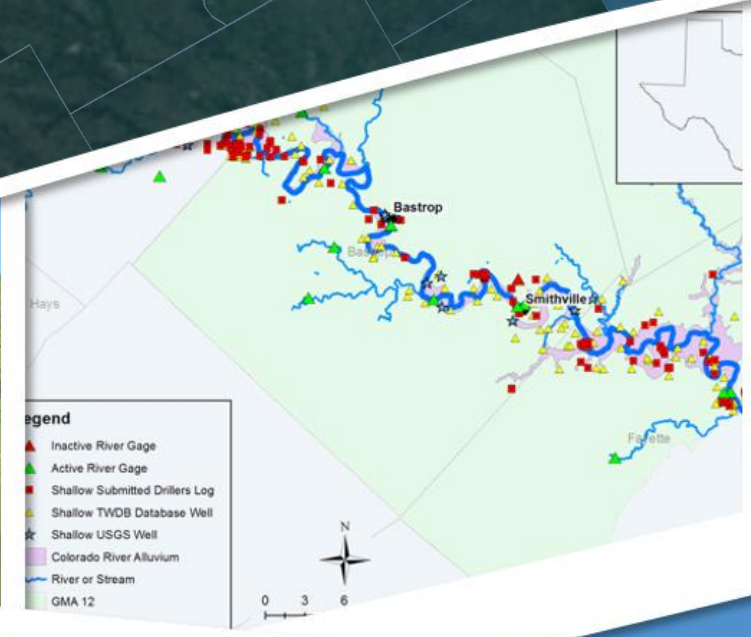
STATEMENT OF QUALIFICATIONS

ORIGINAL

Improving Simulation of Groundwater/Surface Water Interaction in the Groundwater Management Area 12 Groundwater Availability Model

RFQ No. 580-16-RFQ0014



Prepared For:

Texas Water Development Board

Prepared By:

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

April 11, 2016

INTERA Incorporated
1812 Centre Creek Drive, Suite 300
Austin, Texas 78754 USA
512.425.2000

April 11, 2016

Angela Wallace
Purchaser
Texas Water Development Board
1700 N. Congress Avenue, 6th Floor
Austin, TX 78701

RE: Statement of Qualifications for Improving Simulation of Groundwater/Surface Water Interaction in the Groundwater Management Area 12 Groundwater Availability Model

Dear Ms. Wallace and Members of the Evaluation Committee,

INTERA Incorporated (INTERA) is pleased to submit this Statement of Qualifications (SOQ) in response to the Texas Water Development Board's (TWDB or Board) Request for Qualifications (RFQ) No. 580-16-RFQ0014 to conduct the above-referenced work. We understand that the focus of this Project is to improve the capability of the groundwater availability model (GAM) currently under revision (by an INTERA-led team under another contract with the TWDB) for the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers to better simulate groundwater-surface water interaction along the Colorado River and its tributaries within Groundwater Management Area (GMA) 12.

As a leader in performing hydrogeologic evaluations and modeling analyses to characterize and quantify groundwater resources in Texas, INTERA has completed many recent studies of the Carrizo-Wilcox, Queen City, and Sparta aquifers for the TWDB, groundwater conservation districts (GCDs), and commercial industry. To assist us in executing this Project, we have enlisted the support of two additional companies—GSI Environmental (GSI) and Freese & Nichols, Inc. (FNI). Collectively referred to as the 'INTERA Team', we offer the TWDB a number of key assets that will enable us to not only deliver the highest quality analyses and work products that are scientifically-sound and defensible, but do so in a timely and cost-effective manner. These assets are briefly described below.

- **Expertise with the Carrizo-Wilcox, Queen City, and Sparta Aquifers and the Colorado River Basin.** Under the TWDB's Groundwater Availability Modeling Program, INTERA developed the original GAMs for the northern and southern portions of the Carrizo-Wilcox Aquifer and subsequently developed the GAMs for the northern, central, and southern portions of the Queen City and Sparta aquifers (which include the Carrizo-Wilcox and replaced the original GAMs for this aquifer). We are currently working under contract to the TWDB to evaluate the effect of faults on groundwater flow and update the GAM for the central portion of the Carrizo-Wilcox Aquifer to better represent these important structural features. As part of the Lower Colorado River Authority (LCRA) – San Antonio Water System (SAWS) Water Project (LSWP), INTERA staff evaluated the hydrology and hydrogeology of the aquifers in the lower Colorado River Basin where our efforts included developing a groundwater model (called the Lower Colorado River Basin [LCRB] model) to design well fields capable of providing additional water during periods of drought and evaluating groundwater-surface water interaction between the Colorado River Alluvium and the Gulf Coast Aquifer System.
- **Proven Performance for the TWDB.** Under contract to the TWDB, INTERA has led the development of 12 GAMs and completed dozens of other studies in support of the Board's Groundwater Availability Modeling and Brackish Resources Aquifer Characterization System programs. In completing all of this work, we have demonstrated the ability to produce high quality technical work products and successfully complete challenging projects in accordance with schedule and budget requirements and expectations.

- **An Outstanding Team of Management and Technical Personnel.** As a Principal Hydrogeologist at INTERA, I will oversee the INTERA Team's efforts on this Project. I bring over 30 years of technical and management experience, the last 16 of which have been focused on Texas water resources. I have managed the development of numerous GAMs of major and minor aquifers across Texas (including the model of the southern portion of the Carrizo-Wilcox Aquifer and the northern, central, and southern portions of the Queen City and Sparta aquifers) and completed dozens of hydrogeologic evaluations and studies to support the development, management, and use of groundwater resources across the State. Steven Young, PhD, PE, PG will serve as our Project Manager, and brings over 30 years of experience that includes currently managing another TWDB-funded project to refine the central portion of the Carrizo-Wilcox Aquifer. As part of the LSWP, he helped improve the understanding of groundwater-surface water interaction along the Colorado River by installing alluvium wells next to river gages, conducting river gain/loss studies, and performing hydrograph separation analyses on river gage data. Our team also includes technical experts like GSI's Dr. Sorab Panday who co-developed the MODFLOW-USG code that will be used as part of the GAM refinements for this Project.
- **A Sound Technical Approach.** Through INTERA's current work in updating the GAM for the central Carrizo-Wilcox, Queen City, and Sparta aquifers, we are uniquely positioned to directly integrate this Project's scope of work into the new model. INTERA has a long history of providing field technical support for groundwater monitoring studies, and we routinely design and/or install groundwater monitoring systems for a variety of water resource development/management and environmental investigation projects, with great attention paid to data quality control, health and safety, and cost efficiency. The INTERA Team are experts in geospatial analysis, using software such as ESRI ArcGIS, as well as modeling using surface water software such as RiverWare, surface water models such as the TCEQ's WAMs, groundwater software such as MODFLOW, and groundwater models such as the TWDB's GAMs. Our expertise in the areas of field data collection, statistical analysis, programming, geospatial mapping, and modeling will enable us to implement a sound technical approach to collecting and analyzing data associated with surface water-groundwater interaction in the Colorado River Basin.

Equally important to the assets described above, all of the INTERA Team companies and personnel are firmly committed to the success of this Project. We have chosen to work on water resource issues not only because they are challenging and require creative technical and management solutions, but because they are important to us, personally. We share TWDB's overall mission of preserving and protecting the water resources of Texas through effective management. We are confident that the Board's review of this SOQ will confirm the INTERA Team's skills, capacity, and desire to support this mission. Should you have any questions regarding our SOQ, or require additional information, please do not hesitate to contact me at 512-425-2047 or by email at vkelley@intera.com. Again, we look forward to supporting the TWDB with this important work.

Sincerely,

Van Kelley

Van Kelley, PG
Principal Hydrogeologist and Executive Vice President

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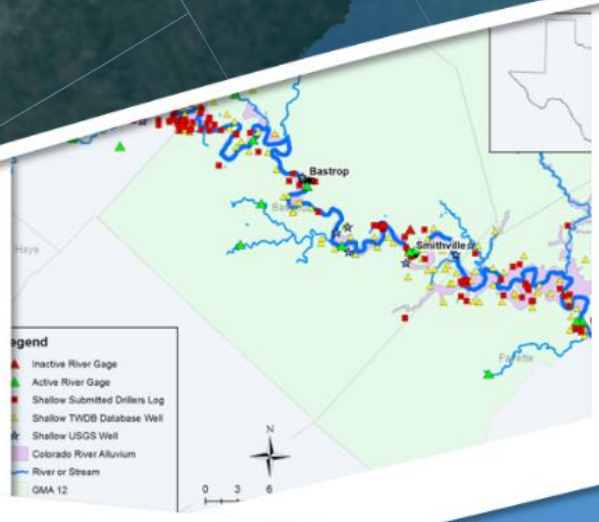

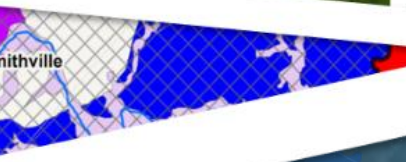

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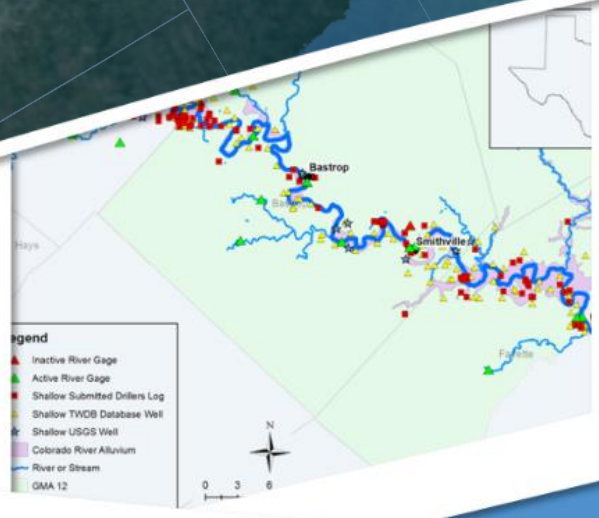

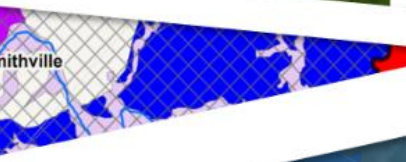

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CONTENT ITEM 1: SIGNED/DATED EXECUTION OF RESPONSE TO THE REQUEST FOR QUALIFICATIONS

INTERA's executed response to the RFQ (Attachment A from the RFQ) is provided below. In response to the conflict of interest requirement defined in Section 5.17 of the RFQ (page 13), INTERA does not have any business interest or relationships that could reasonably be considered to pose possible conflicts of interest in our performance of contract obligations. Furthermore, INTERA represents and warrants that in the performance of services under this contract with the TWDB, (1) we do not have and will not have any actual or potential conflict of interest, and (2) we will take whatever reasonable actions may be necessary and prudent to avoid even the appearance of impropriety. Acknowledgement of INTERA's receipt of Addendum No. 1 to the RFQ is provided in **Attachment A**.

Texas Water Development Board
REQUEST FOR QUALIFICATIONS NO. 580-16-RFQ0014
IMPROVING SIMULATION OF GROUNDWATER/SURFACE WATER INTERACTION IN THE GROUNDWATER MANAGEMENT AREA-12 GROUNDWATER AVAILABILITY MODEL

CONTENT ITEM 1
EXECUTION OF STATEMENT OF QUALIFICATIONS
to the
REQUEST FOR QUALIFICATIONS

Company Name: INTERA Incorporated

Address: 1812 Centre Creek Drive, Suite 300

Austin, TX 78754

Phone Number: 512-425-2000

E-Mail: vkelley@intera.com

I, Van Kelley, am the above-referenced company's representative and I am authorized to submit this response and sign future contract documents. By signing below, the representative certifies that if a Texas address is shown as the address, the respondent qualifies as a Texas Bidder as defined in 34 TAC Rule 20.32(68).

Authorized Signature

April 1, 2016
Date

Senior Vice President
Title:

CONTENT ITEM 2:
COMPANY PROFILE SUMMARY AND HISTORY

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

CONTENT ITEM 2:
Company Profile and History

CONTENT ITEM 2: COMPANY PROFILE SUMMARY AND HISTORY

A summary of the team that INTERA has assembled to revise the GAM for the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers to better simulate groundwater-surface water interaction along the Colorado River and the tributaries along the Colorado River in GMA 12 is provided below. The following general information is provided for INTERA.

a. Company name, address, phone number, and legal status:

INTERA Incorporated, 1812 Centre Creek Drive, Suite 300, Austin, TX 78754, 512-425-2000, Texas Corporation

b. Name and title of person submitting the proposal with the authority to bind the company:

Mr. Van Kelley, Executive Vice President

c. Name, phone number, and email address of contact person for any questions on the proposal:

Dr. Steven Young, 512-425-2071, syoung@intera.com

d. Describe the general nature of previous work, the number of years in business, size and scope of operation: Summaries of INTERA and our proposed subconsultants are provided below.

Established in 1974, **INTERA** is an Austin, Texas-based geosciences and engineering firm. With over 40 years of corporate experience, INTERA is a leader in applying numerical models and other quantitative tools to gain a better understanding of hydrogeologic systems—from determining the availability of a groundwater resource and evaluating groundwater flow and the transport of contaminants in the subsurface, to quantifying specific hydrogeologic processes that effect a site's ability to safely isolate radioactive wastes. Through offices in Texas, New Mexico, Florida, California, Indiana, Washington, France, and Switzerland, INTERA's solutions are provided by an outstanding staff of 125 professionals specializing in geology, hydrogeology, hydrology, water resource and environmental engineering, geostatistics, remote sensing, and GIS technology. In Texas, we are registered to perform geoscientific and engineering services by the Texas Boards of Professional Geoscientists and Engineers (Geosciences Registration Number 50189 and Engineering Registration Number 4722). INTERA has 35 groundwater and surface water professionals located in Texas including eight registered Texas Professional Engineers and 14 registered Texas Professional Geoscientists. In addition, many of our geoscientists are nationally licensed as Certified Ground Water Professionals and Professional Hydrogeologists.

In the Colorado River Basin, INTERA staff have evaluated the hydrology and hydrogeology of the aquifers in this basin as part of projects such as the Lower Colorado River Authority (LCRA) – San Antonio Water System (SAWS) Water Project (LSWP). This project included developing a groundwater model for a 10-county area encompassing the Lower Colorado River Basin that was used to design well fields capable of delivering an additional 90,000 acre-feet per year of water in a year of drought. We have also completed dozens of hydrogeologic studies and evaluations for GCDs and GMAs within the Colorado River Basin. Under the TWDB's Groundwater Availability Modeling Program, INTERA developed the groundwater availability models (GAMs) of the northern and southern portions of the Carrizo-Wilcox Aquifer in 2003. A year later, we completed the development of three GAMs of the Queen City and Sparta aquifers (northern, central, and southern portions) which include the overlying Carrizo-Wilcox Aquifer. As part of developing the Queen City and Sparta GAMs, INTERA addressed several inconsistencies between the Carrizo-Wilcox GAMs that resulted from the models being

developed by two different modeling teams (the original central Carrizo-Wilcox GAM was developed by the Bureau of Economic Geology [BEG] in 2003). As a result, these GAMs now serve as the "official" TWDB water planning tools for use in evaluating groundwater resources in the Carrizo-Wilcox, Queen City, and Sparta aquifers. INTERA is currently working, under contract to the TWDB, to evaluate the effect of faults on groundwater flow and update the GAM for the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers to better represent these important structural features.

We have also developed GAMs for the Brazos River Alluvium, Yegua-Jackson, Dockum, Rustler, and Seymour (includes the Blaine in a first order treatment) aquifers as well as the entire High Plains Aquifer System. We also have experience in updating and revising existing GAMs including the models of the Northern Trinity and Woodbine, Northern Ogallala, and Edwards-Trinity aquifers. Through all of this experience and the valuable lessons we have learned in completing these projects, INTERA staff bring detailed knowledge of the TWDB GAM groundwater geodatabase schema for documenting source data, the application of GIS in support of developing and using these models, transferring the GAM technology to the TWDB and other users, and soliciting input and communicating the results of these projects through stakeholder advisory forums and formal written reports. INTERA's scientists and engineers have also developed and executed plans to monitor and interpret groundwater-surface water interactions. As part of developing the GAM for the Brazos River Alluvium Aquifer, we used surface water modeling results to evaluate impacts that stream flows have on water levels in the aquifer. We have also taken flow measurements using Acoustic Doppler Current Profilers to evaluate surface water gains/losses in the Brazos River Basin of Texas and the Rio Grande River Basin in New Mexico.

GSI ENVIRONMENTAL

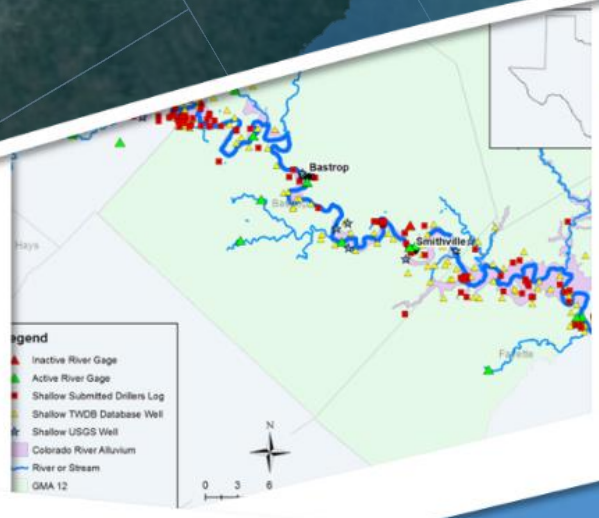
Founded in 1986, **GSI** is an engineering and science consulting firm that provides government and private-sector clients with innovative solutions to soil, groundwater, surface water, and air pollution problems and associated regulatory and technology transfer issues. GSI employs more than 70 staff in offices in Houston and Austin, Texas, and Oakland and Newport Beach, California. The company's modeling staff provide a wide-range of expertise, whether the solution calls for application of standard modeling tools or development of unique numerical solutions for complex applications. This includes supporting the development of widely used modeling tools such as BIOCHLOR, MAROS, MODFLOW-USG, and the Matrix Diffusion Toolkit. GSI's Dr. Sorab Panday is the co-developer of both MODFLOW-NWT and MODFLOW-USG.

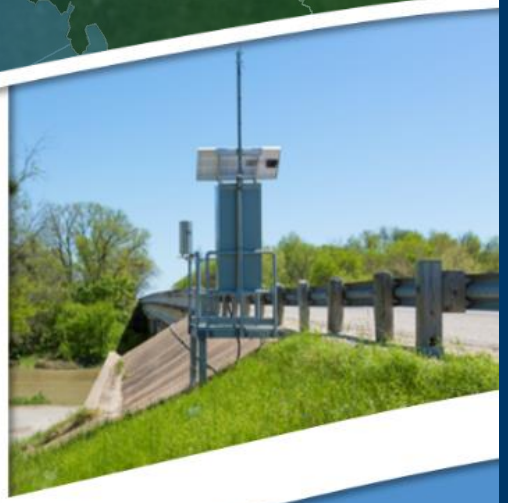
FREESE AND NICHOLS

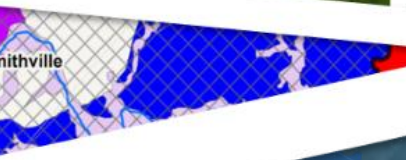
Freese and Nichols, established in 1894, is Texas' oldest continuously operating consulting engineering firm. Since its founding, FNI has developed a specialization in municipal water supply, providing a wide range of innovative solutions to help meet water supply needs. The company's experience includes helping clients understand and successfully integrate the full gamut of available water supply options. FNI brings experience in all forms of regulatory compliance, including surface water permitting, bed and banks permitting for transfer of groundwater, water reclamation and reuse, environmental permitting, and others. The company is a leader in Texas for water supply planning having been involved in the development of water supply plans for nine of the state's 16 Regional Water Planning Groups. FNI has also planned for and designed thousands of water and wastewater treatment facilities, including facilities that require advanced treatment due to diminished water quality. The company's staff understands and has successfully designed for the challenges associated with integrating multiple sources of water into a water supply system. FNI personnel have successfully worked on projects with INTERA to address the issue of groundwater-surface water interaction such as the Brazos River Alluvium GAM, and bring experience that includes reviewing the Colorado River water availability model (WAM) and evaluating water rights in the Colorado River Basin.

