	Yellow sand shell		43	11	30	2		7	16		10	8	
Leptodea fragilis	Fragile papershell		23	7	15	1		3	17		2		
Potamilus ohiensis	Pink papershell		6	1	5				2	2	2		
Potamilus purpuratus	Bleufer		4	1	3			1		3			
Pyganodon grandis	Giant floater		11	5	1	5	2			2	2		
Quadrula apicula	Southern mapleleaf		4	1	3				4				
Quadrula houstonensis	Smooth pimpleback		4		4								4
Quadrula verrucosa	Pistolgrip		4	1	3					4			

Table J-5 (concluded)
Freshwater Mussel Survey Results by Collection Location, Live Specimens, Shell Condition, and Relative Mortality
Cedar Ridge Reservoir Project - Clear Fork Brazos River
19-21 July 2010 and 4-8 October 2010

Scientific Name/ Survey Location	Common Name	Num Sites	Total No.	Whole	Valve	Live	Shell Condition[1,2]						
							Very Recent Dead	Recent Dead	Relative Recent Dead	Relative Long Dead	Long Dead	Very Long Dead	Sub Fossil
CLEAR FORK BRAZOS RIVER	**SHACKLEFORD COUNTY**												
Ft. Griffin US 283 to CR 188	5 October 2010												
Toxolasma parvus	Lilliput		1		1							1	
Truncilla macrodon	Texas fawnsfoot		13	1	12		1			2	10		

[1]Based on shell condition terminology found in Howells (1995, 1996, 2004). See Table J-2.
[2]Relative mortality estimates are gross approximations based only on shell condition.
[3]Circumstances at the Baptist Assembly (high traffic at canoe landing) did not allow a complete search of this location during the July 2010 investigation.

J-5 Discussion

Adult mussels are generally found embedded in the substrate at the bottom of a body of water. Preferred freshwater mussel habitat includes rock, gravel, or firm sand. They are not generally found on muddy or unconsolidated sandy bottoms of rivers or streams or in silty areas. Mussel movement is limited, and they tend to remain stationary for long periods of time.

The distribution of mussels in the five-county area investigated during 2010 indicated a total of 14 unionid species in four watersheds. Qualitative surveys for mussels consisted of tactile (hand grubbing) and visual searches of all representative habitat types within the survey areas. No observations of live protected mussel species were made on or upstream of the Hendrick Ranch property. Most shells and valves were relatively long dead to subfossil, having died years, or decades earlier. Very recently-dead individuals of Texas fawnsfoot have been documented by TPWD and HDR at Fort Griffin in 2010, but according to Howells (1996), the species has become extremely rare in recent years. Additionally, a single valve (or shell) of a long-dead Texas fawnsfoot was found in the spring of 2010 by HDR biologists approximately 48 river-miles downstream of the proposed project during a snake survey.

The type of substrate present is considered an important ecological factor controlling the species of mussels present. Stable mud, sand, and gravelly portions of the Clear Fork that potentially provide suitable habitat was available at numerous sites; however, only 11 living unionids were found at all of the sites examined. In areas where acceptable mussel substrates were found, there was evidence of a black, organic coloration below the immediate surface. Surveys conducted throughout Texas have generally found few to no mussels, and certainly no abundant and diverse assemblages, in substrates displaying this trait (Howells, 2009). Additionally, the presence of abundant algae (attached and floating) in the water suggest nutrient conditions of the river appear mesotrophic to eutrophic based on the 2009 and 2010 survey findings. Given the scarcity of the more common mussel species observed during the survey, inhabitation by these two rare species is unlikely in the habitat present within the section of river proposed for inundation.

J-6 Recommendations for 2011 Sampling Program

A statewide plan providing recommendations for freshwater mussel surveys and relocations has not been adopted yet by either the TPWD or TCEQ, although guidelines are currently being reviewed. As part of the 2011 work plan, HDR proposes two comprehensive

mussel surveys between April and October at 33 locations listed in Table J-6. HDR will continue mussel sampling at most of the 24 previously established monitoring locations in addition to a more concerted effort to sample representative areas inside the reservoir footprint between the Lueders Dam upstream of River Mile 158 and the proposed dam location at River Mile 130 (Figure J-2).

