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TWDB Groundwater Educational Videos Project

Final Report (TWDB contract #: 1248301495)

Date Submitted: April 17th, 2015.
Client: Texas Water Development Board
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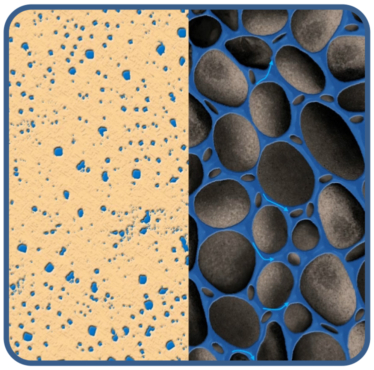

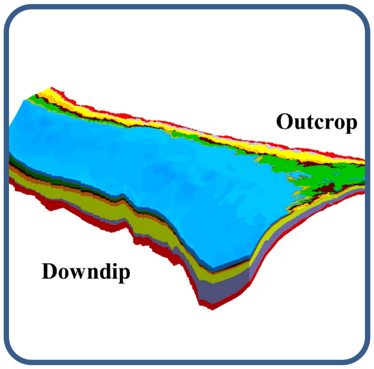

With subcontractors: BL!P BIG LOOK! PRODUCTIONS AQUAVEO Water Modeling Solutions Watearth

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Table of Contents

1. Executive Summary

RPS, along with subcontractors, Big Look! Productions, Aquaveo and Watearth, are pleased to present the deliverables for the TWDB Groundwater Educational Videos Project (TWDB contract #: 1248301495). These include a series of four short educational videos for the Texas Water Development Board to teach citizens of Texas about aquifers, groundwater availability models and how these models are used to manage the State's precious water resources. The four modules are listed as follows:

1. Aquifers of Texas
2. How do Aquifers work?
3. Groundwater Budget and Availability Models
4. Using Groundwater Availability Models in Water Planning.

Each of these modules lasts five to seven minutes. The four video modules are delivered as high definition videos (720p or 1080p) in MP4 format using a high quality h264 or x264 codec. As per the project's Request for Qualifications, the modules contain original computer animations which include time series animation of water level fluctuations through time.

Also included in the deliverables are closed captions (in the form of xml and srt files) for each of the modules for the hearing impaired and transcripts for the visually challenged. The transcripts for the video modules are provided in this report (see Appendix A).

Throughout the project, screenings have been provided by the team and by the TWDB to public audiences to elicit feedback on the video modules. They are listed as follows:

a. October 21, 2013, a preview of the "Frankenstein cuts" of Video Modules 1 and 2 was shown to an audience of 40 to 50 retirees to gather feedback on the direction of the draft videos and the content. A summary of the feedback is attached to this report (see Appendix B). Responses were in general positive with audience indicating interest in seeing the final products of this project.
b. January 27, 2014, Draft Video Module 1 was shown to internal TWDB staff that included staff from conservation education, communications, planning, groundwater resources, and management.
c. March 5, 2014, Draft Video Module 1 was shown to Texas Groundwater Protection Committee Public Outreach and Education subcommittee members and various members of the public.
d. August 13, 2014, Draft Video Modules 2 and 3 were shown to Milam and Burleson Counties Groundwater Summit (http://www.posgcd.org/event/groundwater-summit)

that included professionals in the water industry, oil and gas industries, groundwater conservation district personnel, Texas AgriLife Extension personnel, State Representative Marsha Farney, several judges, Texas Railroad Commission personnel, Texas Water Development Board personnel, and general public.

e. November 12, 2014, Draft Video Modules 2, 3, and 4 were shown Texas Groundwater Protection Committee Public Outreach and Education subcommittee members and various members of the public.

The project approach, methods, issues, and recommendations for the future are provided with this submittal.