CONTENT ITEM 3:

RESUMES OF INDIVIDUALS







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CONTENT ITEM 3: RESUMES OF INDIVIDUALS

The INTERA Team has assembled an outstanding group of management and technical personnel to revise the GAM of the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers to better simulate groundwater-surface water interaction along the Colorado River and its tributaries in GMA 12. Our proposed project organization is shown in **Figure 3-1**. Our organization and management approach is designed to satisfy the following objectives: provide timely and effective administration of the contract; be highly responsive to TWDB; ensure efficient access to and optimal use of our personnel as required by each specific technical task; provide complete, on-schedule, on-budget, quality-assured performance on all tasks; and provide effective communication among team members and the TWDB and other stakeholders. **Figure 3-2** shows the primary roles and responsibilities of our management positions.

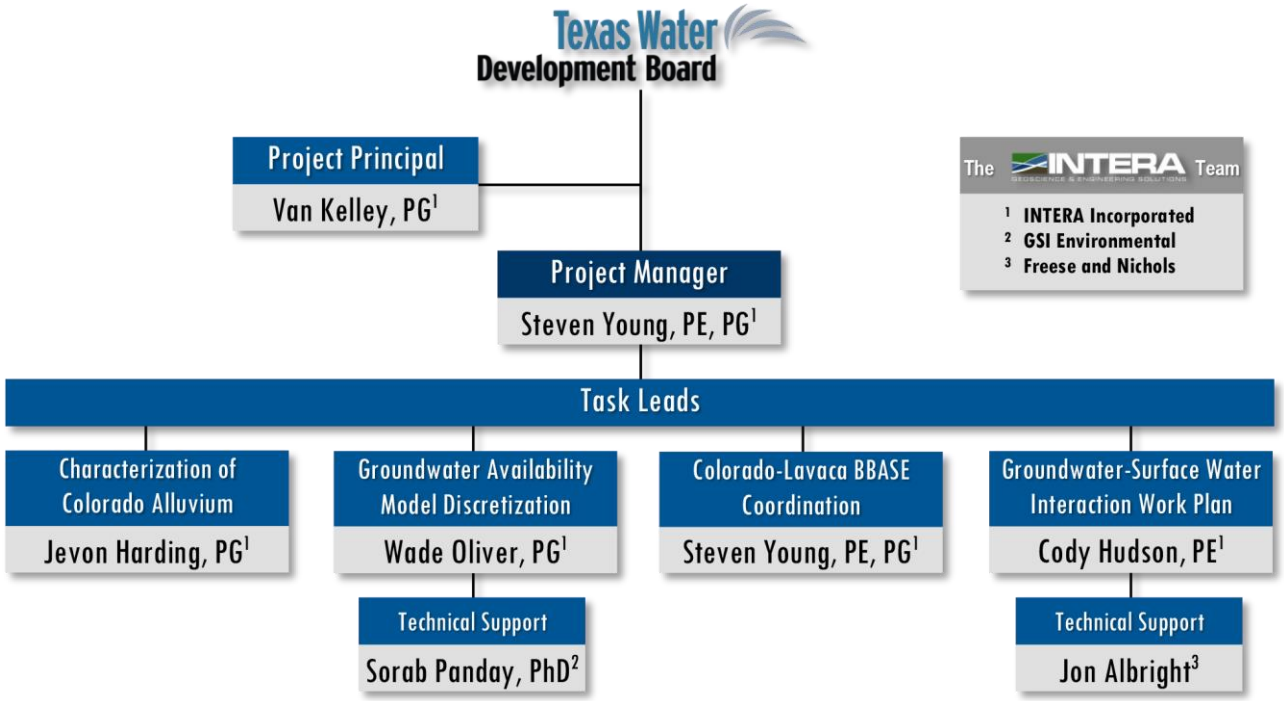

Figure 3-1. Project organizational structure showing proposed personnel

Figure 3-3 provides a summary of our personnel's expertise and capabilities in the areas defined in the evaluation criteria (page 8 of the RFQ) and other required areas defined in Section 2.3 (Requirements) of the RFQ. Resumes of our project team, presented in the order they appear in Figure 3-3 are provided on the following pages. The resume page numbers are preceded by the letter "E" (e.g., E-1, E-2, etc.) to indicate that they are "Excluded" from the 20-page limit for the SOQ. Following the resumes, more detailed descriptions of several relevant projects completed by our proposed staff are provided. These projects address the INTERA Team's knowledge, familiarity, and experience in the areas identified in the six evaluation criteria defined on page 8 of the RFQ, including hydrology and hydrogeology of the Colorado River Basin and associated aquifers; the existing GAMs for the Carrizo-Wilcox and QCSP aquifers; the TWDB's GAM groundwater geodatabase schema for documenting source data and GIS; technology transfer; communication of analyses results; and the development of plans for monitoring and interpreting surface water-groundwater interactions.

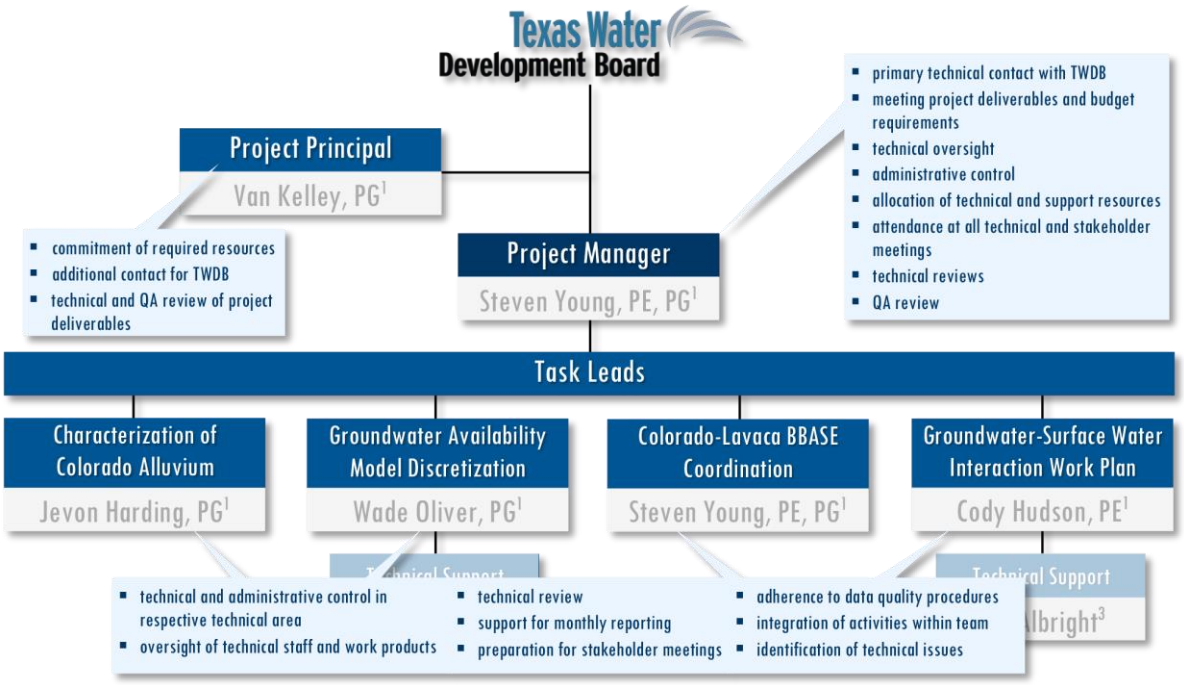

Figure 3-2. Roles and responsibilities of key positions

NAME/ PROPOSED ROLE	EDUCATION (Highest Degree)	YRS EXP	RELEVANT AREAS OF EXPERTISE AND EXPERIENCE: Evaluation Criteria: Hydrology and hydrogeology of the Colorado River Basin	Hydrology and hydrogeology of the Carrizo-Wilcox, Queen City, and Sparta aquifers	GAMs of Carrizo-Wilcox, Queen City, and Sparta aquifers	Groundwater geodatabase schema used in TWDB GAM Program and GIS	Technology transfer including on-schedule and within budget performance	Communication of results of analyses in graphical, written, and oral format	Development of plans to monitor and interpret surface water-groundwater interactions	Additional Scope Elements: Literature searches to estimate hydrogeologic properties (e.g., transmissivity, storage, etc.)	Modification of GAMs to add model layers and/or refine grid size	Application of GAMs in GMA 12	Stakeholder meetings and interaction
Van Kelley, PG / Project Principal	MS Geology	34	■	■	■	■	■	■		■	■	■	■
Steven Young, PE, PG / Project Manager, Task Lead	PhD Earth Sciences	31	■	■	■	■	■	■	■	■	■	■	■
Jevon Harding, PG / Task Lead, Characterization	MS Hydrology	8		■		■	■	■		■		■	■
Wade Oliver, PG / Task Lead, GAM Discretization	MS Geology	10	■	■	■	■	■	■		■	■	■	■
Sorab Panday / Tech. Support / GAM Discretization	PhD Civil/Envir. Engineering	27				■	■	■		■	■		■
Cody Hudson, PE / Task Lead, GW-SW Interaction	MS Envir. Engineering	10				■	■	■	■	■			■
Jon Albright / Tech. Support, GW-SW Interaction	BS Hydrology & Water Res.	35	■				■	■	■				■

Figure 3-3. Summary of expertise and experience of the INTERA Team's proposed personnel

Van Kelley, PG

INTERA

Project Principal

Years of Experience: 33

Education:

- MS, 1985, Hydrogeology, Texas A&M University
- BS, 1982, Petroleum Geology, Mississippi State University

Professional Certifications:

- Professional Geoscientist, Texas, No. 4923

Key Experience:

- 33 years in hydrogeology and modeling, including managing work on 7 GAMs including the Carrizo-Wilcox, Queen City, and Sparta aquifers
- Knowledge of the hydrology and hydrogeology of the Lower Colorado River Basin
- Proven ability to deliver projects involving water resource evaluations on schedule and on budget

Van Kelley is a Principal Hydrogeologist at INTERA with 33 years of experience in the fields of geology, hydrogeology, and numerical groundwater flow modeling. He has given dozens of presentations on aquifer characterization and groundwater flow modeling including published work in conference proceedings and journals. He also has a personal and professional interest in explaining the role of groundwater models in water resources focusing on issues of scale, availability, and water resources management. Mr. Kelley regularly presents to GCDs, GMAs, the Texas Alliance of Groundwater Districts and the Texas Water Conservation Association. He has experience in general hydrogeology ranging from basic aquifer monitoring, aquifer characterization including pumping tests, core analysis, and detailed borehole fluid logging analysis using moment methods and numerical simulators.

Mr. Kelley has managed projects for 26 years and has successfully managed multi-disciplinary teams on projects as small as $10,000 to $5 million. Over the last 24 years, he has served as a Project Manager for several large modeling projects. For the TWDB's Groundwater Availability Modeling Program, he managed INTERA's efforts on the southern Carrizo-Wilcox Aquifer GAM, the three GAMs for the Queen City and Sparta aquifers, the Yegua-Jackson Aquifer GAM, and the Rustler Aquifer GAM. He was modeling task manager for the LSWP, which focused on developing a detailed groundwater flow model in the Lower Colorado River Basin Gulf Coast Aquifer. Mr. Kelley was the Project Manager for refining and updating the Northern Trinity and Woodbine Aquifer GAM. He also managed the technical development of a complex three-dimensional GAM in the Española Basin of New Mexico.

Mr. Kelley has 31 years of experience in general hydrogeology ranging from basic aquifer monitoring, aquifer characterization including pump tests, core analysis, and detailed borehole fluid logging analysis using moment methods and numerical simulators. His experience includes the design, fielding, and interpretation of tracer tests. He has participated in and managed large field characterization programs including large-scale pumping tests, tracer tests in fractured media, and detailed fracture characterization studies using packer testing and dual-tracer techniques. As part of his work on the southern Carrizo-Wilcox Aquifer GAM, he studied the detailed hydrogeology of the Carrizo-Wilcox Aquifer and the overlying Queen City Aquifer. He has actively integrated geologic information into hydrostratigraphic models for dozens of projects including the Carrizo-Wilcox and Queen City aquifers and in the Palo Duro Basin of Texas as part of the DOE's early efforts back in the 1980s to identify potential rock types and locations suitable for disposing of radioactive wastes.

Mr. Kelley also brings experience communicating with the public and with his peers and regularly presents the results of his work at conferences. His management role on several high visibility projects has required communication of complex technical issues to the public. Mr. Kelley led the SAF meetings on the southern Carrizo-Wilcox, Queen City and Sparta, Yegua-Jackson, Rustler, Northern Trinity and

Van Kelley (cont.)

Woodbine aquifers GAMs. He also made presentations to the LSWP Science Review Panel and has made technical presentations to GCDs and other water planning organizations on topics ranging from "Aquifers 101", water budgets, and conceptual models to detailed numerical modeling analyses. In the area of technology transfer, Mr. Kelley has assisted in developing workshops to demonstrate the application of codes developed by INTERA, including SWIFT-II and nSights. He has developed code user documentation for many codes and pre- and post-processors, revised the SWIFT-II User's Manual, and developed test problems with the supporting documentation to support teaching curriculums. He also is experienced in providing client training in the use and application of models.

Representative Project Experience

Development of Groundwater Availability Models (GAMs) for the Queen City and Sparta Aquifers, Incorporating the Carrizo-Wilcox GAMs, Texas Water Development Board (TWDB), Austin, TX. 2002 – 2004. *Project Manager.* In support of the TWDB's GAM program, led INTERA's development of three regional MODFLOW models for the southern, central, and northern portions of the Queen City and Sparta Aquifers. Each model consisted of eight layers representing the Sparta, Queen City, and Carrizo-Wilcox aquifers, as well as the intervening aquitards. Key technical issues included hydraulic properties, recharge, and aquifer-stream interaction. In addition to the standard GAM calibration requirements, developed a set of models that reproduced water balances consistent with the accepted conceptualization of groundwater flow in the aquifer. The Queen City and Sparta GAMs intersect 10 of the 16 Regional Water Planning Groups (RWPGs) in Texas, and consistent with state water planning policy, the models were developed with the support of numerous stakeholders. In addition to leading the modeling efforts, organized and conducted quarterly stakeholder forums involving the TWDB, RWPGs, groundwater conservation districts, river authorities, and the public to present modeling results and solicit input. These GAMs were subsequently used by state planners, RWPGs, consultants, and other interested stakeholders to support water planning.

Development of Groundwater Availability Models for Southern Portion of the Carrizo-Wilcox Aquifer, Texas Water Development Board, Austin, TX. 2001 – 2003. *Project Manager and Lead Modeler*. In support of the TWDB's GAM program, led INTERA's development of a regional MODFLOW model for the southern Carrizo-Wilcox Aquifer (basin divide between the Colorado and Guadalupe Rivers to the Rio Grande River). Efforts included developing a steady-state, pre-development model and a transient model calibrated from 1980 through 1990. The time period from 1991 through 2000 was used for validation and predictions were made from 2001 to 2050. Conceptual model development included the review and assessment of aquifer/aquitard system geometry (geology, hydrostratigraphy, outcrops, river basins, and model boundaries), water levels and regional groundwater flow, aquifer hydraulic properties, recharge, discharge (groundwater/ surface water interaction and pumping), and water quality. Additional project tasks included database development, GIS data development and presentation, reporting and web publishing, and stakeholder meetings. Responsible for leading the modeling team, providing senior technical input, interfacing with the TWDB, and planning and conducting quarterly stakeholder meetings to present the results of the modeling efforts and to solicit input. All project milestones and deliverables were completed on schedule and on budget.

Development of a Groundwater Availability Model for the Yegua-Jackson Aquifer, Texas Water Development Board, Austin, TX. 2008 – 2010. *Project Manager.* Led development of the Yegua-Jackson Aquifer GAM. The model is comprised of five layers and extends from the Rio Grande to the Red River. Since the Yegua-Jackson is a minor aquifer with little supporting data, the modeling efforts

Van Kelley (cont.)

relied heavily on the depositional environment study that was part of an earlier study completed by INTERA to develop the structure for this aquifer system.

Development of Structure for the Yegua-Jackson Aquifer, Texas Water Development Board, Austin, TX. 2006 – 2007. *Project Manager*. Led the team responsible for developing the geologic structure for the Yegua-Jackson Aquifer in Texas to support the subsequent development of a GAM of the aquifer. The analysis augmented previous stratigraphic interpretations with 250 well logs within the outcrop and along the downdip boundaries of the aquifer. The log data were used to subdivide the Yegua and Jackson intervals into genetic units on the basis of maximum flooding surfaces, which were presumed to be time-synchronous. The spontaneous potential (SP) and resistivity curves from 150 logs were digitized for consistent, repeatable percent-sand calculations. These new structural and lithologic data were then incorporated with trends from previous studies to produce updated genetic maps spanning the aquifer trend from Mexico to Louisiana.

Groundwater Modeling to Assess Pumping Impacts in the Lower Colorado River Basin, Lower Colorado River Authority, Austin, TX. 2004 – 2010. *Task Manager*. Led INTERA's modeling efforts as part of the Groundwater for Agriculture Technical Team for the Lower Colorado River Authority (LCRA)–San Antonio Water System (SAWS) Water Project (LSWP). This project involved conserving irrigation water and capturing excess and unused river flows to make available as much as 330,000 acre-feet of water per year (AFY). In periods of drought, as much as 66,000 AFY would be pumped to augment surface water irrigation sources. Tasks included conducting a literature review and data collection to support the development of a conceptual groundwater flow model; developing and calibrating a groundwater model capable of simulating the impacts caused by the LSWP pumping activities to land subsidence, changes in water quality, saltwater intrusion, groundwater availability estimates, and changes in surface water-groundwater interactions; identifying potential groundwater impacts caused by pumping associated with the LSWP; and designing and evaluating alternative LSWP well field designs. Responsibilities included leading the modeling team and providing senior technical input to the model design, calibration, and application; participating in meetings and presentations with other consultants, the Lower Colorado River Authority, the San Antonio Water System, and other project stakeholders; and developing subsequent project tasks to refine the predictive capabilities of the model.

Support of Water Rights Appraisal in the Gulf Coast Aquifer, Queen City and Sparta and Carrizo-Wilcox Aquifers of East and Southeast Texas, Private Client, TX. 2014. *Principal Hydrogeologist and Project Manager*. Retained by a private client to provide technical support for a regional water resources appraisal of groundwater resources in the Tertiary Aquifers of southeast Texas. Led the effort to estimate physical aquifer sustainable production, regulatory constraints, potential for subsidence. Aquifers studies included the Gulf Coast Aquifer System, the Queen City and Sparta Aquifers and the Carrizo-Wilcox Aquifers.

Relevant Publications/Reports

V.A. Kelley and L. Clancy, 2014. Groundwater and Surface Water Interactions: Reconciling the Science and the Law. Joint presentation by INTERA and the Lower Colorado River Authority Presented at the Texas Water Conservation Association Fall Meeting, San Antonio, Texas, October 16th, 2014.

Arroyo, J., R.F. Adams, E.T McDonald, A.H. Plummer, B. Austin and V. Kelley, 2014. Chapter 24 – Innovative Water Technologies, Essentials of Texas Water Resources, 3rd Edition, Mark K. Sahs – Editor, Texas Bar Books, 1188 p.

Van Kelley (cont.)

Schuster, S., and V. Kelley, 2013. Groundwater Monitoring and Texas Groundwater Conservation Districts. Presented at the Texas Water Conservation Association Mid-Year Conference, Galveston, Texas, June 21st, 2013.

Kelley, V.A., B.S. Ramarao, T. Clemo, and M. Lavenue, 2013. An Innovative MODFLOW-based Tool for Managing Ground-Water Resources. Presented at the NGWA Summit — The National and International Conference on Groundwater, April 28-May 2, 2013, in San Antonio, TX.

Sledge, B., B. Mullican, and V. Kelley, 2013. A local Initiative to Improve Groundwater Science of the GMA-scale. Presented at the Texas Water Conservation Association 69th Annual Convention, Austin, Texas, March 6-8, 2013.

Kelley, V.A., N. Deeds, and D. Fryar, 2009. Hydrogeology of the Queen City and Sparta Aquifers with an Emphasis on Regional Mechanisms of Discharge. Published in Aquifers of the Upper Coastal Plains of Texas, TWDB Report 374, 87-116.

Kelley, V.A., and S. Young, 2009. Importance of Groundwater-Surface Water Interactions to Texas Water Programs. Presented at the 65th Annual Convention of the Texas Water Conservation Association, Feb. 26, 2009, Austin, TX.

Kelley, V.A., N. Deeds, D. Fryar, and R. Senger, 2009. Development of Regional Groundwater Availability Models of the Carrizo-Wilcox Aquifer of Texas. Presented at the GCAGS Annual Conference Session: The Wilcox, from the Outcrop to the Abyss, Sept. 29, 2009, Shreveport, LA.