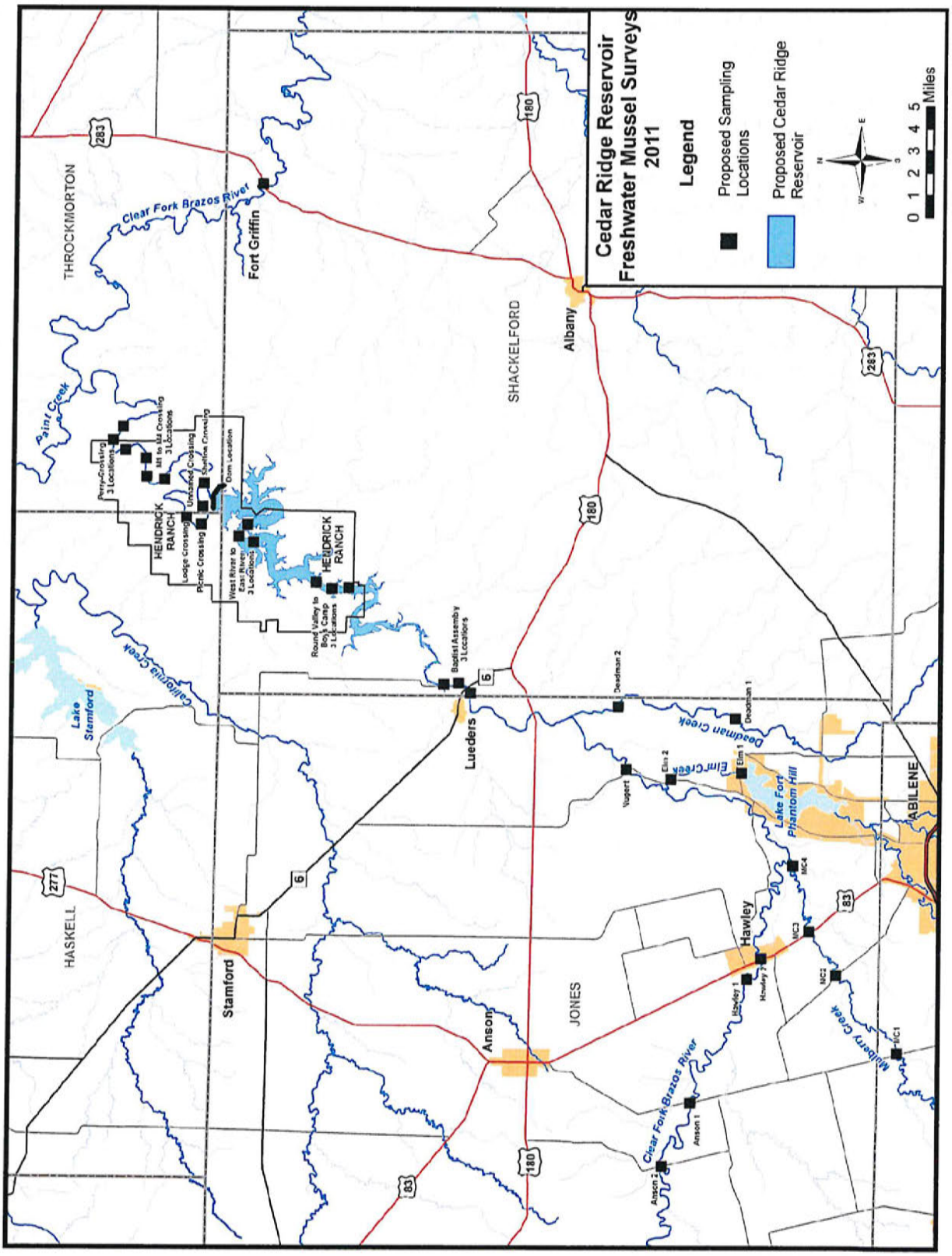
The river segment will be subdivided into five non-equidistant study reaches (three within the reservoir footprint and two downstream of the proposed dam location). It is important to note that access to this portion of the Clear Fork is difficult, often with long distances between access points (e.g., road crossings). The examination of this river segment during both surveys will be accomplished by kayak or canoe. The reaches will be delineated based on existing data from previous HDR mussel, fish, and water snake surveys. Within each of the five reaches, three discrete sample sites will be selected in areas that appear to support high quality mussel habitat. At each site, a one-hour timed survey will be conducted examining all habitat types.

The main study objective is the accumulation of new data on mussel distribution, abundance, and habitat utilization within the section of river that will be potentially affected by the proposed project with continued emphasis on the two threatened endemic mussel species. A thorough search will be conducted at each location, and coverage will be dependant on the amount of bank stability, adequate substrate, canopy shading, and sufficient flow. Sampling adequacy will be determined by best professional judgment as total search time will vary with abundance (more time will be spent in areas containing more individuals). Mussels exposed at the surface will be located by both sight and feel. If or when a patch or bed of living mussels is located, the substrate will be inspected for buried mussels. If live mussel beds are found, a quantitative systematic sampling approach will follow Strayer and Smith (2003). Each live mussel bed will be delineated with a hand-held GPS and a habitat characterization including measurement of current velocity, water depth, substrate type, in-stream cover, and standard water quality parameters will be conducted. Snorkeling or diving gear will be used to determine the upstream and downstream boundaries of mussels in that particular stream reach.