2. Background

An important and essential component of the Groundwater Availability Modeling Program is to continually develop better tools to aid in the understanding and analyses of the aquifers in Texas. Therefore, the objective of this project is to create at four (4) (5 to 10 minute) video modules using three-dimensional (3-D) visualization tools, as applicable, demonstrating the basic differences and similarities in aquifers across the state; how aquifers respond differently to stresses in the confined portion versus the unconfined portion of the aquifers; the concept of a water budget, especially as it relates to a numerical groundwater flow model; what is a regional scale numerical groundwater flow model (MODFLOW) such as those developed for the Groundwater Availability Modeling Program; and a brief overview of how groundwater availability models can be used (and not used) for planning purposes.

The purpose of the video modules of the project is to educate stakeholders and to promote their participation in the management of their groundwater resources. Therefore accessibility requirements for the hearing and visual impaired were followed, including closed captions and transcripts.

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3. Approach

The following describes the approach taken by the team in producing the video modules:

1. At the beginning of the project, the team proposed an outline of four video modules to educate the Texas public about groundwater science and use of Groundwater Availability Models (GAMs) in water planning. The four modules are summarized as follows:
    a. Aquifers of Texas
        - An introduction to Texas aquifers and why groundwater resources are important to the State of Texas;
    b. How do Aquifers work?
        - An introduction to basic groundwater science – explaining concepts such as permeability and porosity, confined and unconfined aquifers, pumping effects on aquifers, etc.;
    c. Groundwater Budget and Availability Models
        - An introduction to the role of groundwater in the water cycle, what is a groundwater budget, and how GAMs provide a science-based method for evaluating the groundwater budget of an aquifer;
    d. Using Groundwater Availability Models in Water Planning
        - An introduction to the rule of capture, how groundwater planning is done at local and state levels, and how GAMs are used to assist water resources planning.
2. Scripts for the four modules were prepared by the team and reviewed by the TWDB. The approved versions of the scripts are included in Appendix A.
3. Rough video cuts (“Frankenstein” Cuts) were prepared for the four modules by fitting live imagery, footage and animations from existing sources (see Section 3.1) over a preliminary narration of the scripts. Gaps in the visual content were highlighted by “black boxes” in the sequences.
4. A preliminary screening of the “Frankenstein” Cuts was conducted in October, 2013 to a public audience to gather feedback on the draft videos. A summary of the responses is provided in Section 4 and Appendix B. Overall, the response was positive with the majority of the audience expressing interest in seeing the final products of the project.
5. The final voiceovers for the approved script were recorded by narrators (Mr. Doug Coker and Ms. Sara Beth Chase) in a studio in November, 2013.
6. Computer animations were developed and additional footage were sought to fill in the visual gaps. This was an iterative process where several intermediate versions of the videos were reviewed by the team and then edited. Some of the draft versions were

sent to the TWDB where they were reviewed internally by the Groundwater Availability Modeling group and by the public.

7. Final drafts of the four modules were prepared and captions were developed in xml and srt formats. The final drafts were submitted to the TWDB for review.
8. Comments and suggestions on the draft deliverables were received from the TWDB. A summary of the responses is provided in Appendix C. A final milestone presentation of the videos was provided to the TWDB on 3/23/2015.

3.1 Existing sources of footage

Most of the live image sequences in the videos were obtained from six DVDs received from the TWDB at the beginning of the project. Five were from Texas Parks and Wildlife Department (TPWD):

1. Texas: The State of Water (Vol I)
2. Texas: The State of Water (Vol II): Finding a Balance
3. Texas: The State of Springs (Vol III)
4. Texas: The State of Flowing Water (Vol IV)
5. Texas Water Stories

One was from the Edwards Aquifer Authority (EAA):

6. Drop inside the Edwards Aquifer

Prior to incorporating them into the videos, the team contacted the TPWD and the EAA and secured permission to use the footage from the DVDs.

For the TPWD, Ms. Lauren Mulverhill of the TWDB contacted the TPWD media department on 8/12/2013 and obtained permission. Mr. Greg Hughs then followed up and visited the department to download the footage.

For the EAA, Mr. Greg Hughs contacted the Ms. Terri Herbold of EAA's Public Policy & External Affairs department in October, 2013. Permission was finally received on 12/23/2013. The EAA footage included some animation clips that were developed by Toxey/McMillan Design Associates LLC. As such, acknowledgements to Toxey/McMillan Design Associates LLC were provided in the end credits of the modules.