Kelley, V.A., 2008. Ground Water Availability–Texas. Presented at the 2008 Ground Water Expo, Ground Water Sustainability Interest Group Public Session, Dec. 3.

Kelley, V.A., R. Mace, and N. Deeds, 2008. Groundwater Availability Modeling –The Texas Experience. Published in The Water Report, 54.

Young, S., and V.A. Kelley, 2007. Size Does Matter–Regional versus Local Groundwater Availability Modeling. Presented at the 63rd Annual Convention of the Texas Water Conservation Association, March 6–8, 2007, Austin, TX.

Kelley, V.A., and N. Deeds, 2004. The Queen City and Sparta GAMs, Strengths and Limitations for Groundwater Management. Presented at Texas Groundwater 2004, Texas Capitol Extension, Nov. 19, Austin, TX.

Kelley, V.A., N. Deeds, D.G. Fryar, and J.P. Nicot, 2004. Groundwater Availability Model for the Queen City and Sparta Aquifers. Report to the Texas Water Development Board, 867 p.

Deeds, N., V.A. Kelley, D.G. Fryar T. Jones, A. Whallon, and K. Dean, 2003. Groundwater Availability Model for the Southern Carrizo-Wilcox Aquifer. Report to the Texas Water Development Board, 452 p.

Kelley, V.A., N. Deeds, D.G. Fryar, and R. Senger, 2003. A Recharge Estimation Technique for Regional Groundwater Availability Models. Presented at MODFLOW 2003, International Ground Water Modeling Center, Sept. 17–19, Colorado School of Mines, Golden, CO.

Kelley, V.A., R. Senger, N.E. Deeds, and D.G. Fryar, 2002. Challenges and Approaches for Groundwater Availability Modeling of the Carrizo-Wilcox Aquifer of Texas. Presented at the Gulf Coast Association of Geological Societies Annual Conference, Beyond the Horizon, Oct. 31–Nov. 1, 2002, Austin, TX.

Steven Young, PhD, PE, PG

INTERA

Project Manager, Task Lead – BBASE Coordination

Years of Experience: 34

Education:

- PhD, 1996, Earth Sciences, University of Waterloo, Canada
- MS, 1982, Environmental Engineering, Stanford Univ.
- BS, 1981, Environmental Sciences, Univ. of Virginia

Professional Certifications:

- Professional Engineer, Texas, No. 88049
- Professional Geoscientist, Texas, No. 231
- Certified Ground Water Professional, No. 3027410

Key Experience:

- 30 years in characterization and modeling of groundwater for water resource supply
- Technology and knowledge transfer through technical workshops, public meetings, and teaching groundwater modeling courses
- Over 100 papers (including peer-reviewed publications), conference presentations, and reports

Steven 'Steve' Young is a Principal Geoscientist and Engineer at INTERA with 34 years of experience in the fields of geology, hydrogeology, and numerical groundwater flow and transport modeling. He is an expert in the hydrogeology of many of the aquifer systems in Texas. For the last 15 years, his work has focused on evaluating groundwater resources in Texas including the Carrizo-Wilcox Aquifer, Gulf Coast Aquifer System, and the Northern Trinity Aquifer. As Project Manager of the Groundwater Study for the LSWP from 2003 to 2010, Dr. Young helped improve the understanding of the groundwater-surface water exchange along the along the Colorado River by installing alluvium wells next to river gauges, assisting with river gain/loss studies, and by performing hydrograph separation analyses on river gage data. He led the development of the Lower Colorado River Basing (LCRB) model which demonstrated the importance of incorporating shallow model layers in regional groundwater models to adequately represent the shallow groundwater flow zone which interacts with surface water bodies and is hydraulically distinct from a deep regional flow zone.

For over 10 years, Dr. Young has worked for the Post Oak Savannah GCD and GMA 12 on projects that include investigating the limitations of the GAMs and data sets used for evaluating groundwater management strategies in GMA 12, interpreting water level monitoring data, estimating groundwater baseflows for the Brazos and Colorado rivers, and interpreting geophysical logs to characterize the water quality and sand thickness in the aquifers beneath GMA 12. He is currently the Project Manager for a TWDB-funded project to update of the GAM of the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers for GMA 12.

Dr. Young has managed numerous large projects for both public and private firms and has worked with over 15 GCDs in Texas. His work for GCDs includes support for developing management plans, groundwater rules, groundwater databases, and assessing groundwater resources. He has participated in joint planning activities with several GMAs and helped with the development and modification of GAMs. He has managed groundwater remediation projects for numerous state and federal agencies, including the U.S. Department of Defense and the Department of Energy, several public utilities, manufacturing companies, and for private industry.

Through his graduate studies, including his PhD research, Dr. Young developed specialized skills and expertise in estimating hydraulic properties of alluvium material. His graduate research at Stanford University and the University of Waterloo focused on using sedimentological concepts to characterize the hydraulic properties of aquifers. He has published several papers that have defined relationships between the physical and hydraulic properties of aquifers in Texas, and has correlated physical and hydraulic properties by examining depositional environments, depth, porosity, core properties, and

Steven Young (cont.)

lithology. To determine the hydraulic properties of aquifers, Dr. Young has designed, performed, and interpreted numerous types of aquifer tests. He has over 100 publications related to the characterization or modeling of aquifer heterogeneity and has conducted training workshops, under contract to the U.S. EPA, focused on analyzing aquifer tests and establishing the relationship between physical and hydraulic properties in heterogeneous aquifers. He has applied sedimentological concepts to estimate hydraulic conductivity for several aquifers in Texas that include the Carrizo-Wilcox, Yegua-Jackson, and Gulf Coast aquifers System including the Catahoula, Jasper, Chicot, and Evangeline aquifers. As part of these studies, he has analyzed geophysical logs to develop comprehensive stratigraphic and sedimentological interpretations, and map sand channels and depositional facies.

Prior to working as a hydrogeological consultant in Texas, Dr. Young worked for 13 years at the Tennessee Valley Authority (TVA). As a project manager at TVA, he supervised several groundwater research projects and developed numerous groundwater models across a seven-state area to help quantify the interactions between groundwater and surface water flows. As part of this work, he performed dye tracer studies, stable isotope and trace element analyses, and detailed water level monitoring between riverine and aquifer systems to help quantify groundwater flow.

Representative Project Experience

Identification and Characterization of Brackish Groundwater Resources in GMA 13, Bureau of Economic Geology, TX. 2015 - 2016. *Project Manager.* Developed conceptual and numerical models to assess the impacts of pumping brackish production zones on existing water supply wells zones in the Carrizo-Wilcox, Sparta, and Queen City aquifers. Developed and applied software to calculate volumes associated with potential brackish production zones. Interpreted geophysical logs to estimate the spatial distribution in porosity and hydraulic properties of sands containing brackish groundwater and clays that could serve has hydrogeological barriers. This work is part of a report for the TWDB.

Update of the Carrizo-Wilcox, Queen City, and Sparta GAM for GMA 12, Texas Water Development Board, TX. 2015 - 2016. *Project Manager.* Updated the conceptual groundwater flow model for the GAM with regard to the regional fault zones, and hydraulic properties for the Carrizo-Wilcox, Queen City, and Sparta aquifers. Analyzed 1200 geophysical logs to map the Mexia-Talco fault zone and the offsets in the Simsboro formation. Used water levels and pumping rates from large scale aquifer tests to estimate aquifer hydraulic properties and to help recalibrate the GAM. Refined the numerical grid around rivers to improve the GAM's capability to simulate groundwater-surface water interaction. Conducted a literature review to characterize the physical and hydraulic properties of the Colorado Alluvium in the GMA 12 area. Developed a geohydrostratigraphic model to provide relationships and constraints for assigning hydraulic properties to aquifers during model calibration. Conducted workshops with stakeholders to request information and to discuss approaches to modeling.

Development of a Groundwater Availability Model for the Yegua-Jackson Aquifer, Texas Water Development Board, TX. 2008 – 2009. *Geoscientist.* Responsible for developing the conceptual model for the hydraulic properties for the Yegua-Jackson GAM based on aquifer tests, sand maps, depositional facies maps, and published studies. Developed methodology for developing aquifer properties based on the aquifer physical properties derived from the interpretation of geophysical logs. This method improved the credibility of the model in areas where pumping tests were either absent or scarce.

Groundwater Availability Model of the Brazos River Alluvium Aquifer, TX. 2014–Present. *Hydrogeologist.* Assisting with the development of the conceptual groundwater model for the Brazos River Alluvium Aquifer. Provided approach for collection of specific capacity information and

Steven Young (cont.)

procedures for developing transmissivity maps using the specific capacity data. Also provided technical review and oversight of the conceptual model report.

Development of a Well Database, Post Oak Savannah Groundwater Conservation District, TX. 2011-2014. *Project Manager.* Developed database to assist the District with managing information from approximately 8,000 registered wells and 700 permitted wells. The database serves as the primary repository for well owner and construction information, well location, and monitoring data, and contains numerous tables, queries, and reports tailored to address the District's management needs. Integrated the database into ARCMAP and developed add-ins to ARCMAP to evaluate well spacing criteria, average drawdowns, and water budgets from groundwater models for selected aquifer zones.

Technical Support, Post Oak Savannah Groundwater Conservation District, TX. 2004 – Present. *Project Manager.* Assisting the District with characterizing and managing groundwater resources by performing a wide range of groundwater simulations to evaluate groundwater availability of District aquifers. Developed major sections of groundwater management plan and was responsible for obtaining approval of plan from the TWDB. Provide technical review of major permits including two over 20,000 AFY and assisted with developing groundwater rules for the District including well spacing. Also estimate groundwater availability and amount of groundwater in storage for the District as needed.

Development of Stratigraphy for Gulf Coast Aquifer from the Rio Grande to the Brazos River, Texas Water Development Board, TX. 2008 – 2010. *Project Manager.* Developed stratigraphy, lithologic and water quality information for the Chicot, Evangeline, and the Jasper Aquifers from the Brazos River to the Rio Grande. A total of 900 logs were used to develop sand thickness and depositional facies maps for ten geological units. Established framework for the geologic framework for the future revisions to the central and southern Gulf Coast Aquifer GAMs.

Groundwater for Agriculture Study for the Lower Colorado River Authority –San Antonio Water System Water Project, Lower Colorado River Authority, Central Texas Gulf Coast, TX. 2004 – 2010. *Project Manager.* Directed the development of a groundwater model for a 10-county area in the Gulf Coast Aquifer to support the evaluation of large-scale pumping on groundwater resources. Assembled 700 oil/gas geophysical logs and supervised the analysis of the logs to revised stratigraphic and sedimentological framework for the Gulf Coast Aquifer System. Mapped sand channels and depositional facies for the geological formations that comprise the Chicot and Evangeline aquifer. Evaluated alternative well designs covering a three county area for 90,000 AFY with regard to pumping impacts to existing wells, land subsidence, degradation of water quality, and life cycle costs. Designed monitoring well network to demonstrate regulatory compliance.

Evaluation of Impaired Groundwater, Tarrant Regional Water Authority and the City of Wichita Falls, TX. 2014-2015. *Project Manager.* Performed a hydrogeological study for a 10-county area to identify and rank potential sites for pumping groundwater to mix with surface water supplies. Transmissivity values for aquifers were generated and evaluated based on analysis of geophysical logs, aquifer pumping tests, and measured water quality parameters. The ranking criteria for the alternative well sites was based a cost benefit analysis that included consideration for long-term and short-term reliability and costs. Five candidate well field sites were selected for a detailed feasibility analysis. Two of the candidate well fields pumped the Seymour Aquifer near the City of Wichita Falls. Three of the candidate well fields pumped the Carrizo-Wilcox Aquifer near Richmond-Chambers Reservoir.

Characterization of the Carrizo-Wilcox Aquifer System for Panola County GCD, TX. 2011 – 2013. *Senior Geoscientist.* Developed approach for characterizing groundwater resources of the District

Steven Young (cont.)

including the base of the Wilcox Aquifer, evaluating current water levels and trends through time, and determining major indicators of water quality. Helped to direct the collection of information and data for the data analyses. Provided technical review of analysis and documents delivered to the District to assist the District with developing management plans and groundwater rules.

Bibliography for Minor and Major Aquifers in Texas, Texas Water Development Board, TX. 2010 – 2012. *Project Manager*. Assembled a comprehensive list of references for all minor and major aquifers in Texas for the TWDB. Identified over 7,000 references from USGS, TWDB, TCEQ, Railroad Commission of Texas (RRC), U.S. Environmental Protection Agency (EPA), journal articles, conference proceedings, and municipalities. References were organized and managed in a Microsoft Access database and then uploaded in End Notes. The bibliography was created to provide the state of Texas with a master list of references for guiding future projects aimed at developing the state's brackish groundwater resource.

Relevant Publications/Reports

Kelley, V.A., J. Ewing, T.L. Jones, S.C. Young, N. Deeds, and S. Hamlin, eds., 2014. Final Report, Updated Groundwater Availability Model of the Northern Trinity and Woodbine Aquifers. Prepared for the North Texas, Northern Trinity, Prairielands, and Upper Trinity Groundwater Conservation Districts.

Young. S.C., Pinkard, J., Basset, R.L., and Chowdhury, A., 2014, Hydrochemical Evaluation of the Texas Gulf Coast Aquifer System and Implication for Developing Groundwater Availability Model: prepared by INTERA Incorporated, TWDB Contracted Report, TWDB, Austin, TX.

Deeds, N., T. Yan, A. Singh, T. Jones, V. Kelley, P. Knox, and S. Young, 2010. Groundwater Availability Model for the Yegua-Jackson Aquifer. Prepared for the Texas Water Development Board.

Young. S.C., Kelley, V., Budge, T., Deeds, N., and Knox, P., 2009, Development of the LCRB Groundwater Flow Model for the Chicot and Evangeline Aquifers in Colorado, Wharton, and Matagorda Counties: Lower Colorado River Authority.

Knox, P.A., S. C. Young, V. Kelley, T. Budge, and N. Deeds, 2008. Regional Groundwater Model for the Chicot and Evangeline Aquifer, Central Texas Gulf Coast: Benefits of a Chronostratigraphic Approach. Presented at the 2008 Joint Meeting of the Geological Society of America, Oct. 6, Houston, TX.

Budge, T., S. C. Young, V. Kelley, N. Deeds, and J. Ewing, 2007. Importance of a Properly Conceptualized Shallow Flow System on Groundwater Availability Estimates for Regional Flow Systems Near Coastlines with Dipping Stratigraphy. 2007 NGWA Ground Water Summit, April 30–May 2, Albuquerque, NM.

Deeds, N., V. Kelley, S. C. Young, and G. Saunders, 2007. Estimation of Spatially Varying Recharge for a Regional Scale Groundwater Model in the Texas Gulf Coast. 2007 NGWA Ground Water Summit, April 30–May 2, Albuquerque, NM.

Young, S.C, T. Budge, N. Deeds, V. Kelley, P. Knox, E. Baker, G. Saunders, and J. Waugh, 2007. A Groundwater Flow Model of the Texas Central Coast Constructed from a Detailed Site Conceptual Model, Transactions of the 57th GCAGS/GCSSEPM Annual Convention, October 21, Corpus Christi, TX.

Young, S.C., and Kelley, V., eds., 2006, A site conceptual model to support the development of a detailed groundwater model for Colorado, Wharton, and Matagorda counties: unpublished report prepared for the Lower Colorado River Authority, Austin, TX.

Jevon Harding, PG

INTERA

Technical Lead –
Characterization of Colorado River Alluvium

Years of Experience: 8

Education:

- MS, 2012, Hydrology, New Mexico Institute of Mining & Technology
- BS, 2007, Geosciences, Princeton University

Professional Certifications:

- Professional Geoscientist, Texas, No. 12050

Key Experience:

- 8 years in hydrogeology, water chemistry, and numerical groundwater flow and transport modeling using codes that include MODFLOW
- 3 years in the field data collection and interpretation of water quality and water isotopes
- Contribution to multiple TWDB GAMs including High Plains, Brazos River Alluvium, and Northern Trinity
- Six publications, conference presentations, and reports on aquifer characterization and groundwater flow

Jevon Harding is a Hydrogeologist at INTERA with eight years of research and applied experience in the fields of hydrogeology, water chemistry, and numerical groundwater flow and transport modeling. In support of water resource evaluations, she has performed analyses to quantify hydrologic and hydrogeologic processes and properties, applied GIS to manage, analyze, and map data, developed and applied numerical models, and implemented field data collection programs. Ms. Harding has contributed to projects for state, regional, and local water authorities, as well as commercial industry, including the development of GAMs of aquifer systems to support long-term water planning, the use of models to evaluate seawater intrusion and its impacts on water supply systems, the assessment of impacts to watersheds from climate change, and the design of rainwater harvesting systems to reduce water usage.

For the TWDB's Groundwater Availability Modeling Program, she has supported the development of conceptual models for the Brazos River Alluvium Aquifer, High Plains Aquifer System, and the Northern Trinity and Woodbine aquifers. For all GAMs, she was integrally involved in the analysis and conceptualization of stream/aquifer interaction as well as estimations of spatially-distributed aquifer recharge. For the Brazos River Alluvium and High Plains GAMs, she conducted literature reviews and data analysis to establish distributions of hydraulic properties such as transmissivity and storage. In the Brazos River Alluvium, where existing field measurements studies of hydraulic conductivity and transmissivity were sparse, her work included expanding the spatial coverage of hydraulic properties data for the aquifer by calculating transmissivity values from specific capacity measurements. Other activities on these GAMs have included preparing GIS databases and maps of the study areas, calculating shallow areal recharge estimates using hydrograph separation, and investigation of aquifer interaction with surface water. She has worked with both state and federal databases, particularly the TWDB's Groundwater Database and SDR Database as well as the USGS NWIS. Based on analyses of this data, she has characterized hydrogeology, evaluated groundwater availability, and produced appropriate input for groundwater models at sites in Texas and other states. She has experience with analytical solutions and numerical codes including the application of MODFLOW and its associated family of codes, as well as the finite-element modeling program COMSOL Multiphysics and the multi-layer transient analytic element solver TTim.

Ms. Harding worked with the New Mexico Experimental Program to Stimulate Competitive Research on academic research investigating the impacts of climate change on New Mexico's mountain sources of water. As part of this project, she developed a conceptual model for stream/aquifer interaction in a small watershed in northern New Mexico. Supported by a field water sampling campaign, distributed temperature sensing, and finite-element modelling, this work provided a new conceptualization of deep

Jevon Harding (cont.)

groundwater flow in mountainous environments. She has also been involved in projects for private industry and/or local, state, and federal government agencies concerning water resources management and groundwater modeling.

Ms. Harding also has experience in communicating with the public and peers. For the Post Oak Savannah GCD, she has presented scientific information and modeling results to both the GCD board as well as local stakeholders. As part of developing the Brazos River Alluvium Aquifer GAM, she presented the conceptual model to a diverse group of stakeholders including GCD representatives. Through her role with NM EPSCoR, she presented her research to mixed audiences of stakeholders and community education partners as well as primary, secondary, and university educators. In Meghalaya, India, she organized a workshop for both local stakeholders and state policy makers to develop plans for state rain water harvesting initiatives. She also served as a volunteer educator in a Rio Grande river water quality testing program for primary students. In addition to her work with the public, she has also presented her research in academic settings and at professional conferences such as the Environmental & Water Resources Institute, American Geophysical Union and Geological Society of America.

Representative Project Experience

Development of a Groundwater Availability Model (GAM) of the Brazos River Alluvium Aquifer, Texas Water Development Board, TX. 2014 – 2016. *Hydrogeologist.* As part of the state-wide TWDB groundwater availability modeling (GAM) program, member of the team that developed the groundwater availability model of the Brazos River Alluvium Aquifer (BRAA). Conducted research to help characterize the surface water-groundwater interaction as well as the interaction between the BRAA and underlying aquifers by analyzing groundwater level and quality data, estimating hydraulic properties based on available field measurements, and performing hydrograph separation analyses. The groundwater model constructed as part of this research provides a tool that will help assess these analyses and evaluate various water management scenarios and their impacts on the BRAA and the Brazos River. Responsibilities included preparing a GIS geodatabase and creating maps of physiography, climate, geology, surface hydrology, hydraulic properties, and water quality; conducting a literature review of historical references to collect all relevant information on water chemistry, hydraulic properties and groundwater-surface water interaction; developing spatial coverages of recharge and hydraulic properties; presenting the research to the Texas Water Development Board as well as local stakeholders; and documenting the conceptual model in a detailed report.