Table J-6
Proposed Mussel Survey Locations
2011 Monitoring Study
Clear Fork Brazos River Watershed

Site Name	Survey Location	Stream	County
Hawley 1	County Road (CR) 509	Clear Fork	Jones
Hawley 2	US 83/277	Clear Fork	Jones
Elm 1	FM 1082	Elm Creek	Jones
Elm 2	W. Lake Road	Elm Creek	Jones
Deadman 1	CR 310	Deadman Creek	Jones
Deadman 2	CR 303	Deadman Creek	Jones
Nugent	W. Lake Road	Clear Fork	Jones
Anson 1	FM 707	Clear Fork	Jones
Anson 2	FM 3116	Clear Fork	Jones
MC1	FM 707	Mulberry Creek	Taylor
MC2	FM 2404	Mulberry Creek	Jones
MC3	US 83/277	Mulberry Creek	Jones
MC4	CR 341	Mulberry Creek	Jones
Big Country Baptist Assembly	Upper Reservoir Footprint FM 142 and SH 6 (3 areas)	Clear Fork	Shackelford
Round Valley to Boys Camp	Middle Reservoir Footprint Hendrick Ranch (3 areas)	Clear Fork	Shackelford
West River to East River	Lower Reservoir Footprint Hendrick Ranch (3 areas)	Clear Fork	Shackelford
Shelton Crossing	Hendrick Ranch	Clear Fork	Throckmorton
Unnamed Crossing	Hendrick Ranch	Clear Fork	Throckmorton
Picnic Crossing	Hendrick Ranch	Clear Fork	Haskell
Lodge Crossing	Hendrick Ranch	Clear Fork	Throckmorton
M1 Crossing to M4 Crossing	Downstream of Dam Hendrick Ranch (3 areas)	Clear Fork	Throckmorton
Perry Camp	Downstream of Dam Hendrick Ranch (3 areas)	Clear Fork	Throckmorton
Fort Griffin	State Park	Clear Fork	Shackelford

Figure J-2. Mussel Survey Locations Proposed for 2011



J-7 Literature Cited

Howells, R.G. 1996a. *Distributional surveys of freshwater bivalves in Texas: Progress report for 1994*. Texas Parks and Wildlife Department, Management Data Series 120, Austin, Texas.

Howells, R.G. 1996b. *Distributional surveys of freshwater bivalves in Texas: Progress report for 1995*. Texas Parks and Wildlife Department, Management Data Series 125, Austin, Texas.

Howells, R.G. 2004. *Distributional surveys of freshwater bivalves in Texas: Progress report for 2003*. Texas Parks and Wildlife Department, Management Data Series 222, Austin, Texas.

Howells, R. G. 2009. *Freshwater mussels of the Clear Fork: Cedar Ridge Project*. Report prepared for HDR Engineering, August 2009.

Strayer, D.L. and D.R. Smith. 2003. *A guide to sampling freshwater mussel populations*. American Fisheries Society.

ATTACHMENT E

USGS TOPOGRAPHIC MAP

LAKE STAMFORD EAST
USGS 1:24,00
QUADRANGLE

HOOVER MOUNTAIN
USGS 1:24,00
QUADRANGLE

Outlet Works
Stilling Basin

Principal
Spillway

Dam Site

Access
Roads

Outlet
Works

Access
Road

Emergency
Spillway

Pipeline to Lake
Fort Phantom Hill
or City of Abilene

LUEDERS NE
USGS 1:24,00
QUADRANGLE

Intake and
Pump Station

ANTELOPE HILLS
USGS 1:24,00
QUADRANGLE

COLLINS CREEK SW
USGS 1:24,00
QUADRANGLE

LUEDERS EAST
USGS 1:24,00
QUADRANGLE

LUEDERS

6

Legend

Conservation Pool - 1,489 ft-msl

100-Year Flood Pool - 1,500.6 ft-msl

N
W E
S

0 4,000 8,000 Feet

May 2011

HDR

W:\201644\000098093-Cedar_Ridge-Task_1\GIS\map_docs\arcmap\Cedar_ridge_reservoir__dam_site_092010_30x50.mxd