3.2 Additional footage

In addition, the team incorporated footage from the TWDB and USGS. TWDB footage included field activities by the groundwater staff, downhole video clips, photographs of various rock formations, and meetings by the Board of the TWDB. USGS footage included a graphic of subsidence in Houston (Kasmarek, M.C., et al, 2009). Acknowledgements to the TWDB and the USGS were provided in the videos.

3.3 Original animations

Original computer animations developed by the team include (and are not limited to) the following:

1. Map animations of aquifers, Groundwater Conservation Districts, Groundwater Management Areas, Regional Water Planning Groups;
2. 3D animations of Groundwater Availability Models (see example in Figure 1), aquifers, and the data needed to construct a Groundwater Availability Model;

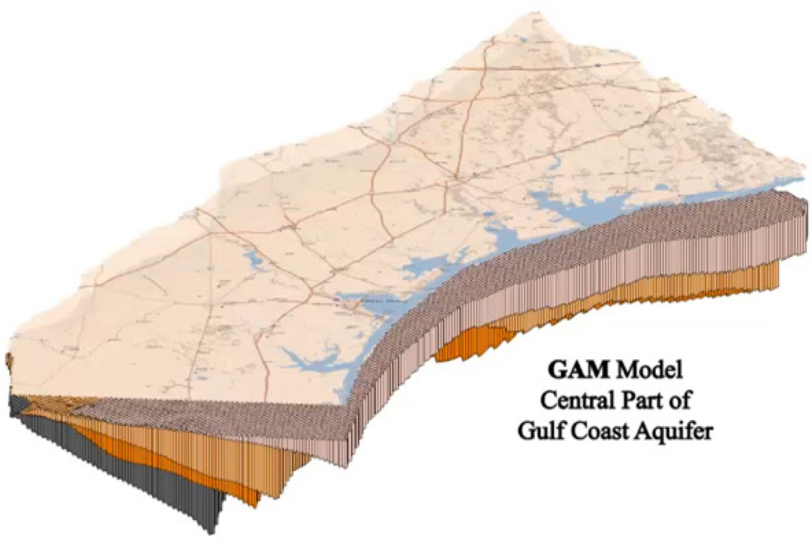

Figure 1. 3D Animation of the Gulf Coast Aquifer GAM.

3. Illustrative cross sections explaining the water cycle (see example in Figure 2), spring flows, recharge, water budget, subsidence, saltwater intrusion, pumping, etc.;