Development of a Groundwater Model for the Antlers Aquifer, Choctaw and Chickasaw Tribes, Southeastern OK. 2013. *Hydrogeologist.* INTERA prepared a groundwater model of the Antlers Aquifer for the Choctaw and Chickasaw Tribes of Oklahoma that can provide a basis for future groundwater management in the region. In support of developing this aquifer model, responsibilities included collecting available hydrologic data and locating historical reports from state and federal government agencies; creating maps of physiography, climate, geology, surface hydrology, hydraulic properties, water quality, and structure; developing pumping distributions for the region; preparing maps to visualize this data; using parameter estimation software to determine the model's sensitivity to input parameters; and documenting the conceptual model in a detailed report.

Modification and Recalibration of the Groundwater Model for Paleozoic Aquifers in the Upper Trinity Groundwater Conservation District, Upper Trinity Groundwater Conservation District, TX. 2014. *Hydrogeologist.* Supporting the updates to and recalibration of a groundwater model for the Paleozoic aquifers in Upper Trinity Groundwater Conservation District and surrounding areas. Since the

Jevon Harding (cont.)

Paleozoic aquifers are not formally recognized by the Texas Water Development Board as either a major or minor aquifer, no official groundwater availability model has been developed. This study was designed to update key issues identified with an earlier "exploratory" uncalibrated model, calibrate the model to observed conditions in the district, and document the changes so that the model can be accepted and used as the best-available tool for evaluating groundwater availability in Upper Trinity GCD. Responsibilities on this project included compiling all well information, including water levels and pumping for the study area, distributing precipitation data and well information to the model grid, and creating datasets compatible with the Northern Trinity-Woodbine Aquifer GAM.

Property Water Availability Assessment, Benbrook Water Authority, TX. 2015. *Hydrogeologist/Groundwater Modeler*. Evaluated a property in Tarrant County to determine its suitability for development as a groundwater source for the Benbrook Water Authority. Conducted a literature review to collect existing hydraulic property values and information on the hydrogeology of the site. Utilized TTim software to create multiple potential pumping scenarios and model the resultant drawdown conditions. Created maps and figures illustrating the results of the analyses, and compiled a technical memorandum that was presented to the client with results of the assessment.

Fatal Flaw Analysis for Water Supply and Texas Pollutant Discharge Elimination System (TPDES) Permitting for Two Proposed Power Plants, Private Energy Client, TX. 2013 – 2014. *Hydrogeologist.* Provided analyses in support of the well permitting process for two proposed power plants. Responsibilities included collecting water level and water quality data for nearby wells from state and federal government agencies; using TTim software to create multiple potential pumping scenarios and model the resultant drawdown scenarios; documenting findings in a report for the client; and provided recommendations for locations of wells and pumping scenarios that best meet water demands.

Development of a Groundwater Availability Model (GAM) of the High Plains Aquifer System, Texas Water Development Board, TX. 2012 – 2015. *Hydrogeologist.* Supporting the development of an integrated GAM of the High Plains Aquifer System (HPAS), an extremely vulnerable and complex system comprised of the southern and northern portions of the Ogallala Aquifer (including the Rita Blanca Aquifer), the Edwards-Trinity High Plains Aquifer, and the Dockum Aquifer. While three GAMs currently exist that include these aquifers, inconsistencies between the models, and in particular the hydraulic connections between the various aquifers, make integrated aquifer planning in the High Plains area very difficult. In support of this effort, responsibilities included preparing a GIS geodatabase and creating maps of physiography, climate, geology, surface hydrology, hydraulic properties, and water quality; collecting historical references containing previous water chemistry studies with emphasis on pre-development conditions, evidence of cross-formational flow, and influence of irrigation practices; acquiring representative well logs from available well databases; and documenting the conceptual model in a detailed report. The integrated HPAS GAM provides a much improved modeling tool for supporting joint water planning in the High Plains region of Texas.

Update of the Northern Trinity-Woodbine Aquifer Groundwater Availability Model, Multiple Groundwater Conservation Districts in Groundwater Management Area 8, TX. 2012 – 2014. *Hydrogeologist.* Provided technical support to update the groundwater availability model (GAM) for the Northern Trinity and Woodbine aquifers. Originally developed in 2004, the updated version of the model incorporates new data to improve the accuracy of predictions made to assess and manage groundwater resources over a 50-year period. In support of developing this conceptual model of the aquifers, responsibilities included preparing a GIS geodatabase; creating maps of physiography, climate, geology, and surface hydrology; calculating shallow areal recharge estimates for the study area using

Jevon Harding (cont.)

hydrograph separation; locating historical reports on past groundwater conditions in the study area; performing a county-wide analysis of the specific capacity measurements collected to date and preparing maps to visualize this data; and documenting the conceptual model in a detailed report.

Groundwater Model Update and Predictive Simulations to Support a Water Rights Transfer, Confidential Federal Client, NM. 2015-Present. *Hydrogeologist.* Evaluating an existing groundwater model currently being used to provide predictive groundwater simulations in support of water rights transfers on a major river in New Mexico. Responsibilities include identifying and documenting input for the existing regional model in a geodatabase; conducting a literature review of geologic and hydrologic data released since the development of the existing model; compiling historical well records and publications into a digital database; and evaluating the suitability of the geologic structure used in the existing model in support of potentially extending or revising the existing groundwater model.

Water Resource Assessment, City of Crownpoint, NM, 2013. *Hydrogeologist.* Supported update of the previous model of San Juan Basin to include Westwater Canyon formation and inform decision-making for the water supply in the City of Crownpoint. Responsibilities included identifying pumping sources near Crownpoint; retrieving static and transient water level data and river stage data from state and federal agencies; performing river stage-groundwater elevation analyses to determine groundwater gradients in the region; and preparing maps to visualize the data.

Climate Change Impacts on New Mexico's Mountain Sources of Water, National Science Foundation (NSF) New Mexico Experimental Program to Stimulate Competitive Research (EPSCoR), Albuquerque, NM. 2009 – 2012. *Research Assistant*. Developed and led a field campaign to assess the Rio Hondo watershed in northern NM. This included stream gauging, water sampling, distributed temperature sensing (DTS) measurements, and implementation of a precipitation collection network as well as laboratory stable isotope analysis of water samples.

Relevant Publications/Reports

Harding, J.J. and S. Young, 2016. Proposed Bio-solids Land Application Site in Milam County. Presented at the Post Oak Savannah Groundwater Conservation District public meeting.

Harding, J.J., V. Kelley, B. Scanlon, R. Reedy, 2015. Estimating Recharge for Regional Groundwater Models in Texas. Presented at the Environmental & Water Resources Institute (EWRI) Congress 2015, May 17-21, 2015.

Deeds, N.E., J.J. Harding, T.L. Jones, A. Singh, S. Hamlin, and R.R. Reedy, 2015. Final Conceptual Model for the High Plains Aquifer System Groundwater Availability Model. Report prepared for the Texas Water Development Board. August 2015.

Ewing, J.E., J.J. Harding, T.L. Jones, 2015. Conceptual Model Report for the Brazos Alluvium Aquifer Groundwater Availability Model. Prepared for the Texas Water Development Board.

Oliver, W., J. Harding, and D. Lupton, 2013. Development of a Groundwater Model for the Antlers Aquifer in Southeastern Oklahoma. Report prepared for the Choctaw and Chickasaw Nations as part of the Choctaw and Chickasaw Regional Water Plan.

Tolley, D., J.J. Harding, M. Frisbee, and J. Wilson, 2012. Deep Groundwater Contributions to Surface Water in a Mountainous Watershed, Northern New Mexico. Presented at the American Geophysical Union Annual Meeting.

Wade Oliver, PG

INTERA

Technical Lead –
Groundwater Availability Model Discretization

Years of Experience: 10

Education:

- MS, 2008, Geology, University of Utah
- BS, 2006, Environmental Geoscience, Texas A& M University

Professional Certifications:

- Professional Geoscientist, Texas, No. 11112

Key Experience:

- 8 years in geology, hydrogeology, and numerical groundwater flow and transport modeling and associated documentation and reporting
- 6 years developing conceptual models for Texas aquifers, and 8 years using TWDB groundwater geodatabase and schema
- 4 years managing various technical components of GAM models

Wade Oliver has ten years of research and applied experience focusing on the characterization of groundwater systems in Texas and the development and application of numerical flow models to analyze these systems. His experience includes characterizing the structure, water quality, and water levels of aquifers, updating aquifer management plans for GCDs, and developing GAMs to support water planning strategies for both public and private entities.

While at TWDB, he led more than 90 projects involving evaluations of aquifer recharge, groundwater-surface water interaction, inter-aquifer flow, and future groundwater conditions and availability for local and regional groundwater management entities in Texas. Many of these entities were those that manage the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers in Groundwater Management Area 12. As a part of these evaluations while at TWDB and in subsequent work at INTERA, Mr. Oliver regularly presents technical concepts and findings to stakeholder groups and at public meetings. Through his experience, Mr. Oliver has in-depth knowledge of the Texas Groundwater Availability Modeling Program including the development and uses of GAMs, the standardized GAM database schema, and the needs of Texas water management entities for reliable information to inform decision-making.

For modeling and data analysis studies he regularly employs groundwater codes, including the many versions of MODFLOW, as well as the application of PEST for calibrating and optimizing numerical models. He has 12 years of experience working with the GIS software ArcGIS and is a skilled Perl programmer. In the environmental area, his experience includes characterizing sites with underground storage tanks, evaluating the fate and transport of contaminants in surface water, and modeling complex long-term groundwater conditions in support of mine closures. He also has experience characterizing brackish aquifer resources in water-scarce areas of Texas, New Mexico, and Oklahoma for energy companies to help clients secure reliable water for operations while protecting local fresh water supplies.

He served as the lead hydrogeologist and project manager on the development of the groundwater model for the Paleozoic aquifers in the North-Central Texas, Upper Trinity Groundwater Conservation District modeler and the evaluation of the Wilcox Aquifer and Management Plan assistance for the Panola County GCD and served as the lead modeler for the evaluation of potential desired future conditions using numerical groundwater flow models for 12 of the 15 GMAs from 2008 through 2011.

Representative Project Experience

Groundwater Model for the Paleozoic Aquifers, Upper Trinity Groundwater Conservation District, North-Central TX and Southern OK. 2013 – 2014. *Project Manager and Lead Hydrogeologist.* Developed an updated groundwater model for the Paleozoic Aquifers in north-central Texas and southern

Wade Oliver (cont.)

Oklahoma including the Wichita, Bowie, Cisco, Canyon and Strawn groups. These often brackish aquifers are a significant resource where the Trinity and Seymour aquifers are not present. Updates included refinement of the model grid, development of a connection to the newly-developed groundwater availability model for the Trinity Aquifer, and improved representation of the aquifer structure, groundwater-surface water interaction, recharge from precipitation, hydraulic properties and pumping. Model was calibrated to measured water levels and baseflows, and is being used by the Upper Trinity Groundwater Conservation District to better understand and manage the aquifers.

Technical Support for Groundwater Management, Groundwater Management Area 10, TX. 2014 – Present. *Lead Hydrogeologist.* Developing the information needed by the groundwater conservation districts within Groundwater Management Area 10 to adopt desired future conditions for the Trinity and Northern Saline Edwards Aquifers. This information includes water supply needs and management strategies, estimates of historical groundwater uses, hydrological conditions such as recharge and aquifer storage, and potential environmental impacts of proposed management strategies. Activities also include development and calibration of an analytical model for the Trinity Aquifer in Hays County to evaluate the potential impacts of expanded groundwater development.

Development of Analytical Well Impacts Tool, Panola County Groundwater Conservation District, Panola County, TX. 2015 – 2016. *Project Manager and Lead Hydrogeologist.* Led the development of an analytic element tool for evaluating the localized impacts of new and existing wells over short and long time-periods. Using the analytic element approach combined with district-specific structure, hydraulic properties and well screen information, the tool allows the district to evaluate the expected impacts of new wells on existing wells quickly and reliably during permitting decisions.

Evaluation and Modeling of Groundwater Resources, Confidential Client, Reeves and Ward Counties, TX. 2015. *Project Manager and Lead Hydrogeologist.* Led the evaluation of groundwater resources throughout large portions of Reeves and Ward counties in west Texas. The client was seeking significant quantities of water to support oil production activities. Helped to evaluate the structure, hydraulic properties, recharge, water levels and well locations for the Santa Rosa portion of the Dockum Aquifer and the Pecos Valley Aquifer. For the Santa Rosa, helped to develop a numerical groundwater model to evaluate the long-term sustainability of the client's proposed production and developed well spacing recommendations customized to the hydrogeology of the aquifer. For the Pecos Valley Aquifer, helped use logs to create a three-dimensional lithologic model to identify the areas with the thickest sequences of productive sands. The results of the study confirmed that the client could sustainably produce from the Santa Rosa, where present, and guided well field development in the Pecos Valley Aquifer toward the areas most suitable for groundwater development.

Development of a Groundwater Model for the Antlers Aquifer in Oklahoma and North Texas, Choctaw and Chickasaw Nations, OK. 2012 – 2014. *Lead Hydrogeologist and Modeler.* Led the development of an updated groundwater model to evaluate the impact of pumping in Texas and the potential for the Antlers Aquifer to serve as a primary water supply source in southeastern Oklahoma. Previously developed models were insufficient for serving as long-term water planning tools for the aquifer. Efforts included readdressing each component of the conceptual model of the aquifer, including recharge, hydraulic properties, evapotranspiration, structure, and pumping. The calibration efforts employed PEST to adjust model parameters within reasonable limits. The resulting tool is being used to evaluate future water management strategies, quantify impacts of out-of-state pumping on the aquifer in Oklahoma, and better understand the quality and availability of water in the aquifer.

Wade Oliver (cont.)

Evaluations of Groundwater Resources in West Texas and Southeast New Mexico, Confidential Client, TX and NM. 2012 – 2015. *Project Manager and Lead Hydrogeologist*. Managed nine separate evaluations spanning 18 counties in the Permian Basin region of west Texas and southeast New Mexico involving the compilation review, interpretation, and presentation of hydrogeologic information for multiple aquifers. The evaluations were used to help determine potentially suitable water sources for hydraulic fracturing operations while minimizing impacts to existing groundwater users. These studies included detailed evaluations of water levels, water quality, well locations, geologic framework, and hydraulic properties for the Ogallala, Dockum (including Santa Rosa formation), Pecos Valley Alluvium, Edwards-Trinity (Plateau), Rustler, Capitan Reef Complex, Edwards-Trinity (High Plains), and Roswell Artesian Basin aquifers. Brackish groundwater reservoirs not defined as aquifers by the TWDB were also evaluated as potential alternative supplies. One study also included the development of a MODFLOW-NWT numerical groundwater model to evaluate the sustainability of groundwater production from a brackish aquifer. Using this model, the expected impacts of pumping of the brackish aquifer on the overlying fresh groundwater sources were very limited.

Development of an Alternative Groundwater Model for the Aquifers in Groundwater Management Area 16, Texas Water Development Board, TX. 2009 – 2011. *Hydrologist.* Assisted with the development of the updated conceptual model for the Gulf Coast, Yegua-Jackson, and Carrizo-Wilcox aquifers in GMA 16. The existing GAMs for the area, specifically those for the central and southern portions of the Gulf Coast Aquifer, were found to be ineffective for evaluating potential DFCs. Collected spatially distributed precipitation information for Texas and Mexico and evaluated previous approaches for estimating recharge to the aquifers in GMA 16.

Development of Standardized Program for Calculating Texas Groundwater Availability Model Water Budgets, Texas Water Development Board, TX. 2008 – 2011. *Lead Programmer.* Developed, documented, and maintained the primary tool the Texas Groundwater Availability Modeling Program uses for the extraction and summary of water budget information from MODFLOW numerical groundwater models. The tool, written in Perl, uses the standardized grid files developed for each GAM and the ZONEBUDGET code developed by the USGS to quickly produce consistent and accurate results. Since being developed, most groundwater model water budget results reported by the TWDB, including estimates of managed/MAG, relied on this tool.

Update of the Dockum Aquifer Groundwater Availability Model, Texas Water Development Board, TX. 2010. *Lead Modeler*. Modified and recalibrated the GAM for the Dockum Aquifer to better simulate predictive conditions necessary for the development of DFCs. The changes to the model focused on reconfiguring how interaction with overlying aquifers was implemented in the model. Used PEST to aid with the recalibration of aquifer properties. The updated model was the primary tool used by GCDs for assessing potential DFCs for the aquifer and estimating MAG.

Relevant Publications/Reports

Oliver, W., and Kelley, V., 2014. Modification and recalibration of the groundwater model for Paleozoic aquifers in the Upper Trinity Groundwater Conservation District. Draft report prepared for Upper Trinity GCD, 127 p.

Lupton, D., Oliver, W., and G. Grisak, 2014. Evaluation and use of brackish groundwater resources. Shale Play Water Management Magazine, May/June 2014. Available in print and online at: http://www.shaleplaywatermanagement.com/2014-May-June.html.

Wade Oliver (cont.)

Oliver, W.A., and D.M. Lupton, 2013. Wilcox structure, water levels, and water quality in Panola County Groundwater Conservation District, Technical report prepared for Panola County GCD, 28 p.

Oliver, W., J. Harding, and D. Lupton, 2013. Development of a groundwater model for the Antlers Aquifer in southeastern Oklahoma. Prepared for the Choctaw and Chickasaw nations as part of the Choctaw and Chickasaw Regional Water Plan, 344 p.

Oliver, W.A., 2012. Technical Analysis of Petitions Challenging the Reasonableness of the Desired Future Condition for the Trinity Aquifer in Groundwater Management Area 9, Texas Water Development Board, 48 p.

Hutchison, W.R., M.E. Hill, R. Anaya, M.M. Hassan, W. Oliver, M. Jigmond, S. Wade, and E. Aschenbach, 2011. Groundwater Management Area 16 Groundwater Flow Model, Texas Water Development Board, 306 p.

Oliver, W., 2010. GAM Task 10-012: Predictive Simulations of Groundwater Availability in the Yegua-Jackson Aquifer, Texas Water Development Board, 48 p.

Oliver, W., 2010. GAM Task 10-009: Predictive Simulations of Groundwater Availability in the Carrizo-Wilcox, Queen City, Sparta, and Yegua-Jackson aquifers in Groundwater Management Area 11, Texas Water Development Board, 11 p.

Oliver, W., 2010. Dockum Aquifer model modifications and GAM Run 09-014. Presented at the Groundwater Management Area 1 meeting, Amarillo, TX, May 11, 2010.

Oliver, W., 2010. GAM Run 09-026 MAG: Managed Available Groundwater for the Ogallala Aquifer in Groundwater Management Area 1, Texas Water Development Board, 19 p.

Oliver, W., 2010. GAM Run 10-023: Predictive Simulations of Groundwater Availability in the Northern Portion of the Gulf Coast Aquifer, Texas Water Development Board, 32 p.

Oliver, W., and W.R. Hutchison, 2010. Modification and Recalibration of the Groundwater Availability Model of the Dockum Aquifer, Texas Water Development Board, 114 p.

Oliver, W., 2009. GAM Run 09-021: Historical Groundwater Availability Information for Neches and Trinity Valleys Groundwater Conservation District management plan, Texas Water Development Board, 9 p.

Oliver, W., 2009. GAM Run 08-79: Evaluation of Drawdown in the Gulf Coast Aquifer in Southeast Texas Groundwater Conservation District Under District-Specified Constant Pumping Conditions, Texas Water Development Board, 23 p.

Oliver, W., 2009. Quick Reference for the Groundwater Availability Model for the Southern Portion of the Ogallala Aquifer and the Edwards-Trinity High Plains Aquifer, Texas Water Development Board, 53 p.

Sorab Panday, PhD

GSI

Technical Support-
Groundwater Availability Model Discretization

Years of Experience: 27

Education:

- PhD, 1989, Civil and Environmental Engineering, Washington State University
- MS, 1986, Civil Engineering, University of Delaware
- BT, 1984, Civil Engineering, Indian Institute of Technology

Key Experience:

- Over 27 years in geology and hydrogeology
- 20 years of groundwater modeling including groundwater-surface water interaction, and impact and safe yield analyses
- Expert in characterization and modeling of hydrogeologic systems

Sorab Panday is a Principal Engineer at GSI with over 27 years of experience in directing, managing, developing, reviewing and troubleshooting flow and transport models for groundwater evaluations and water resource management. As a water resource modeling consultant, Dr. Panday has worked on modeling projects spanning a wide range of schedules and budgets, of multiple spatial and temporal scales, complex geological settings, diverse climatic conditions, unique water/contaminant management issues and challenging numerical conditions. He has helped to develop several of the industry's state-of-the-art water resource modeling codes and is the lead author on MODFLOW-USG, an unstructured-grid version of MODFLOW released by the USGS. He has published refereed articles in reputed journals, provides review and support to industry publications and associations, and conducts short courses and workshops on water resource and contaminant transport modeling.