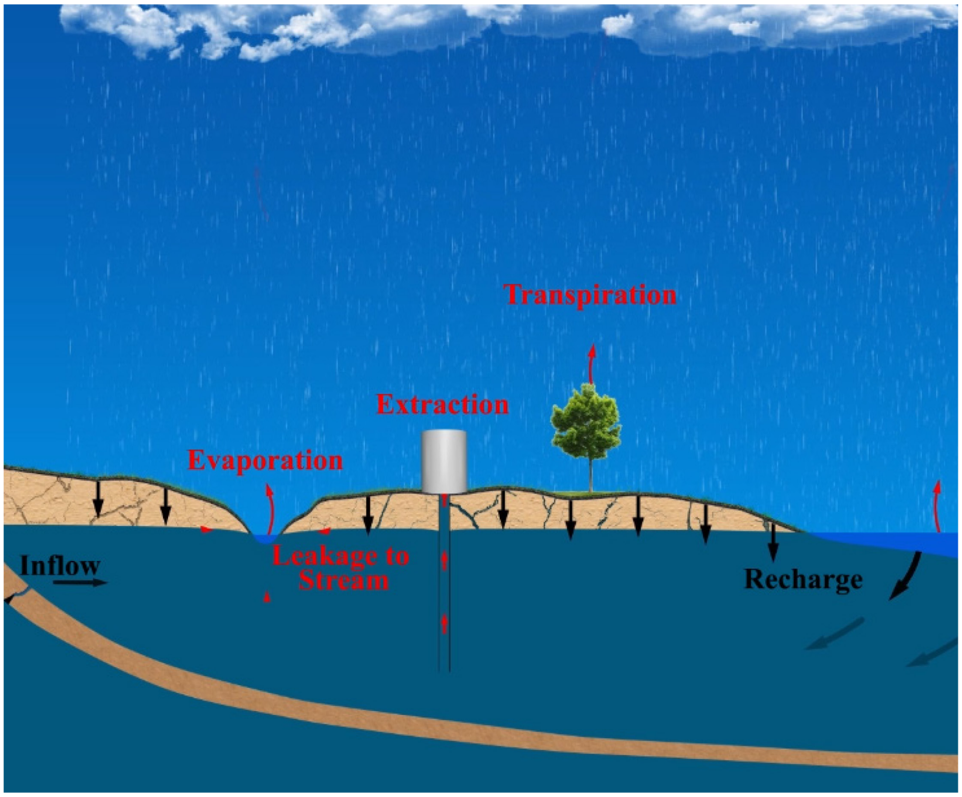

Figure 2 Animation of a water cycle.

4. Pore-scale animations illustrating porosity and permeability
5. Animations of projections of population and groundwater availability; and,
6. Title sequences of the four video modules.

4. Screenings

Appendix B provides a summary of the responses from a preview of the Frankenstein cuts of Modules 1 and 2 on Monday, October 21, 2013. The audience was comprised of attendees of UT SAGE – a seminar series for retirees from a wide variety of backgrounds. They were about 40-50 attendees in the room. These videos were shown to them with the knowledge that they were works-in-progress.

The responses were generally positive. A couple of attendees mentioned that the videos instantly got their attention. The combination of computer graphics, live footage, narration and music really made it interesting and helped them visualize aquifers. It also helped them understand the technical terms they have heard in the media or in earlier seminars (such as what is an acre-foot). After the seminar, some attendees wanted to find out when the final videos would be available and mentioned that they would be very interested in seeing them. They were in general excited about the videos' potential.

General areas for improvement suggested by the audience include:

1. Most felt that the pace of the narration could be slowed down a little. In the final recording of the voiceover on November 7, 2013, special attention was paid to the pace to make sure the audience had enough time to absorb the material.
2. Some audience commented that the second video (How do Aquifers work?) may have had too much technical detail. As such, the script for video #2 underwent some revisions to simplify it prior to recording the final voiceover.

After the screening, survey forms were handed to the audience to get feedback. A summarized version of the form that tallied up the number of responses for each answer box, and compiles the answers to the questions is provided in the next few pages.

5. Technology transfer

The four video modules were developed in Adobe Premiere Creative Cloud (2014). The Adobe Premiere project contained all the video and audio sequences used and the size was about 1 Terabyte. For the draft deliverable, condensed versions of the draft video modules were provided for review and comment. For the final deliverable the following was provided on a portable hard drive:

a. High definition videos (720p or 1080p) on FLASH/HDD/CD/DVD media (MP4, M4Vfiles using a high quality h264 or x264 codec),
b. A copy of the Adobe Premiere Creative Cloud project files,
c. Closed captions (in the form of XML files or srt files as discussed with TWDB contract manager Cindy Ridgeway) and transcripts for the hearing impaired and visually challenged, and
d. A report on the project detailing approach, methods, issues, and recommendations for the future (hard copy and electronic versions in both Microsoft Word format and in Adobe Acrobat PDF compatible format).

Please see appendix D on how to find the above deliverables in the portable drive.

6. Recommendations for future work

The Adobe Premiere project mentioned in Section 5 will provide the TWDB with the framework and the flexibility to perform all kinds of edits to the four video modules. As new footage or statistics become available, (e.g. TWDB Board meetings, field activities, or new population/groundwater projections from future State Water Plans) they can be edited into the videos to make these videos current and up-to-date.