Representative Project Experience

Groundwater / Surface-Water Interaction Model, Los Angeles County Sanitation Districts, CA. Project manager and principal investigator for developing and applying a flow and transport Groundwater/Surface-Water Interaction Model (GSWIM) of the Upper Santa Clara River watershed to address chloride TMDL issues. The model has been an invaluable tool for evaluating basin management alternatives and has been in use for years since its initial development. All available data in the domain was evaluated to develop a thorough and detailed basin conceptual model including surface-water and groundwater flows and salt loadings from point and non-point sources over a period of 31 years (1975 through 2005). An associated numerical model was developed representing the conceptual system understanding for surface and subsurface flow. The model was calibrated to the assimilated data for groundwater levels, stream flows, groundwater chloride levels and stream chloride measurements for daily-averaged rainfall stresses over the analysis period. The model was applied to examine the effects of various scenarios on chloride levels within the basin. The model is currently being used to evaluate impacts of alternative discharge plans on surface and groundwater quality.

Integrated Surface Water-Groundwater Model, St. Johns River Water Management District, Western Orange and Seminole Counties, Palatka, FL. Project manager and principal investigator for development and application of an integrated surface-water/subsurface water model for in East-Central Florida to investigate the effect of pumping on various lakes, wetlands, surface water bodies, spring flows and stream flows. Tasks for this project included providing leadership to a team of hydrologists, hydrogeologists, engineers and scientists; assimilating vast quantities of information and data; providing technical direction and leadership to model development, calibration and application; preparing monthly/task/final reports and presentations; conducting training sessions; and communicating regularly with the client regarding progress and issues.

Sorab Panday (cont.)

Evaluation of Streamflow Reductions due to Pumping, Northwest Florida Water Management District, Havana, FL. Principal investigator for a modeling evaluation of groundwater flow and surface-water interactions in the Apalachicola-Chattahoochee-Flint River Basin. An evaluation was conducted of all available reports on the hydrology, hydraulics and hydrostratigraphy of the regional system. Previous modeling efforts in the region were also reviewed to develop a conceptual model for surface-subsurface interactions. The USGS finite-element code, MODFE, was applied for simulating the basin to estimate transient streamflow reduction due to pumping, for various alternative scenarios. Sensitivity analyses were also conducted to determine the range of streamflow reductions subject to parameter uncertainty.

Groundwater Modeling for Impact Analysis at Red Gap Ranch, City of Flagstaff, AZ. Principal Modeler for construction and calibration of a groundwater model simulating various groundwater pumping scenarios from future wells in the C-Aquifer at RGR. Geologic and hydrogeologic conceptual models and long term water balances were developed for the basin considering local and regional available data. The numerical model was based on this information and transient local pump-test information in the RGR area. The 100-year drawdown and associated uncertainty were evaluated to demonstrate groundwater availability for the 100-year projected demands as per ADWR's Adequate Supply Program and proposed Hydrologic Guidelines and Proposed Rulemaking Changes. Projected recycled water reuse was included in the forecasts.

Safe Yield Analysis of County Wellfields, Pinellas County Water System, Pinellas County, FL. Project manager for the development of a safe yield analysis model for the Eldridge-Wilde and East Lake Road wellfields operated by the County. Water management concerns included drying up of lakes and wetlands, and saltwater intrusion from the Gulf of Mexico and Tampa Bay. Assimilated all available information in a comprehensive conceptual model of the aquifer system for use with a finite-element model groundwater flow and density-dependent transport model to investigate the effects of pumping on saltwater intrusion and the surface water impacts. Performed safe yield analyses to optimize operation with minimal intrusion of saltwater or degradation of wetlands and lakes.

Water Resources Assessment Program HCWRAP2, Southwest Florida Water Management District, Brooksville, FL. Directed the development of MODFLOW-based regional groundwater flow and saltwater intrusion models used in conjunction with management optimization techniques to determine optimal locations of wells/recharge basins to minimize impacts on surface water and on the movement of the saltwater/freshwater interface. Several models were developed and calibrated which were then used with the well optimization simulations to investigate various objectives of the District.

Lead Developer of the MODFLOW-USG Groundwater Flow Model, U.S. Geological Survey, Reston, VA. Co-investigator for development of the MODFLOW-USG code which is an enhancement of MODFLOW to use unstructured grids. Version 1 of the code has been released by the USGS in May 2013 with several enhancements planned for version 2 including turbulent fracture flow, contaminant transport, and saltwater intrusion simulation capabilities.

Co-Developer of the MODFLOW-NWT Groundwater Flow Model, U.S. Geological Survey, Reston, VA. Co-investigator for development of the MODFLOW-NWT code which is an enhancement of MODFLOW that overcomes drying and rewetting difficulties of unconfined solutions. The code uses an upstream-weighting formulation with a Newton Raphson linearization to provide robust solutions to highly nonlinear problems. Under-relaxation and residual control schemes are also used to stabilize

Newton iterations. MODFLOW-NWT is gaining in popularity since its recent release and is being used throughout the world.

Sorab Panday (cont.)

Principal Developer of MODFLOW-SURFACT and MODHMS Codes till 2007. HydroGeoLogic Inc, Reston, VA Principal Developer of the popular commercial MODFLOW-SURFACT and MODHMS suite of codes from inception through 2007. The USGS groundwater simulation code, MODFLOW, was greatly enhanced to include hydrologic cycle and vapor phase simulations of flow and transport among several other advanced modeling capabilities.

Co-Developer of the HydroGeoSphere Integrated Groundwater, Surface Water Model, U.S. Bureau of Reclamation, Sacramento, CA. Co-investigator for development of the HGS code for physically-based, spatially-distributed modeling. Responsible for basic surface water module development.

3-D Density-Dependent Flow and Transport Code Development, St. Johns River Water Management District, Palatka, FL. Co-developer of DSTRAM, a 3-D density-dependent flow and transport code intended for saltwater intrusion investigations. Responsibilities included code development, verification, validation, benchmarking, and documentation.

Relevant Publications/Reports

Shanafield, M., R.G. Niswonger, D. E. Prudic, G. Pohll, R. Susfalk, and S. Panday, 2014. A method for estimating spatially variable seepage and hydraulic conductivity in channels with very mild slopes, Hydrological Processes, DOI: 10.1002/hyp.9545, 2014.

Langevin, C.D., and S. Panday, 2012. Future of Groundwater Modeling. Invited article for Column Theme: 50th Year Tribute to Modeling: Past, Current, and Future, Groundwater, Vol. 50, No. 3, p. 333-339, doi: 10.1111/j.1745-6584.2012.00937.x.

Panday, S., and C. D. Langevin, 2012. Improving sub-grid scale accuracy of boundary features in regional finite-difference models. Advances in Water Resources, Volume 41, pages 65-75.

"Simulating Dynamic Water Supply Systems in a Fully Integrated Surface–Subsurface Flow and Transport Model." S. Panday, N. Brown, T. Foreman, V. Bedekar, J. Kaur, and P. S. Huyakorn. Vadose Zone Journal. 8: 858-872. Nov. 1 2009.

Panday, S., and P.S. Huyakorn, 2008. MODFLOW SURFACT: A State-of-the-Art Use of Vadose Zone Flow and Transport Equations and Numerical Techniques for Environmental Evaluations. Vadose Zone Journal, Vol. 7, No. 2, pp. 610-631.

Young, S.C., Budge, T.J., Panday, S., and Waugh, J., 2007, Correct Conceptualization Can Cut Controversy, Abstract Book of the 2007 Ground Water Summit Program.

Young, C.A., W.W. Wallender, G. Schoups, G. Fogg, B. Hanson, T.H. Harter, J.W. Hopmans, R. Howitt, T. Hsiao, S. Panday, K.K. Tanji, S. Ustin, and K. Ward, 2007. Modeling shallow water table evaporation in irrigated regions, Irrigation and Drainage Systems, 21(2), 119-132.

Panday, S., and P.S. Huyakorn, 2004. A Fully Coupled Physically-Based Spatially-Distributed Model for Evaluating Surface/Subsurface Flow. Advances in Water Resources. Vol. 27, pp. 361-382.

Young, S.C., S. Panday, T. Budge, and W. Jones, 2001, "A Comprehensive Approach for Incorporating Aquifer Heterogeneity Into Conceptual and Numerical Models." AGWSE Annual Meeting and Conference: "Groundwaterdata.net-Ground Water Data: Collection, Reliability, Access, and Manipulation of Basic Data," Nashville, TN.

Cody Hudson, PE

INTERA

Technical Lead –
Groundwater-Surface Water Interaction Work Plan

Years of Experience: 10

Education:

- MS, 2010, Environmental Engineering, University of Texas at Austin
- BS, 2005, Civil Engineering, University of Arkansas at Fayetteville

Professional Certifications:

- Professional Engineer, Texas, No. 108292

Key Experience:

- Technical support on the Rustler and Brazos River Alluvium GAMs
- Experience with TWDB's groundwater geodatabase schema
- Ability to communicate results of analyses in graphical, written, and oral format

Cody Hudson has ten years of experience in surface and groundwater model development and analysis, collecting and analyzing surface water flow data for streams, bathymetric and land surveying, GIS development, and site water quality monitoring. He has worked on a variety of state, municipal, and privately contracted projects investigating current/future water availability and water quality. His work has included creating models to assess floodplain elevations, water quality, environmental impacts, and infrastructure design.

Mr. Hudson has also evaluated water availability using water accounting models. He has analyzed and collected flow data for streams, estimated baseflow in streams to gain an understanding of long term trends and develop recharge estimates from aquifers, and developed flow regimes from streamflow data to assess instream flows. In support of modeling projects and bed and banks permit applications, he has measured flow in streams using FlowTracker and Acoustic Doppler Current Profilers. To assess water availability and sediment accumulation in lakes, he has conducted bathymetric surveys using a multi-frequency transducer and Real Time Kinematic land surveying equipment. Mr. Hudson also has a strong background in Python programming, which he uses to obtain and process data for models and for statistical analysis of stream flow trends. He has successfully written Python scripts for use with ArcGIS that have processed NEXRAD data, estimated long term precipitation trends, and developed head boundaries for groundwater models. Some of the water quality monitoring work that he has done includes collecting water quality samples at federal Superfund sites, decommissioned power plants, and roadways to assess the efficacy of using a new type of pavement to improve runoff water quality.

Representative Project Experience

Recharge Estimation, Post Oak Savannah Groundwater Conservation District, Milano, TX. 2010. *Hydrologist.* Supported the assessment of groundwater availability in the Post Oak Savannah Groundwater Conservation District in order to develop a groundwater conservation plan. Efforts included delineating watersheds for stream gages using ArcHydro, estimating groundwater recharge to rivers based on baseflow analysis of stream gages using BFI code, and determining average precipitation in each watershed with multiple precipitation sites using ArcGIS Spatial Analyst.

Flow Measurement Verification of three Brazos River Pumping Plants, Gulf Coast Water Authority, Texas City, TX. 2013. *Water Resources Engineer.* Performed flow measurements using an Acoustic Doppler Current Profiler (ADCP) on the Brazos River upstream and downstream of three Gulf Coast Water Authority pumping plants, along each canal into which the water was being pumped, and at permanent gauging sites located on each canal downstream of the pumping stations. The measurements

Cody Hudson (cont.)

were used to assess the reliability of the flow rates being recorded at each gauging station and to test whether or not there was a gain/loss between the pumping stations and gauging sites.

Estimating Flows in the Brazos River Basin to Assess Water Availability in the Brazos Alluvium, TWDB, Austin, TX. 2015 – 2016. *Water Resources Engineer.* Reviewed the U.S. Army Corps of Engineers (USACE) Brazos River RiverWare model. Made model runs, and exported simulated streamflow data. This data was used to develop flow scenarios with different operational constraints in order to understand the effect that management decisions in the basin have on water availability in the Brazos Alluvium, a minor aquifer in Texas. Water levels in the aquifer are deeply dependent on flows in the Brazos River, so an understanding of possible surface water flows was needed in order to plan for future conditions.

Recharge Estimation in the Texas Gulf Coast Aquifer from Baseflow Analysis, Texas Water Development Board, TX. 2010 – 2011. *Hydrologist.* Supported efforts to determine stream recharge from groundwater sources in the Gulf Coast Aquifer. This study is critical to quantifying the water availability in the aquifer, so that groundwater conservation districts can plan for desired future conditions. Duties included the development of watersheds for 27 stream gages in the Gulf Coast Aquifer using ArcHydro and then writing Python script to automate the calculation of average monthly precipitation in each of the watersheds using the PRISM dataset. Additional responsibilities involved calculating baseflow time series for each gage, using BFI code, and calculating the following statistics in R: baseflow/precipitation regression, baseflow trends over time, and flow duration curves.

Recharge Estimation in the Rustler Outcrop, Texas Water Development Board, Austin, TX. 2010. *Hydrologist.* Supported the development of the Rustler groundwater availability model (GAM), so that officials will be able to evaluate the effects that different conservation measures will have on aquifer levels. Responsible for determining estimates of surface water recharge rates from the aquifer. Duties for this project included running BFI code on gages within the Rustler outcrop to determine yearly baseflow, developing flow duration curves for stream gages using HEC-SSP, and creating figures in ArcGIS to display data for the final report.

Assessing Losses of Irrigation Canals, Gulf Coast Water Authority, Texas City, TX. 2013. *Water Resources Engineer.* Measured discharge in an irrigation canal using an Acoustic Doppler Current Profiler from a moving boat. Performed over 30 measurements at different locations along the canal while a constant flow rate was being supplied from an upstream pumping station. Measurements were used to assess locations along the canal that were losing water and needed to be lined in order to conserve water.

Groundwater Resource Investigation, HFSJ Water Services, Wichita Falls, TX. 2014. *Water Resources Engineer*. Presented data and identified locations for potential groundwater sources in the Seymour Aquifer. Developed scripts to process Texas Water Development Board Well Logs and estimate the depth the confining red clay layer below the Seymour Alluvial Sediments. Created figures showing the location of well data in the area, including estimates of saturated thickness, well yield, and specific capacity and recommend potential sites for the construction of a new well field.

Measuring Discharge in the Rio Grande using an Acoustic Doppler Current Profiler, Confidential Client, NM. 2012 – 2013. *Water Resources Engineer*. Performed field measurements of discharge on the Rio Grande in northern New Mexico to determine gains/losses due to groundwater flows. Measurements were taken using an Acoustic Doppler Current Profiler from a moving boat. The information gained in this study will be used to assess basin transfers into the Rio Grande in the study

Cody Hudson (cont.)

region. Statistical analysis of long term flow data was used to estimate travel times between gages and to make long-term estimates of gain or loss in different stretches of the river.

Steam Gage and Baseflow Analysis in the ACF Basin, Florida Department of Environmental Protection, Tallahassee, FL. 2011 – 2012. *Water Resources Engineer*. Assisted in the analysis of stream gage data in order to better understand how upstream anthropogenic factors are affecting streamflow in Florida. Downloaded and processed streamflow data from 175 gages in the Apalachicola, Chattahoochee, and Flint River basins. Used PRISM rainfall data with ArcGIS and custom Python codes to develop monthly rainfall time series for USGS HUC 8 areas in the three basins. Calculated one-, two-, and five-year monthly averages of precipitation for each basin. Performed baseflow separation analysis using Baseflow Index (BFI) code for the entire record of each of the 175 gages for which data were collected.

Seawater Intrusion Barrier Modeling, Water Replenishment District of Southern California, Lakewood, CA. 2016-Present. *Water Resources Engineer.* Assisting in an annual update to the groundwater models used to simulate the Alamitos, West Coast Basin, and Dominquez Gap injection barrier projects in Southern California. Developing Python scrips to process monitoring, injection, and production well data collected from the District during 2015. Future work will include developing model input files from the processed data, making model runs, and reporting.

Potential Well Field Analysis near Noblesville Indiana, Indiana American Water Company, Greenwood, IN. 2014 -2015. *Water Resources Engineer.* Created a MODFLOW model to assess potential well field locations. Created Python scripts to process over 10,000 well logs and develop aquifer properties such as top aquifer depth and aquifer thickness. Performed Kriging in ArcGIS to create model input parameters. Processed Indiana Department of Natural Resources Significant Water Withdrawal Facility data to get pumping estimates from large producing wells in the model domain.

Legal Support for Well Head Dispute near Jackson Michigan, O'Connor, DeGrazia, Tamm & O'Connor, P.C., Bloomfield Hills, MI. 2014. *Water Resources Engineer.* Provided maps and data that were used in a dispute over declining water levels believed to be caused by over-pumping in adjacent wells. Downloaded and processed well data from Michigan Department of Environmental Quality Statewide Groundwater Database. Analyzed precipitation and baseflow data and trends in the area to assess the effect climate might have on the water levels.

Potential Well Field Analysis and Well Permitting, Valparaiso City Utility, Valparaiso, IN. 2014. *Water Resources Engineer.* Assisted in the creation of a MODFLOW groundwater model to correctly site and assess well production and interference from a new well field. Created boundary condition grid property inputs from data obtained through the Indiana Department of Natural Resources. Also, created maps and helped gather data needed for well permitting after well field site selection.

Groundwater Monitoring of Superfund Site, Houston, TX. 2011 – 2012. *Water Resources Engineer.* Performed groundwater sampling and level readings of monitoring wells as part of a biannual monitoring program to assess the efficacy of a lined containment cell, which stores hazardous materials at a closed industrial facility. Recorded groundwater depths using an electric tape and collected water samples using a peristaltic pump.

Groundwater Monitoring of Decommissioned Power Plant Site, City of Austin, Austin, TX. 2011. *Water Resources Engineer.* Performed groundwater sampling for heavy metals in remediation area, so that the material could be disposed of properly.

Cody Hudson (cont.)

Water Quality Sampling, Texas Department of Transportation, Austin, TX. 2010. *Research Assistant.* Installed stormwater runoff collection devices along Loop 360 and Highway 620 and collected water quality samples after multiple rainfall events. Compared the water quality of runoff from permeable friction course (PFC) pavement and conventional pavement in order to test the effectiveness of using PFC as best management practices in highway construction. These experiments showed that there was a substantial decrease of total suspended solids in highway runoff when PFC was utilized and that PFC could be used as a means to help reach runoff water quality standards.

Estimation of Canal Capacity using HEC-RAS, Gulf Coast Water Authority, Texas City, TX. 2015. *Water Resources Engineer.* Constructed a HEC-RAS model to assess the ability of the GCWA B-canal system to transport stormwater runoff from a proposed construction project located adjacent to the canal. Collected elevation data for model input using GPS surveying equipment. Also, collected streamflow and water level measurements for model calibration purposes. Used the calibrated model to assess canal capacity under different operating conditions and degrees of canal maintenance.

Relevant Publications/Reports

Kellogg, W., B. Austin, C.F. Gaitan, D. Rosendahl, C. Hudson, and X. Xue, 2016. Impacts of Climate Change on Flows in the Red River Basin. South Central Climate Science Center.

Hudson, C., and J. Wittman, 2015, Resource Availability at Lake Shafer and Lake Freeman. Indiana Finance Authority, November 2015.

Hudson, C., 2015. Modeling the impacts of Climate Change to Reservoirs, Water Users, and Environmental Flows in the Red River Basin. 2015 RiverWare User Group Meeting, Boulder, CO. Feb. 3-4, 2015.

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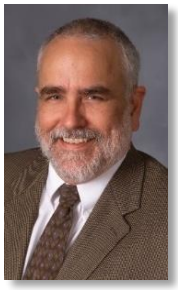
Jon Albright

FREESE AND NICHOLS

Technical Support –
Groundwater-Surface Water Interaction Work Plan



Jon Albright is an FNI Associate and Hydrologist/Project Manager. He has participated in a variety of water resource planning and water supply modeling projects. Mr. Albright has provided water supply analysis support to Regions A, B, C, E, F, G, H, I and J. He also has participated in the development and/or applied WAMs of the Colorado, Brazos, Trinity, Neches, San Jacinto-Brazos, Rio Grande, Red, Sulphur, Cypress, Sabine, and Lavaca river basins**.**

Years of Experience: **35**

Education:

- BS, Hydrology and Water Resources, Tarleton State University

Key Experience:

- Current experience working with INTERA on development of Brazos River Alluvium GAM
- Independent review of the Colorado River WAM
- Over 20 years in conducting gain-loss studies and evaluating river base flow from USGS stream gage data

Representative Project Experience

Review of Colorado WAM Naturalized Flow, Lower Colorado River Authority, TX. 2015. Performed independent review of the recent revision and extension of the hydrology for the TCEQ Colorado River Water Availability Model (Colorado WAM). As part of this review, performed a detailed review of the data used in the developing the naturalized flows for 43 stream gages, including comparisons of historical to naturalized records, review of methods to estimate missing data, review of diversion and return flow data for consistency, and recommendations for documentation of the project.

Brazos Alluvium GAM, Texas Water Development Board (sub to INTERA), TX. 2013-2014. As a subcontractor to INTERA, assisted with development of surface water data for use in the Brazos Alluvium GAM. As part of this study, performed a review of previous gain-loss studies in the Brazos Basin and development of historical base flow series at nine USGS stream gages.

SB1 Regional Water Planning for Regions B, C, E, F, G, H, I and J, Multiple clients, 1998-current. Participated in multiple regional water plans including: surface water availability modeling for Regions B, C, E, F, I and J. Water supply evaluation for Region F included evaluation of a subordination strategy with the Lower Colorado region. Evaluations included reallocation of flood storage in federal reservoirs, aquifer storage and recovery, conjunctive use of groundwater and surface water, use of saline water supplies, new groundwater development and water conservation measures.

Sulphur Watershed Basin Study, Sulphur Basin Group and the U.S. Army Corps of Engineers, 2011-current. Provided yield analyses of various combinations of five water supply alternatives in the Sulphur River Basin. Analyses were performed using an updated version of the Sulphur River WAM and the USACE RiverWare model. These analyses are part of a basin-wide study that comprehensively addresses long-term water availability within the basin and adjacent areas.

Lower Bois d'Arc Creek Reservoir Development-Phase II, North Texas Municipal Water District, TX. 2006-current. Hydrologist for permitting and preliminary design services of a proposed water supply reservoir on Bois d'Arc Creek, a tributary of the Red River in Fannin County. Modeling for this project included water availability analyses using the Red River WAM, as well as development of a daily RiverWare model of the Bois d'Arc Creek watershed for environmental flow analyses.

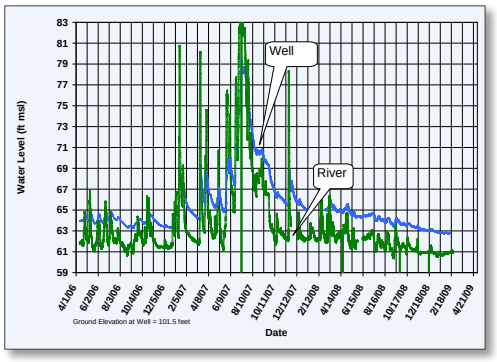
Familiarity, Knowledge, and Experience in Key Project Areas

The INTERA Team's familiarity and knowledge in the areas defined in the evaluation criteria, gained from our experience on similar projects, is summarized in **Figure 3-4** below. Additional details on the projects that appear in the figure are provided on the following pages. To ensure the experience and lessons learned from these projects are successfully transferred to our work in improving simulation of groundwater/surface water interaction in the GMA 12 GAM for the TWDB, members of our proposed project team served in key roles on all of the projects presented below.

PROJECT NAME, LOCATION	RELEVANT AREAS OF EXPERTISE AND EXPERIENCE										
	Evaluation Criteria							Additional Scope Elements			
	Hydrology and hydrogeology of the Colorado River Basin	Hydrology and hydrogeology of the Carrizo-Wilcox, Queen City, and Sparta aquifers	GAMs of Carrizo-Wilcox, Queen City, and Sparta aquifers	Groundwater geodatabase schema used in TWDB GAM Program and GIS	Technology transfer including on-schedule and within budget performance	Communication of results of analyses in graphical, written, and oral format	Development of plans to monitor and interpret surface water-groundwater interactions	Literature searches to estimate hydrogeologic properties (e.g., transmissivity, storage, etc.)	Modification of GAMs to add model layers and/or refine grid size	Application of GAMs in GMA 12	Stakeholder meetings and interaction
Development of a Groundwater Availability Model and Evaluation of Surface Water-Groundwater Interaction in the Lower Colorado River Basin, Texas	■				■	■	■	■			■
Development of Groundwater Availability Models of the Southern, Central, and Northern Portions of the Queen City and Sparta Aquifers, Texas		■	■	■	■	■		■	■	■	■
Refinement of the GAM for the Central Carrizo-Wilcox, Queen City, and Sparta Aquifers to Incorporate Flow Near Faults and Rivers, Texas	■	■	■	■	■	■		■	■	■	■
Development of Groundwater Availability Models of the Southern and Northern Portions of the Carrizo-Wilcox Aquifer, Texas		■	■	■	■	■		■			■
Development of a Groundwater Availability Model of the Yegua-Jackson Aquifer, Texas				■	■	■		■			■
Joint Planning Support for Groundwater Management Area 12, Texas	■	■	■			■		■		■	■
Development of a Groundwater Availability Model of the Brazos River Alluvium, Texas		■		■	■	■		■			■
Management and Monitoring of Groundwater Resources for the Post Oak Savannah Groundwater Conservation District, Texas		■	■			■		■		■	■
Soil and Groundwater Characterization at the Holly Power Plant on the Colorado River, Texas	■					■	■				■
Evaluation of Groundwater Withdrawals on Baseflow in the St. Johns River, Florida						■	■	■			■
Review of Naturalized Flow in the Water Availability Model of the Colorado River Basin, Texas	■					■					■
Development of an Integrated Groundwater-Surface Water Model to Support Optimization of Tampa Bay Water Operations, Florida						■	■	■			■
Evaluation of Baseflow and Gain-Loss Study for the Rio Grande River, Texas						■	■	■			■

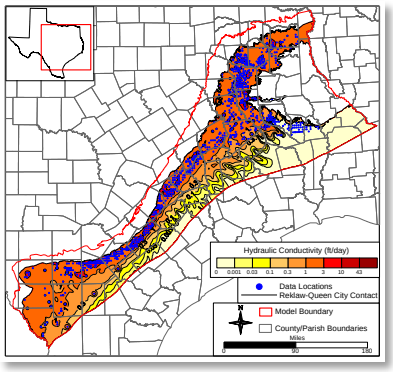
Figure 3-4. Representative project experience of the INTERA Team's proposed personnel

Development of a Groundwater Availability Model and Evaluation of Surface Water-Groundwater Interaction in the Lower Colorado River Basin, Texas



INTERA served as the modeling lead subcontractor for the development of a groundwater model to assess the impacts of additional pumping in the Lower Colorado River Basin as part of the Lower Colorado River Authority (LCRA) and San Antonio Water System (SAWS) Water Project (LSWP). INTERA was part of the Groundwater for Agriculture Study Team responsible for evaluating optimal well field alternatives for pumping an average of 36,000 acre-feet/year of additional groundwater supply to the irrigation districts in the Lower Colorado River Basin. Specific study tasks included: conducting a literature review and data collection to support the development of a conceptual groundwater flow model; developing and calibrating a groundwater model capable of simulating the impacts caused by the LSWP pumping activities to land subsidence, changes in water quality, saltwater intrusion, groundwater availability estimates, and changes in surface water-groundwater interactions; identifying potential groundwater impacts caused by pumping associated with the LSWP; and designing and evaluating alternative LSWP well field designs.

In addition to the typical activities associated with development of a GAM, the project team also spent considerable efforts developing a quantitative assessment of the groundwater and surface water interactions within the Gulf Coast Aquifer and the alluvial aquifers within the eight-county study region. INTERA applied the technique of shallow recharge estimation from streamflow data including the Colorado River Alluvium. Groundwater discharge to a stream (baseflow) was estimated using hydrograph separation on daily streamflow data. The baseflow rate was divided by the catchment area (where basin divides are assumed to approximately coincident with groundwater divides) to estimate a shallow recharge flux. In addition to traditional baseflow separation techniques, INTERA's Dr. Steven Young used monitoring wells to physically and directly establish hydraulic gradients between the Colorado River Alluvium and the underlying Gulf Coast Aquifer. These data were instrumental in providing direct evidence that the Colorado was gaining within the study area and that the relationship between the alluvial aquifer and the underlying aquifer was complex and temporally variable. The project team developed annual reports on the interactions between the aquifers and the Colorado River for LCRA and other project participants.



Development of Groundwater Availability Models of the Southern, Central, and Northern Portions of the Queen City and Sparta Aquifers, Texas

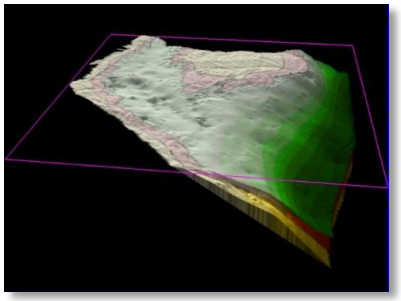
Under the TWDB's Groundwater Availability Modeling Program, INTERA developed three-dimensional groundwater flow models for the southern, central, and northern portions of the Queen City and Sparta aquifers. We developed the three Queen City and Sparta aquifer models using MODFLOW and the TWDB modeling protocols for GAMs. Important technical issues that we addressed included hydraulic properties, recharge, and aquifer stream interaction. Water levels from river gages and alluvium water wells were analyzed to quantify and surface water interactions. Stream aquifer interaction targets were developed for all major streams and rivers in the aquifer outcrop. The method used the TCEQ WAMs to develop gain loss

estimates. A method was also developed to estimate aquifer hydraulic properties while maintaining properties consistent with aquifer lithology and confining stresses (i.e., depth of burial). A recharge model was built to account for precipitation, ET, local geology, and topography.

Refinement of the Groundwater Availability Model for the Central Carrizo-Wilcox, Queen City, and Sparta Aquifers to Incorporate Flow Near Faults and Rivers, Texas

INTERA is updating the GAM for the Carrizo-Wilcox, Queen City, and Sparta aquifers in GMA 12. The work focuses on improving the simulation of groundwater–surface water interactions and the impacts of faults on groundwater flow. The project involves the analysis of hundreds of aquifer pumping tests, thousands of geophysical logs, and tens of thousands of water levels. INTERA will update the GAM using MODFLOW-USG to allow for local discretization near rivers and faults. The calibration period will expand from starting at 1975 and extending until 1999 to starting at 1920 (predevelopment) and extending until 2010.

Development of Groundwater Availability Models of the Southern and Northern Portions of the Carrizo-Wilcox Aquifer, Texas



Under the TWDB's Groundwater Availability Modeling Program, INTERA developed the original GAMs for the southern and northern portions of the Carrizo-Wilcox Aquifer (these models were subsequently replaced by the Queen City-Sparta Aquifer GAMs which include the Carrizo-Wilcox Aquifer and were also developed by INTERA). Project tasks included database development, GIS data development and presentation, model conceptualization/ design, model calibration/prediction, reporting and web publishing, and stakeholder meetings. Conceptual model development included the review and assessment of: groundwater-surface water interaction, aquifer/aquitard system geometry (geology, hydrostratigraphy, outcrops, river basins, and model boundaries), water levels and regional groundwater flow, aquifer hydraulic properties, recharge, and pumping. Recharge was estimated using the Soil Water Assessment Tool (SWAT) with MODFLOW in an uncoupled method.

Development of a Groundwater Availability Model of the Yegua-Jackson Aquifer, Texas

Under the TWDB's Groundwater Availability Modeling Program, INTERA developed the GAM for the Yegua-Jackson Aquifer. The model extends from the Rio Grande in the south to the Sabine River on the eastern border of the state. Recharge to the Yegua-Jackson Aquifer was estimated based on analysis of discharge to streams, using hydrograph separation (to determine shallow recharge/discharge), and basic application of Darcy's law at the point where the aquifer enters the subcrop (to determine deeper recharge). Aquifer hydraulic properties were based on analysis of geophysical logs and aquifer pumping tests. The model calibration period included simulating predevelopment conditions (prior to significant groundwater withdrawal) and transient aquifer conditions from January 1980 through December 1997.

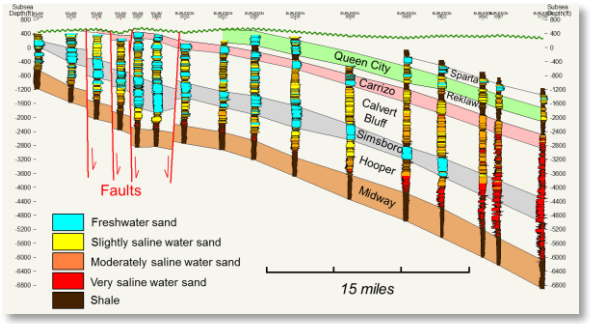
Joint Planning Support for Groundwater Management Area 12, Texas

INTERA provided technical support to GMA 12 to help develop and evaluate Desired Future Conditions (DFCs) for the constituent GCDs. The evaluation process included determining the impacts of pumping on average drawdown in counties and on baseflows in the Colorado and Brazos rivers. We responded to concerns raised by stakeholders regarding the appropriate protection and conservation of water resources that DFCs should provide. This work included re-examination of the assumptions, data, and modeling tools used to predict impacts from pumping. In addition, INTERA created future pumping scenarios

based on projected water demands and used aquifer GAMs to simulate impacts from pumping through the year 2070.

Development of a Groundwater Availability Model of the Brazos River Alluvium, Texas

INTERA developed a GAM for the Brazos River Alluvium Aquifer (BRAA). As part of developing a detailed conceptual model, we compiled and analyzed approximately 600 specific capacity values in the alluvium and compiled and re-analyzed gain-loss studies on the Brazos River. Based on results from the gain-loss study, we calculated long-term baseflow estimates from river gage data and estimated local interaction (including bank storage effects) at several points along the river. Assessment of river-aquifer interactions indicates that a direct and measureable relationship exists between river stage and groundwater flow components. Use of MODFLOW-USG allows the model to have grid cell sizes as small as 0.125-mile in the vicinity of the river and grid cell sizes of 1-mile a few miles away.

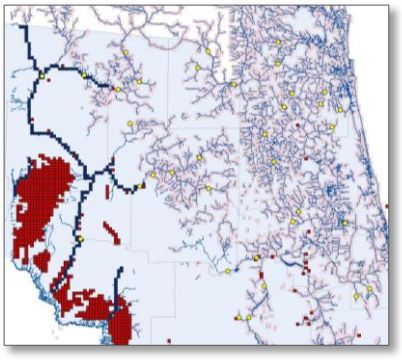


Management and Monitoring of Groundwater Resources for the Post Oak Savannah Groundwater Conservation District, Texas

INTERA has provided a wide-range of technical services in support of the Post Oak Savannah GCD's efforts to manage and monitor groundwater resources in Milam and Burleson counties. One of our tasks has included performing detailed evaluations of permits for pumping from the Carrizo-Wilcox Aquifer, including permits of up to 70,000 acre-feet per year (AFY). These permit evaluations have required detailed evaluation of local geological conditions, potential biases in the Central Queen City/Sparta GAM, and assessment of impacts on groundwater resources. INTERA is also working on a multi-year effort for the District to improve the characterization of aquifer properties, faults, groundwater flow, groundwater–surface water interactions, and recharge. To assist with the management of groundwater resources, we developed a Microsoft Access database that consolidates the District's well information including well specifications, water level and quality measurements, permitting, and pumping data.

Soil and Groundwater Characterization at the Holly Power Plant on the Colorado River, Texas

In support of Austin Energy's efforts to decommission and close the Holly Power Plant, INTERA performed environmental investigations of areas near the plant wastewater discharge and in the fuel storage tank farm. As part of the investigations, we conducted groundwater sampling and surface and subsurface soil sampling on the plant property, and surface water and sediment sampling in the Colorado River (Lady Bird Lake) located adjacent to the plant. Initially, the main focus of the on-site investigation was closure of the fuel oil storage tank area. Groundwater sampling in this local area yielded results indicating a wider area of concern and the groundwater sampling effort was extended sitewide. The initial groundwater sampling included nine existing onsite wells. The main chemical of concern (COC) in this investigation was arsenic. Due to the site's proximity to Lady Bird Lake, the TCEQ was concerned that arsenic concentrations measured in the existing wells could impact the nearby surface water quality. INTERA expanded the well network to include two additional upgradient monitor wells and two wells that were reinstallations of previously decommissioned wells. These wells were completed in the Colorado River Alluvium at the site and the new well network along with surface water and lake sediments were sampled. The additional sampling efforts indicated that the arsenic concentrations in the groundwater were localized and were not impacting surface water or lake sediments.



Evaluation of Groundwater Withdrawals on Baseflow in the St. Johns River, Florida

INTERA modified the existing USGS Peninsular Florida Model to enhance the model's ability to evaluate the impact that groundwater withdrawals have on river baseflow as well as aquifer levels in the Surficial and Floridan Aquifers in the St. Johns River Water Management District. Of particular concern was the impact on established minimum stream flow and minimum lake level flow regimes. The National Hydrography Dataset was used to develop a MODFLOW River Package. The model calibration targets included baseflow, which was determined from the observed USGS streamflow, and spring flow, which was determined from published spring discharges. A sensitivity analysis was conducted in order to assess the impacts of aquifer parameters on drawdown in the Surficial and Floridan aquifers.

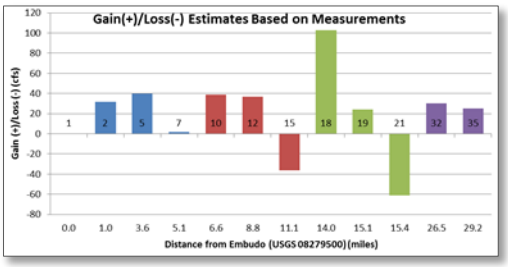
Review of Naturalized Flow in the Water Availability Model of the Colorado River Basin, Texas

FNI reviewed the naturalized flow for the Colorado River Basin Water Availability Model (Colorado WAM) developed by the TCEQ. The study provided independent verification and quality control of the revised naturalized flows. FNI obtained the naturalized flow data sets and checked the assumptions and data used in the development of the model. FNI provided LCRA with technical support at meetings in discussions with TCEQ regarding the assumptions, procedures and results of the WAM modeling. FNI prepared a report that summarized the review process and identified potential areas of concern.

Development of an Integrated Groundwater-Surface Water Model to Support Optimization of Tampa Bay Water Operations, Florida

INTERA developed an integrated groundwater surface water model by coupling HSPF and MODFLOW to simulate the full hydrologic cycle. The model domain covers 4,000 square miles, and 173 river basins. Model calibration was performed through a weight of evidence approach using stream flow, baseflow, target ET, wetland stage, and hydraulic heads as calibration targets. INTERA also developed a GIS tool for the generation of surface water model component parameters. The application fully automates the process of parameter data generation through user friendly drop-down menus and input forms. Once developed, INTERA applied IHM to a complex Gulf Coast setting in western Florida to reproduce highly transient surface discharges and groundwater levels over a 10-year historical period. The model is being used to predict both short-term (2-week predictions updated weekly) and long-term (5-year) capacities of the Upper Floridian Aquifer to meet demand forecasts.