7. Acknowledgments

The team would like to acknowledge the Texas Parks and Wildlife Department, Edwards Aquifer Authority, United States Geological Survey, Toxey/McMillan Design Associates LLC and the Texas Water Development Board in providing graphics and footage that were incorporated into the videos.

8. References

Texas Parks and Wildlife Department, 2003. Texas: The State of Water (Vol I), DVD media.

Texas Parks and Wildlife Department, 2005. Texas: Texas: The State of Water (Vol II): Finding a Balance, DVD media.

Texas Parks and Wildlife Department, 2007. Texas: Texas: The State of Springs (Vol III), DVD media.

Texas Parks and Wildlife Department, 2007. Texas Water Stories, DVD media.

Texas Parks and Wildlife Department, 2009. Texas: Texas: The State of Flowing Water (Vol IV), DVD media.

Edwards Aquifer Authority, 2010, Drop inside the Edwards Aquifer, DVD media.

Kasmarek, M.C., Gabrysch, R.K., and Johnson, M.R., 2009, Estimated land-surface subsidence in Harris County, Texas, 1915–17 to 2001: U.S. Geological Survey Scientific Investigations Map 3097, 2 sheets.

Appendix A – Scripts for Modules 1 to 4

A1. Transcript for Module 1: Aquifers in Texas

Groundwater from aquifers sustains life of every kind in Texas. It is a key resource to every industry in Texas, from farming, ranching, and manufacturing to energy exploration and refining. However, we cannot see this resource until it flows out of the ground in the form of a spring, or is pumped out of a well.

Aquifers are water-bearing rocks underneath the land surface. A spring flows when an aquifer is filled to the point that the groundwater overflows onto the land surface. Many Texas rivers and streams are spring-fed. Natural springs originally helped support Native American settlements and served as the key junctions along hunting and migration trails. Later missions and towns developed around these springs and grew into the Texas cities we see today.

While surface water from the State's many rivers and reservoirs continues to fulfill some of the state's water needs, groundwater from aquifers still supply 60% of all water used in Texas. But rising groundwater usage has led to steadily declining supplies. Some springs that sustained early communities have dried up. "Big Spring" in west Texas has long gone dry, but because of its significance to the town, the illusion of a flowing spring is kept up by piping in surface water.

Groundwater volume is measured in acre-feet. One acre-foot of water - about 330,000 gallons - would cover a football field to a depth of one-foot. This amount of water is sufficient to meet the needs of two average-sized families for one year.

When we look at the numbers, Texas used a total of 8 million acre-feet groundwater in 2010 – more than other sources of water such as surface water from reservoirs and rivers. Groundwater is used not only for drinking water, but also to meet the needs of many commercial enterprises, including agriculture, manufacturing, and energy production.

The amount of groundwater that was available in 2010 was thirteen million acre-feet. By 2060, the amount of groundwater available is expected to decline to ten million acre-feet per year. Meanwhile, the Texas population is expected to increase from 25 million to 50 million. With declining supplies and growing demands for water, groundwater availability is a critical concern, both now and in the future.

Texas has nine major aquifers. A major aquifer covers a large geographic area and can produce large amounts of groundwater. Major aquifers accounted for 84 percent of available groundwater in 2012. The remaining 16 percent was contained in 21 minor aquifers. A minor aquifer is an aquifer that can produce only small amounts of water over large areas, or large amounts over small areas.

Some of these aquifers are the principal source of water for communities in Texas, especially in the arid western part of the State. In San Antonio, nearly all the water comes from an aquifer. And it is a good quality, cost effective, reliable resource during times of drought.

The Texas Water Development Board works with nearly 100 Groundwater Conservation Districts throughout the state. The Agency provides these Districts with a wide range of educational and technical resources to help develop effective groundwater management plans. As of 2012, all confirmed districts have plans that are approved by the Texas Water Development Board or are in the process of being approved.