Evaluation of Baseflow and Gain-Loss Study for the Rio Grande River, Texas



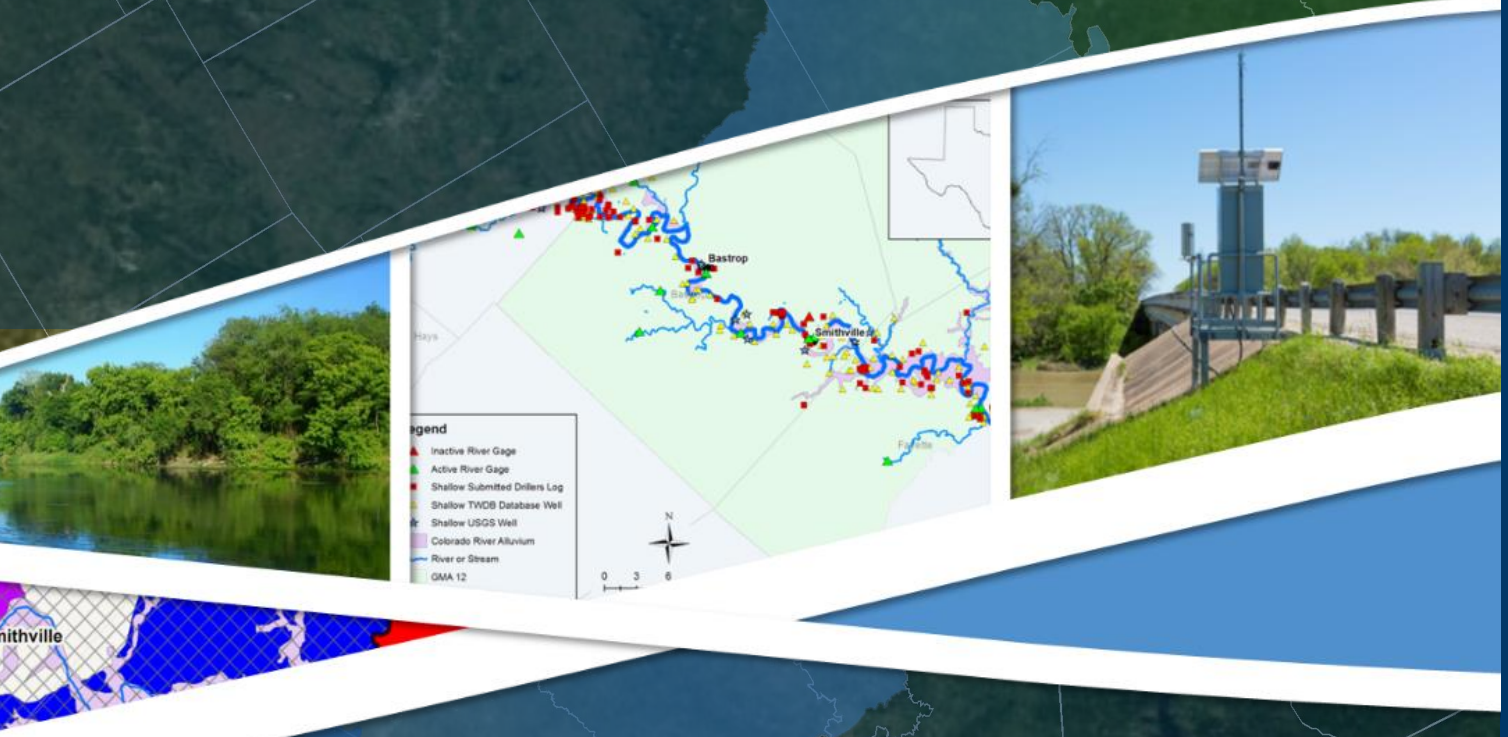
INTERA developed and implemented work plans to measure groundwater contribution to baseflow along the Rio Grande River. The field study involved collecting stream flow and diversion data at approximately 30 locations. The field data was collected during the winter to reduce errors that might be introduced due to numerous diversions that occur during the summer months. The analysis integrated the field data with flow measurements from existing USGS gaging data to estimate the long term gain loss at the same location. The final report identified locations of possible recharge and loss along the Rio Grande River.

STATEMENT OF QUALIFICATIONS

CONTENT ITEMS 4 & 5:

HISTORICALLY UNDERUTILIZED BUSINESSES SUBCONTRACTING PLAN

INTERA OWNERSHIP INFORMATION



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CONTENT ITEMS 4 & 5:
HUB Subcontracting Plan
INTERA Ownership Information

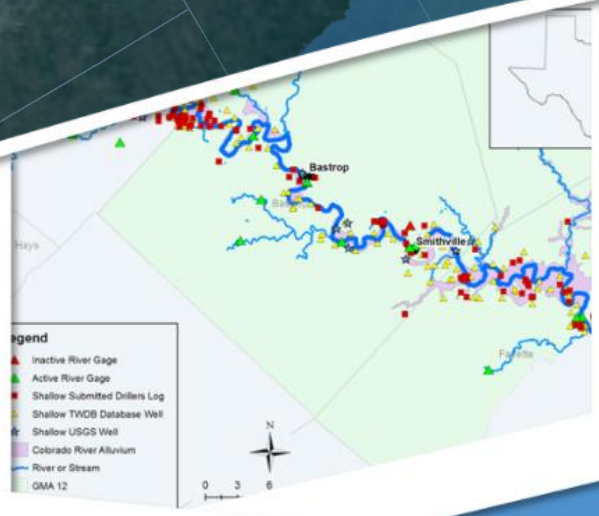
CONTENT ITEM 4: HISTORICALLY UNDERUTILIZED BUSINESSES SUBCONTRACTING PLAN

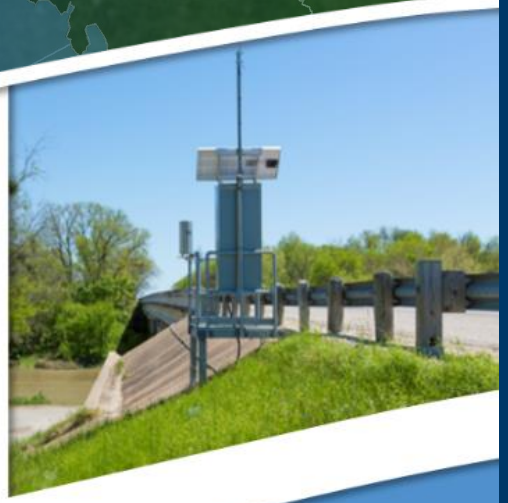
While INTERA is fully committed to providing opportunities for historically underutilized businesses (HUBs), we are proposing to complete the vast majority of work associated with revising the GAM for the central portion of the Carrizo-Wilcox and QCSP aquifers with our own internal resources. The only portions of the work being subcontracted are for very specialized services (i.e., modification and application of the MODFLOW-NWT code) that are available from single sources. Accordingly, and consistent with the TWDB's guidance that the lack of a HUB plan will not affect the completeness of the SOQ, INTERA is not submitting a formal HUB subcontracting plan.

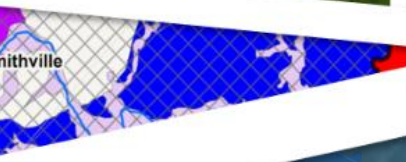
CONTENT ITEM 5: INTERA OWNERSHIP INFORMATION

While INTERA is an employee-owned company, our ownership is broad-based. No single employee has a 25 percent ownership in the company.

CONTENT ITEM 6:
TECHNICAL APPROACH







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CONTENT ITEM 6: TECHNICAL APPROACH

Based on our experience in developing and applying GAMs and conducting hydrogeologic and hydrologic studies of groundwater and surface water resources throughout Texas, the INTERA Team will employ a technically-sound and efficient approach to executing the following six key tasks, the first five of which are specified in the scope of work included in the RFQ.

- Task 1 – Conduct literature search and estimate hydrogeologic properties of Colorado River Alluvium
- Task 2 – Add shallow layer to central Carrizo Wilcox, Queen City, and Sparta aquifers GAM
- Task 3 – Reduce size of grid cells representing the Colorado River Alluvium and tributaries of Colorado River
- Task 4 – Meet with Colorado-Lavaca Basin and Bay Area Stakeholder Committee (BBASC)
- Task 5 – Develop work plan for measuring surface water-groundwater interactions
- Task 6 – Project management

Our overall technical approach includes integrating the work associated with Tasks 1 through 4 into an ongoing TWDB project that INTERA is completing to update the GAM for the central Carrizo-Wilcox, Queen City, and Sparta Aquifers. This model, hereafter referred to in this section as the "Updated CWQCS GAM" is currently being revised under a contract with TWDB (#1548301856) to better represent the impacts that structural faults have on groundwater flow in the aquifers. Since this GAM is currently being updated, this is the ideal time to also integrate changes to improve simulation of surface water-groundwater interaction with the Colorado River Alluvium within GMA 12. We anticipate that given a start date of July 1, 2016 for this project, Task 1 will be completed by December 31, 2016 and Tasks 2 and 3 will be completed by June 30, 2017. This completion schedule enables the results from Task 1 to be included in the Conceptual Model Report for the Updated CWQCS GAM and the results from Tasks 2 and 3 to be fully implemented in the final Updated CWQCS GAM, which is scheduled for completion in late 2017 or early 2018. Additional details on the activities and the INTERA Team's approach to each of the six key project tasks are provided below. Literature references cited throughout this section are included in **Attachment B**.

Task 1 – Conduct literature search and estimate hydrogeologic properties of Colorado River Alluvium

INTERA will perform a literature search for hydrogeological and geological studies relevant to the characterization of Colorado Alluvium in GMA 12. The area identified as alluvium along the Colorado River in the Geological Atlas of Texas (BEG, 2007), shown in **Figure 6-1**, will define the extent of the Colorado River Alluvium for this project. This area has been used by a number of previous studies on the Colorado River (Saunders, 2005; Dutton and others, 2003; Young and others, 2006). Our literature search will emphasize information regarding alluvium associated with the Colorado River and its tributaries in GMA 12, but will also include information and data outside of GMA 12 that may help with characterizing the hydrogeology of the Colorado River Alluvium within GMA 12. The INTERA Team will assemble and analyze information and data from state and federal agencies as well as educational institutions. The literature search will focus on characterizing the following attributes of the Colorado River Alluvium within GMA 12: base (or bottom) surface, ground (or top) surface, lithology, hydraulic properties, water levels, interaction with the Colorado River, and recharge. Our approach to addressing each of these attributes is described below.

Bottom of Colorado River Alluvium. Although the areal extent of the Colorado River Alluvium can readily be defined using surface geologic mapping (see Figure 6-1), the thickness of the aquifer is more difficult to determine. Groundwater reports have estimated that the Colorado River Alluvium can be as thick as 60 feet in Travis County (Brune and Duffin, 1983; Duffin and Musick, 1991) and Fayette County (Rogers, 1975), and up to 50 feet thick in Bastrop County (Follett, 1972). Near Austin, Texas, alluvium thickness has been mapped or estimated as part of general geologic mapping projects in the area (Rodda and others, 1969; Garner and Young, 1976). A potential source for higher resolution alluvium thickness information is the original central Carrizo-Wilcox Aquifer GAM developed by Dutton and others (2003). This model, which was subsequently replaced by the central Queen City and Sparta aquifers GAM, included a model layer to represent the Colorado River Alluvium. Dutton and others (2003) based the thicknesses of the alluvium on the analysis of well depths and well screens from the TWDB's Groundwater Database. Using this analysis as a starting point, we will expand the review of well depths and well screens from the TWDB's Groundwater Database to cover the rest of the Colorado River Alluvium within the GMA 12 region of interest. We will supplement this analysis with the lithologic and well construction information from the Submitted Drillers Reports (SDR) Database currently maintained by the TWDB.

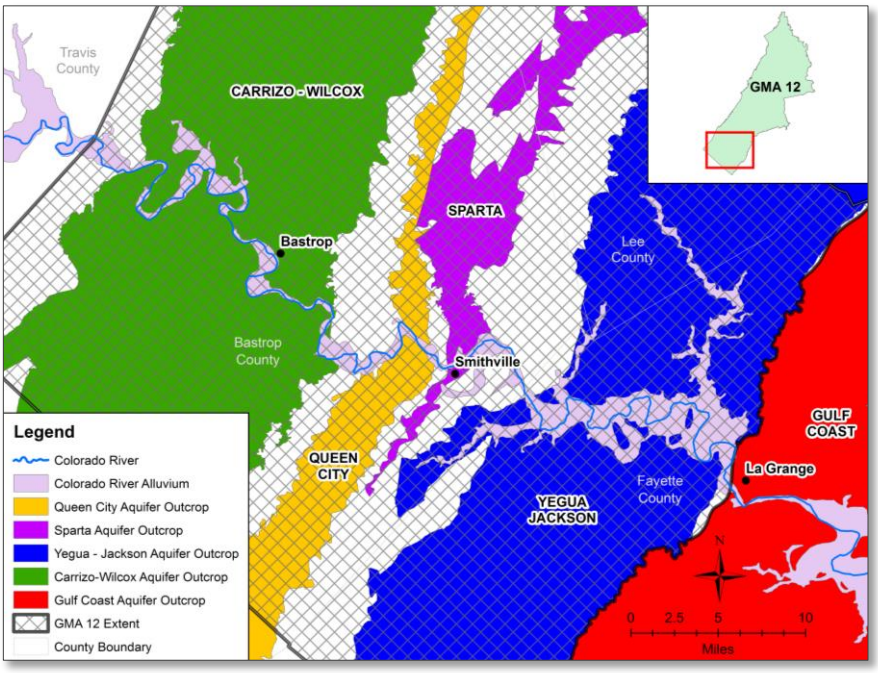


Figure 6-1. Colorado River Alluvium and other aquifers in southwestern portion of GMA 12

Top of Colorado River Alluvium. As in Dutton and others (2003), we will assume that land surface represents the top of the Colorado River Alluvium and its thickness will be determined by subtracting the alluvium depth from the land surface elevations. However, while previous work was based on the coarser 30-meter resolution digital elevation model (DEM), we will improve the characterization of the alluvium by mapping thickness based on the newer 10-meter resolution DEM. We will also evaluate using Lidar data, which can provide elevation data on the centimeter scale and is available for this area from the Texas Natural Resources Information System (TNRIS).

Lithology (or distribution of sands and clays). Aside from simplified descriptions characterizing it as a mixture of gravel, sand, and silt, there is little information available on lithological variation throughout the extent of the Colorado River Alluvium. To provide more site-specific information on the characteristics of the alluvium, we will review the lithologic logs from the SDR. There are almost 600 digital logs from this database available for wells within a mile of the Colorado River Alluvium. These represent digitally-available well logs for the post-2001 period. There are also approximately 1,600 pre-2001 scanned paper well records available from the Texas Commission on

Environmental Quality's (TCEQ) Water Well Report Database in our area of interest. Analyzing logs from both sources will give us better control on alluvial thickness as well as provide information on the layering and percent distributions of gravel, sands, and silts throughout the entire extent of the Colorado River Alluvium.

Hydraulic Properties. One of the primary goals of our literature review is to find either reported hydraulic properties or data that can be used to calculate hydraulic properties of the Colorado River Alluvium. As an example of reported hydraulic property values, Hibbs and Sharp (1993) provide hydraulic conductivity values between 95 feet per day (ft/day) and 174 ft/day for the Colorado River Alluvium based on slug tests. However, based on our preliminary search for information as part of preparing this SOQ, there are likely to be very few reported values. The majority of our literature search will focus on reviewing the hundreds of submitted drillers reports for specific capacity tests in the Colorado River Alluvium. A specific capacity test consists of two values: a pumping rate and drawdown for a designated time. Although much less informative than long-term pump tests, specific capacity can provide useable and valuable information for mapping transmissivity values (Mace, 2001). Our team has previously used specific capacity data from drillers logs to develop the Brazos River Alluvium Aquifer GAM (Ewing and others, 2016), the Northern Trinity and Woodbine GAM (Kelly and others, 2014), and the LCRB model (Young and Kelley, 2010). Unlike transmissivity, storativity cannot be estimated from specific capacity tests. As a result, we anticipate that storativity values will be developed from a few reported values for the Colorado River Alluvium and interpretation of properties assigned to similar alluviums in Texas. As part of developing a previous GAM, Dutton and others (2003) assumed a specific yield value of 0.25 for the Colorado River Alluvium.

Water Levels. Because the Colorado River Alluvium is not an official TWDB aquifer, there have been very few studies to map the alluvium water levels. For the studies that have been done, the analyses of water levels are generally limited to a specific time and location (Rettman, 1981; Larkin, 1988; and Hibbs and Sharp, 1993). Because the existing maps of water levels are limited in areal extent, another focus of the INTERA Team's literature review will be on collecting water level elevations from various sources, including the TWDB Groundwater Database, GCDs in the area of interest (Lost Pines and Fayette County GCDs), and databases maintained by the United States Geological Survey (USGS) and the TCEQ.

Interaction with the Colorado River. Historical gain/loss studies in the state of Texas, including for the Colorado River and its tributaries, are compiled in Slade and others (2002). A more recent, and better documented, gain/loss study focused on the Colorado River from Travis County to Matagorda County was performed by Saunders (2005). The water flow between the Colorado River and the Colorado River Alluvium is dynamic and dependent on several factors including water levels and the alluvium hydraulic properties. The highest rate of water exchange occurs during a flood wave when bank storage accumulates with rising stream stage (Hibbs and Sharp, 1993). The potential importance of bank storage on the Colorado River has been investigated by Hibbs and Sharp (1993). The dynamics of this groundwater-surface exchange are very different for a river system with reservoir-controlled flooding like the Colorado River than for one with natural flooding. For instance, a recent study conducted on the Colorado River below Lady Bird Lake found that dam operations alter the hydrological dynamics of riparian aquifers (Sawyer, et. al., 2009). As part of the literature review, we will assemble and analyze studies that address groundwater-surface water exchange along the Colorado River.

Recharge. Based on a percentage of precipitation, Brune and Duffin (1983) estimated 1.68 inches per year of recharge to the Colorado River Alluvium in Travis County. However, aquifer recharge is highly uncertain and dependent on the properties of aquifer. For this reason, Dutton and others (2003) based their estimates of recharge for the Colorado River Alluvium at least partially on soil properties rather than solely on precipitation. As part of the literature search, we will evaluate sources of soil data such as county soil maps and the STATSGO/SSURGO soil coverages maintained by the United States Department of Agriculture's National Resources Conservation Service. Since baseflow can provide a lower bound on recharge estimates, we will also use the gain/loss studies discussed earlier, as well as any additional baseflow analyses (including hydrograph separation) produced as part of the field data collection efforts defined in the work plan (see Task 5 below) for measuring surface water-groundwater interactions at specific locations in the Colorado River Basin. As part of this process, we will also use sources such as the report entitled *Groundwater Recharge in Texas* (Scanlon and others, 2002) to guide the process of recharge estimation.

The INTERA Team will compile the findings from the literature search into a draft report and submit it to the Colorado-Lavaca BBASC for review. We will document and respond to comments and issue a final report within a month after receiving input from the Colorado-Lavaca BBASC. Major sections of the report will be included in the draft conceptual model report for the Updated CWQCS GAM.

Task 2 – Add shallow layer to the central Carrizo Wilcox, Queen City, and Sparta aquifers GAM

Adding a model layer, or layers, into a regional groundwater model to represent a shallow groundwater flow system enhances the model's ability to simulate groundwater-surface water interactions. INTERA staff demonstrated the importance of using shallow model layers during the development of the Lower Colorado River Basin model (Young and Kelley, 2010). Since the development of the LCRB model in 2010, we have successfully incorporated shallow layers into the Yegua Jackson GAM (Kelly and others, 2011) and the Northern Trinity and Woodbine GAM (Kelley and others, 2014).

As part of this project, INTERA will incorporate two shallow model layers into the Updated CWQCS GAM. All of the grid cells associated with the two shallow layers will represent a specific hydrostratigraphic unit. In the vicinity of the Colorado River, one of the shallow layers will represent the Colorado River Alluvium. In the vicinity of the Colorado River and its tributaries, the second shallow layer will be used to improve the Updated CWQCS GAM's ability to represent the changes in storage properties with depth in the aquifer outcrop areas.

The INTERA Team will incorporate the two shallow layers in the Updated CWQCS GAM after developing a thickness map for the Colorado River Alluvium. We anticipate that the shallow layers will be fully incorporated and functional by June 2017. As part of this project, interim simulations with the Updated CWQCS GAM will be documented in a report prepared for the TWDB. Additional documentation of the shallow layers will be provided as part of the final report for the Updated CWQCS GAM, which will be completed in early 2018.

Task 3 – Reduce size of grid cells representing the Colorado River Alluvium and tributaries of Colorado River

Refining the size of grid cells in groundwater models along rivers enables a more accurate representation of the location of river channels, river alluvium, and wells. This, in turn, enables a model to more accurately simulate the exchange of water between aquifers and rivers. To better represent

groundwater-surface water interaction in the GAM, we will use a grid cell size of 0.25-miles for the Colorado River Alluvium and the tributaries of the Colorado River. To accomplish this further reduction in grid cell size, we will sample GIS maps of alluvium properties at a 0.25-miles grid spacing and delineate the Colorado River and its tributaries using 0.25-miles grid spacing. The tributaries that will be represented by the 0.25-miles grid cells are those identified in the current Central Queen City/Sparta GAM (Kelley and others, 2004). The assignment of grid properties and mapping of the river channel will be accomplished using a methodology similar to that used by Young and Kelley (2010) to create the LCRB model where ground surface values were extracted from 10-meter topographic maps and river bathymetry surface water models were used to map the locations of the Colorado River and its tributaries into the numerical grid of the groundwater model.

The construction of the 0.25-miles numerical grid will be accomplished using the groundwater code MODFLOW-USG (Panday and others, 2013). This version of the MODFLOW code is a recent advancement that allows refinement of grid spacing to be confined to specific areas of interest or groups of grid cells. In previous versions of MODFLOW (McDonald and Harbaugh, 1988) used for developing models under TWDB's Groundwater Availability Modeling Program, grid refinement could only occur along an entire row or column of grid cells. By refining only those grid cells that contain (or are near) the Colorado River, the use of MODFLOW-USG will enhance the simulation of groundwater-surface water interaction without creating a model with an excessive (and undesirable) number of grid cells.

Task 4 – Meet with Colorado-Lavaca Basin and Bay Area Stakeholder Committee

The INTERA Team will meet with the Colorado-Lavaca BBASC at least three times to provide project updates, address project related questions, and if appropriate, provide a summary of the final product. The first meeting, planned for September 1, 2016, will serve as a kickoff meeting for the development of the field data collection work plan (Task 5) to discuss key objectives and priorities of the data collection and analysis activities, potential partners, and funding sources. The second meeting, planned for January 15, 2017, will occur after the completion of Task 1 and focus on the results of this task. The third meeting, scheduled for June 30, 2017, will be held after the completion of Tasks 2 and 3 and will focus on the development and calibration of the Updated CWQCS GAM.

Task 5 – Develop work plan for measuring surface water-groundwater interaction

In cooperation with the TWDB and Colorado-Lavaca BBASC, we will develop a comprehensive work plan for evaluating surface water–groundwater interactions in the Colorado River Basin. A goal of this work is to better understand the groundwater base flow contribution to the flows in the Colorado River, with an emphasis on these contributions within GMA 12. Therefore, the study will require assembling and interpreting water levels and water quality in the Colorado River and the Colorado River Alluvium. While the kickoff meeting for this task (scheduled for September 1, 2016) will serve to establish a consensus on the specific work plan contents, major sections are expected to include the following:

- Objectives and general approach
- Site selection and preparation
- Field instrumentation
- Data collection
- Data analysis
- Budget and schedule
- Partnerships and funding sources

Three important components of the work plan—the selection of sites for collecting measurements, data collection, and data analysis—as well as the INTERA Team's expertise and experience to complete these activities are discussed below.

Site Selection. Our investigation will begin with identifying existing wells and streamflow monitoring sites in the Colorado River Basin that provide reliable data in the basin and can potentially be used in field investigations. **Figure 6-2** shows the locations of existing LCRA and USGS surface water gaging sites in the GMA 12 area. The LCRA's HYDROMET (http://hydromet.lcra.org/) data collection system monitors streamflow, river stage, lake levels, rainfall, air/water temperature, and relative humidity. The USGS operates several stream gaging sites in the basin that record stage, streamflow, and various water quality parameters. In addition to surface water information, the USGS also collects groundwater level and quality information at various monitoring wells. Data for both streamflow monitoring sites and monitoring wells are available in the online USGS National Water Information System (NWIS) database. The TWDB provides well data, including groundwater level and quality measurements in both their Groundwater Database and SDR database. In addition, GCDs may help provide access to water wells that are closely located near river gages.

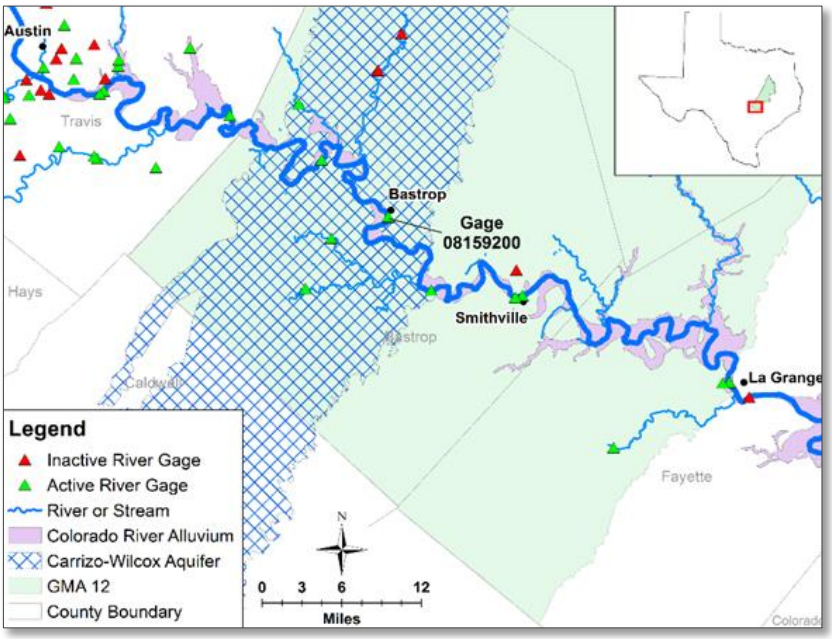


Figure 6-2. Locations of LCRA and USGS surface water gaging sites along the Colorado River in GMA 12

The substantial spatial coverage provided by the river gages will provide options for evaluating different areas of the Colorado River Basin. Since different sites will prove more useful in meeting specific objectives, the selection of a site, or sites, for detailed studies will depend on the priorities defined by project stakeholders. For example, if stakeholders prioritize a quantification of input to the river from underlying aquifers, we will select sites where the river flows are gaged over aquifer outcrops. The USGS gage 08159200 (shown in Figure 6-2) on the Colorado River near Bastrop, Texas is ideally suited for this since it is located near the lower boundary of the Carrizo-Wilcox outcrop. As another example, if establishing hydraulic gradients near the river is determined to be a priority, we might select stream gaging sites that are near shallow wells with water level records. If no existing wells are suitable for meeting defined objectives and priorities, the installation of new wells will be considered.

Data Collection. The first stage of data collection will be a literature search for existing data and monitoring sites, primarily from the state and federal monitoring databases discussed above. We will also consider existing site studies on the hydrogeology of the Colorado River Basin, with an emphasis on stream/aquifer interaction. The USGS has compiled historical gain/loss studies for the state of Texas including several studies on the Colorado River and its tributaries (Slade and others, 2002). The LCRA has also conducted several field studies to quantify groundwater-surface water interaction in the

Colorado River Basin. The LCRA studies include instrumenting two monitoring well fields along the Colorado River in Austin and Travis County to characterize bank storage (Hibbs and Sharp, 1993). LCRA also performed a gain/loss analysis, taking low-flow field measurements at sites along the Colorado River from Utley to Bay City, Texas in November 2005 (Saunders, 2006). In addition, LCRA conducted a stream/aquifer interaction study in 2006 and 2007, comparing water levels in two alluvium monitoring wells in Wharton and Matagorda counties to water levels in nearby Colorado River gage monitoring sites (LCRA, 2007). These field studies provide historical data in the basin and potential locations and infrastructure for future field investigations.

The nature and extent of field measurements considered in the work plan will depend on the specific objectives and guidelines defined by stakeholders. INTERA has a long history of providing field technical support for groundwater monitoring studies, and we routinely design and/or install groundwater monitoring systems for a variety of water resource development/management and environmental investigation projects. In cooperation with the LCRA, INTERA staff installed and monitored the shallow alluvial monitoring wells involved with the stream/aquifer interaction study along the Colorado River in Wharton and Matagorda counties (LCRA, 2007). Our staff also includes experts in performing aquifer pumping tests and gain/loss river water budget studies, collecting manual water level and water quality measurements, and deploying and maintaining long-term in-well monitoring instrumentation. For the proposed work plan, INTERA will use existing infrastructure to the extent possible to minimize costs during implementation.

Data Analysis. The INTERA Team's expertise in the areas of statistical analysis, programming, geospatial mapping, and modeling will enable us to develop a sound methodology for analyzing data associated with surface water-groundwater interaction in the Colorado River Basin. Hydrograph separation techniques are used to quantify the amount of streamflow contributed by groundwater sources and likely will be necessary for the proposed project. INTERA has experience using several automated hydrograph separation programs including the Nature Conservancy's IHA, USGS's HYSEP, the U.S. Bureau of Reclamation's BFI, and Texas A&M University's Bflow. We have applied these hydrograph separation techniques and documented analysis results in research reports for the LCRA and TWDB as well as part of the conceptual model development for several GAMs in the state of Texas. Given this experience, we are also able to identify the potential biases or errors associated with hydrograph separation calculations and correct these biases. The INTERA Team also has expertise and experience using surface water software such as RiverWare, surface water models such as the TCEQ's WAMs, groundwater software such as MODFLOW, and groundwater models such as the TWDB's GAMs.

Two examples that highlight INTERA's experience are the development of the Brazos River Alluvium Aquifer GAM and our analysis of hydrographs in the City of Wharton for a water resource project. INTERA recently developed a MODFLOW-based groundwater-surface water model to simulate the effects that the Brazos River has on water levels in the Brazos River Alluvium Aquifer, which like the Colorado River Alluvium, is a system heavily dependent on the interaction between surface water and groundwater. As part of the LSWP, INTERA staff helped quantify groundwater-surface water interaction along the Colorado River at the City of Wharton by comparing water levels from stream stage gages to nearby shallow wells. **Figure 6-3** illustrates the results of this analysis for a paired river gage and alluvium groundwater well in Wharton, Texas. INTERA staff are also experts in geospatial analysis, another key tool that will be required for the proposed project. Using programs like ESRI ArcGIS, we perform geostatistical analyses as well as create and deliver maps on both local and regional scales. We provide all data and maps in a single cohesive geodatabase and in formats appropriate for public distribution on client websites.

Additional Partnerships and Funding Sources. Because understanding surface water-groundwater interactions in the Colorado River Basin is important to a wide variety of stakeholders, it is likely that some of the objectives of the proposed work will overlap with the interests of other stakeholders in the region. For this reason, the INTERA Team will explore potential partnerships with diverse organizations including state entities such as GCDs and the LCRA; environmental groups like Environmental Stewardship, The Nature Conservancy, and Sierra Club; and large water users such as municipalities and industries in the region. If established, these partnerships will help guide work plan development and ensure that the final plan delivers results that will be useful not only for future groundwater model development, but for future planning and research by other stakeholders. Additional funding from these partners may also enable a more comprehensive study and analysis of surface water-groundwater interactions in the Colorado River Basin. Other state and federal sources with similar funding objectives may also provide additional funding and scope. For example, programs like the Resources & Ecosystems Sustainability, Tourist Opportunities & Revived Economies of the Gulf Coast States Act of 2012 (RESTORE Act), have opened up funding opportunities for projects in Texas with similar goals to the proposed field project.

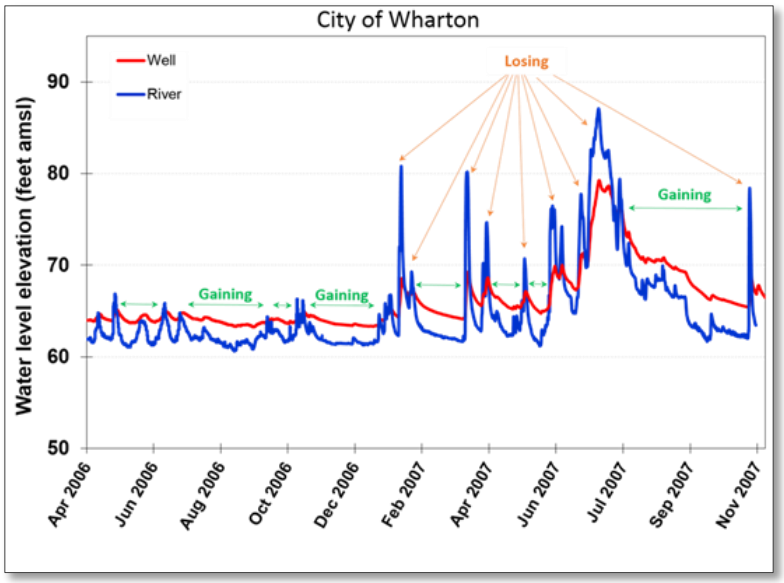


Figure 6-3. Hydrograph analysis to quantify groundwater-surface water interaction along the Colorado River in Wharton

Task 6 – Project management

One of the keys to successfully executing this scope of work is assigning a Project Manager that is intimately familiar with the data, models, geology and hydrogeology of this portion of Texas, and the TWDB groundwater program. The INTERA Team's proposed Project Manager, Dr. Steve Young, meets these requirements. Through our past project experience with TWDB, Dr. Young, in conjunction with our proposed Project Principal, Mr. Van Kelley, bring a proven ability to complete challenging projects within schedule and budgetary constraints. Dr. Young will serve as the primary point of contact for the TWDB, the Colorado-Lavaca BBASC, and other project stakeholders. His project management responsibilities will include providing prompt and comprehensive information to TWDB and stakeholders regarding the project schedule, budget, and technical considerations.

Dr. Young will monitor project progress using the same procedures that have enabled us to meet scheduled deliverables on other TWDB projects. Monthly status reports, including technical information regarding progress on the study in the preceding month, will be provided to TWDB. The monthly report will also summarize project progress relative to the baseline schedule. Cost summaries, by task and subconsultant will be provided to the TWDB with our monthly invoices. These cost summaries will show costs relative to budget. Monthly project reports will be used as a means of documenting issues, either technical or programmatic, which require consultation with the TWDB. Coordination with TWDB staff and other stakeholders will be critical throughout the project. We anticipate regular communication with the TWDB's Project Manager during the project through meetings held either in person or via

teleconference. INTERA's Austin office, located approximately five miles from the TWDB office, will facilitate this communication.

Project management and control functions are carried out in accordance with a well-established system. Dr. Young will use Axiom's Ajera Complete, a computer-based project control system that integrates time keeping, accounting, and accounts receivable. This system enables him to monitor project hours and charges in real time since the system updates with every hour added on a time sheet (time is entered on a daily basis). This system provides for detailed tracking of resources and schedules and allows early identification of problem areas so that any required corrective measures can be applied in a timely manner. Dr. Young will establish the budget for each task, and assign each element of work an appropriate task code designation. He will monitor the performance of each work element and will prepare the monthly status reports. These reports will provide various levels of information for each task, as well as for the entire project. This includes personnel hours and direct costs charged to date, current estimates to complete the project, and a comparison of the current estimated total with the previously established budget. The INTERA Team's proposed project schedule for completing the work is shown in **Figure 6-4**. For purposes of developing our schedule and timeline, we are assuming a start date of July 1, 2016. In accordance with the schedule requirements defined in the RFP, the project end date is August 31, 2017.

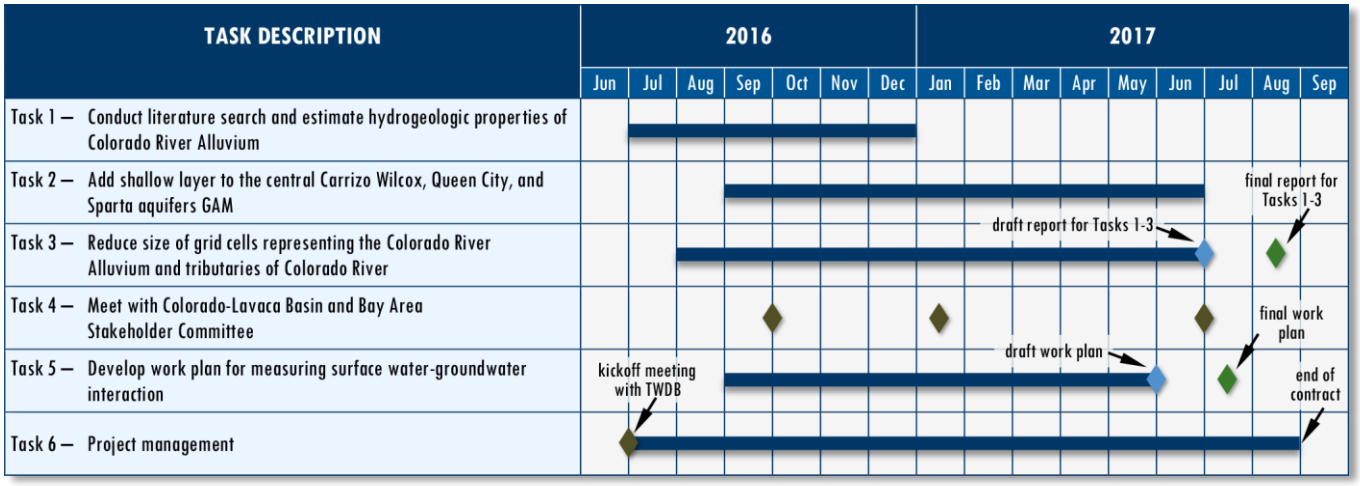
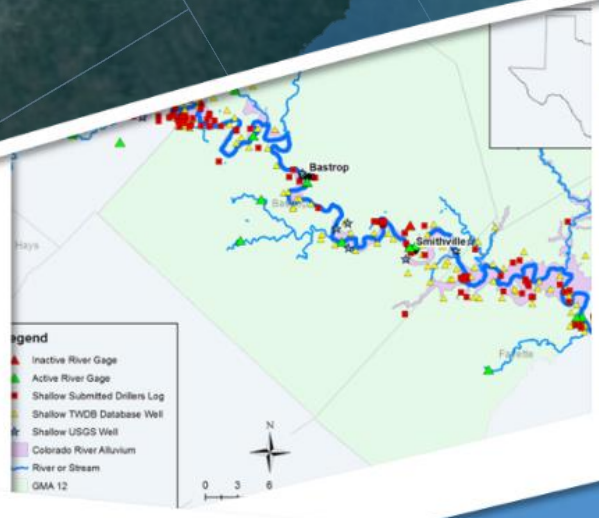
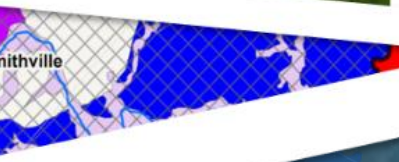


Figure 6-4. Schedule showing task durations, deliverables, and meetings for improving simulation of groundwater-surface water interaction in the GMA 12 GAM

ATTACHMENT A:

ACKNOWLEDGMENT OF ADDENDUM #1





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ATTACHMENT A:
ACKNOWLEDGMENT OF ADDENDUM #1

Texas Water Development Board
P.O. Box 13231, 1700 N. Congress Ave.
Austin, TX 78711-3231, www.twdb.texas.gov
Phone (512) 463-7847, Fax (512) 475-2053

Addendum to RFQ No. 580-16-RFQ0014
IMPROVING SIMULATION OF GROUNDWATER/SURFACE WATER INTERACTION IN THE GROUNDWATER MANAGEMENT AREA 12 GROUNDWATER AVAILABILITY MODEL

RFP NO:	580-16-RFQ0014	**ADDENDUM NO. :**	1
Deadline for Submission for RFQ:	3:00 PM, Friday, April 1, 2016		
Contact: Tina Newstrom	Phone: 512-463-7979 Email: angela.wallace@twdb.texas.gov		

PURPOSE OF ADDENDUM

Please change the following:

On cover page listed as RESPONSES DUE and also under SECTION IV, 4.4 SCHEDULE OF EVENTS, EVENT DATE: Deadline for Submission: Change due date from April 1, 2016, to **Monday, April 11, 2016.**

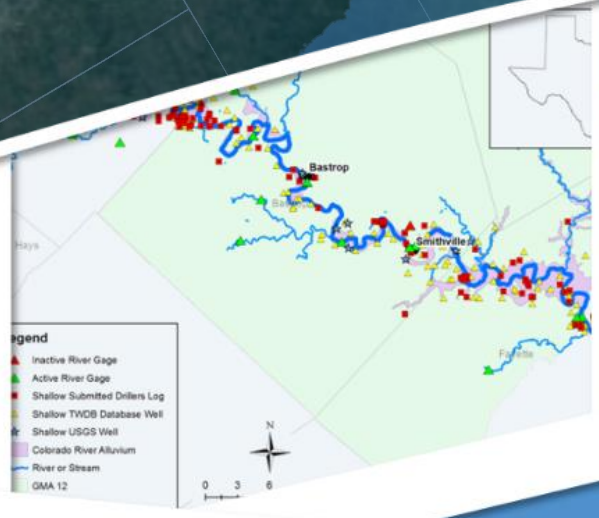
End of Addendum No. 1

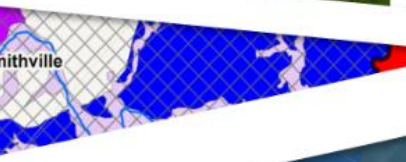
IN THE SUBMISSION OF RFQ, RESPONDENT SHOULD ACKNOWLEDGE RECEIPT OF THIS ADDENDUM; OTHERWISE THE SUBMISSION MAY NOT BE GIVEN CONSIDERATION. RESPONDENT MAY ACKNOWLEDGE RECEIPT BY RETURNING A SIGNED COPY WITH THEIR SUBMISSION.

Van Kelley, Senior Vice President
RESPONDENT NAME

Van Kelley April 1, 2016
AUTHORIZED SIGNATURE

ATTACHMENT B:
CITED REFERENCES





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ATTACHMENT B:
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INTERA Incorporated
1812 Centre Creek Drive, Suite 300
Austin, Texas 78754
512.425.2000