At the state level, regional water planning groups across Texas have designed groundwater management strategies to meet future demands brought on by population growth. Plans include new ideas for water conservation, development of new water wells, increased withdrawal at current well fields, desalination of brackish groundwater, using surface water to offset groundwater demands, and transferring water between river basins. Module 4 of this video series describes how groundwater is managed at the local, regional and state levels in Texas. The Texas Water Development Board's "Water IQ: Know your water" is a statewide public awareness program that educates Texans about water conservation. Water IQ provides information on water conservation practices, raises awareness about the importance of water conservation, and helps Texans use less water.

With the projected doubling of the state's population over the coming decades - and the ever-present threat of drought - Texas is preparing to meet the challenge of supplying water to its citizens. Throughout the state, dedicated water management professionals and community leaders are working together to ensure the availability of quality water - the essential element - past, present, and future - in the development of the great state of Texas.

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A2. Transcript for Module 2: How do Aquifers work?

Beneath the surface of Texas are extensive water-bearing geologic formations that make up the state's vast and diverse system of aquifers. These aquifers provide more than half of the water Texans use each year. Aquifers are rarely underground lakes like you might see in a cave. They are typically rock formations that are mostly solid, but like sponges they have interconnected fissures and pore spaces that hold water and allow it to move within the formation. An aquifer is best defined as a layer of saturated rock and the water in its pores.

Aquifers are formed very slowly over vast periods of time. Water in aquifers comes originally from the surface of the earth. When rain falls, some of the water infiltrates underground and collects in the pore spaces. Water in rivers and lakes can also seep into subsurface pores. Eventually some interconnected pore spaces become saturated with water. In other words, they become an aquifer.

The ability of an aquifer to produce water depends on the properties of the aquifer's rock formation. The two most important properties are porosity and permeability.

The porosity is a measure of the volume of empty space - - - or pore spaces -- - inside the rock. Pore spaces can be openings between grains, fractures in the rock, and even caverns. Porosity represents the volume of water a rock formation can hold.

Porosity itself isn't enough to create an aquifer. The areas filled with water must connect with each other so the water can flow from one pore space to another.

That connectivity between pores is known as permeability. Permeability is a measure of how readily water can flow within the rock. Rocks such as pumice and shale can have high porosity but do not form productive aquifers because the pores within the rock are not connected The permeability of pumice and shale is low. On the other hand, gravel transmits water quickly because of large connected pore spaces. The permeability of gravel is high.

Compared to water movement through rivers or lakes, the rate of movement through an aquifer is slow. Of the nine major aquifers in Texas. Six of them (the Ogallala, Gulf Coast, Carrizo-Wilcox, Pecos Valley, Seymour and Hueco-Mesilla Bolsons consist of sedimentary rock with relatively high porosity and permeability. Sedimentary rocks are composed of sand, gravel, silt, and clay. The three other major aquifers - Edwards Aquifer (sometimes referred to as the Balcones Fault Zone) the Trinity Aquifer and the Edwards-Trinity (Plateau) Aquifer - consist either mainly or partly of limestone. Water in limestone aquifers is held in crevices and caverns left by the dissolution of the limestone by groundwater. This subterranean landscape is known as Karst and is highly permeable.

Being on a fault zone, the Karst limestone of the Edwards Aquifer is highly fractured. Rainwater seeps very quickly into the Edwards Aquifer through the fault lines - even while a storm event is happening. Not all limestone aquifers in Texas recharge this quickly.

In nature, aquifers are seldom separated neatly into geographic areas. Instead, like a stack of pancakes, aquifers overlay each other and dip at different angles. Some parts are exposed to the earth's surface while other parts are buried under other aquifers. The part of an aquifer that is exposed at land surface is known as the outcrop. The part that is in the subsurface is known as the downdip extent. For example, the outcrop of the Carrizo-Wilcox Aquifer is a narrow band that lies parallel to the Gulf Coast. As we move towards the coast, the aquifer slopes beneath the land surface – forming the downdip.

Aquifers are separated from each other by aquitards. Aquitards are impermeable layers that prevent water from easily flowing from one aquifer to another. An aquifer is confined when it is buried beneath other aquifers and/or aquitards. The combined weight of the rocks and water above pressurizes the groundwater. This is sometimes referred to as artesian pressure.

When the aquitard above a confined aquifer is punctured by drilling a well, artesian pressure causes the water in the well to rise. Sometimes this water reaches land surface resulting in a flowing well. Springs are water flowing to the surface through natural pathways caused by the faulting or dissolution of aquifer rocks. Pumping in a confined aquifer causes the pressure of the groundwater to reduce. The reduction in pressure lowers water levels in artesian wells and springs.

Because confined aquifers are, by definition, not always well connected to surface water sources like streams and lakes, recharge may be slow, if it happens at all.

When an aquifer is exposed to the earth surface, such as at the outcrop, it is unconfined. The groundwater is not pressurized. When we pump an unconfined aquifer, it lowers water levels in the aquifer itself.

In addition, because the water is not under pressure, it takes more energy to pump water out of the aquifer.

Unconfined aquifers are usually replenished more easily than confined aquifers because rainfall and water from rivers and streams can flow into the exposed areas of the aquifer. In addition, the material above an unconfined aquifer is usually porous, so surface water can seep into the aquifer.

The better we understand the geologic properties of aquifers the better we can understand their sensitivity and susceptibility to human use such as pumping and contamination.

A3. Transcript for Module 3: Groundwater Budget and Availability Models

Texas decision makers work to ensure that groundwater is available for beneficial use today and for the next generation. Managing groundwater is the same as managing any budget. A household cannot continuously spend more money than it earns. In the same way, an aquifer cannot continuously give more water than it is taking in.

Accounting for the groundwater budget requires thinking about the water cycle. The water cycle is the continuous movement of water on, above, and below the surface of the earth.

Water that enters an aquifer from the surface is called recharge. Recharge includes rainwater that seeps down through the soil to reach the water table. Only a small portion of total precipitation gets down this far. Recharge also includes water draining into the aquifer from streams and lakes. Water that enters from another aquifer is called inflow. Inflows and recharge are comparable to a deposit in a bank account. They add to the overall wealth of an aquifer.

Water exiting an aquifer naturally or artificially is called discharge. Examples of naturally occurring discharge are evaporation, groundwater used by plants, springs, leakage into streams or lakes, and leakage from one aquifer to another. The most common discharge from an aquifer by humans is pumping.

Discharge is comparable to a withdrawal from a bank account. The amount of water inside an aquifer is called storage. This is comparable to the balance in a bank account.

Any time we pump water from an aquifer, we are drawing down the water level in the aquifer storage. As long as the amount of inflows can replace what we pump, drawdown is temporary and does not affect water availability.

When inflows can't keep up with pumping, we are depleting the aquifer.

Prolonged pumping in excess of inflows reduces the amount of water in the aquifer and as a result, pumping becomes more difficult and costly, as water must be lifted from increasing depths.

The Ogallala Aquifer is located in northwest Texas and extends northward into Kansas and Nebraska. Since people began tapping its groundwater, the aquifer has dropped an average of 105 feet. This is an example of an aquifer being steadily depleted by pumping.

Pumping can also impact water that isn't underground. Springs and streams can dry up and no longer sustain wildlife and vegetation.

This is what has happened to "Big Spring" in west Texas. Its spring has long gone dry, but because of its significance to the town, the illusion of a flowing spring is kept up by piping in surface water.

Depletion of certain aquifers can cause the land above to sink, making it susceptible to flooding This sinking (also called subsidence) happens when too much water is removed from an aquifer and void spaces that were once filled with water become empty and collapse due to the weight of rocks above them.

Subsidence is a serious concern along the hurricane-prone Gulf Coast. In parts of east Houston land elevations have dropped as much as nine feet since 1900.

In addition to pumping, contamination also affects the amount of available groundwater. A variety of activities may introduce contamination into an aquifer thus requiring costly treatment or abandonment of the water source.

Contamination may also result from saltwater movement caused by pumping wells. This is an obvious problem in Texas aquifers that are close to the Gulf of Mexico, but also can impact aquifers that are located far inland. Some of these aquifers contain ancient saltwater trapped deep underground. Drawing down deep aquifers can result in migration of this ancient trapped saltwater into parts of the aquifer that previously contained freshwater – causing a decline in water quality.

To tackle the challenges of water-level declines, the State of Texas incorporates the best available scientific methods in groundwater management and planning. A critical component in the State's planning process is the Texas Water Development Board's Groundwater Availability Models program.

Groundwater Availability Models are computer programs that simulate groundwater flow. They account for the amount of water entering as a credit, or deposit, the amount of water leaving as a debit, or withdrawal, and the amount of water remaining in an aquifer as the balance. These models can be used to predict the impact of large pumping activities on an aquifer.

Because groundwater systems are complex, these models require extensive amounts of information to represent the many different physical properties in an aquifer.

Scientists from the Texas Water Development Board collect and organize data associated with groundwater and aquifer properties including groundwater levels, well drilling reports, pumping records, and rock and sediment types.

They add to it data on streams, lakes, springs, precipitation, climate, surface water runoff, geologic structure, vegetation maps, root depths, evaporation and more. This information is analyzed to quantify aquifer properties, and groundwater inflows and outflows. The product of this analysis is a Groundwater Availability Model of an aquifer system.

The model is used to answer a series of “What-if” questions. For instance, what happens to an aquifer if a city increases pumping to satisfy its growing population? How much does it impact the flow from a nearby spring? How much will water levels fall in the aquifer due to increases in pumping or due to the placement of large well fields? The scientists use model simulations and then interpret numerical output from the model to answer these questions.

The models generate numbers that require review and interpretation. The scientists check the outputs to ensure that they reflect reality. This is often done by comparing model results against real world measurements, such as water levels of monitoring wells. Numerical model results may be converted into graphics. For instance, water level predictions can be graphed on charts, plotted on maps, or even animated in three dimensions.

But most important of all, Groundwater Availability Models are critical scientific tools that State and local authorities and citizens can depend on when making decisions on groundwater use.

A4. Transcript for Module 4: Using Groundwater Availability Models in Water Planning

Historically, groundwater in Texas has been governed by the Rule of Capture, which grants landowners the right to pump the water beneath their property. The Rule of Capture allows any landowner to pump whatever they can, even if it results in drying up a neighbor's well. Whoever has the biggest pump – and the deepest well – can keep on drawing down the water level, sometimes leaving neighboring landowners high and dry. However the landowner must use the water for a beneficial purpose and cannot waste the water.

Unlimited pumping of groundwater could eventually affect the longevity of Texas aquifers. Without proper groundwater stewardship, Texas water costs would rise, land could subside in some areas, water quality could degrade, and people in some areas could run out of water.

In response to these potential problems, the Texas Legislature authorized groundwater conservation districts to manage pumping. A Groundwater Conservation District can be formed by citizens to jointly manage their groundwater resources. A district has the local authority to set rules for conserving, protecting, recharging, and preventing waste of groundwater. For instance, it can establish pumping limits and spacing between wells. Landowners and other stakeholders, work together on governing their district.

Today, Groundwater Conservation Districts are legally recognized as the preferred groundwater management method in Texas. Some districts are composed of one county or even a portion of a county, however a larger groundwater conservation district may contain all or parts of as many as fourteen counties. At the beginning of 2013, there were a total of 99 confirmed districts in Texas.

Stakeholders manage their groundwater resource by first asking themselves the question, "What do we want our aquifer to look like in 10, 20, or 50 years?" The answer to this question is the desired future condition. A desired future condition is a set of measurable targets that are related to the groundwater budget. Examples of desired future conditions include acceptable average water-level declines, maintaining spring flow levels, and preserving aquifer storage volumes. Once the desired future condition is adopted, the district develops management policies, such as setting pumping limits, to achieve each target.

The Texas Water Development Board provides important technical knowledge resources for the districts. The Board works with the districts to analyze desired future conditions and calculate the amount of groundwater that may be produced on an average annual basis to achieve those desired conditions. This amount of water is known as Modeled Available Groundwater. In 1998, the Board initiated the Groundwater Availability Modeling program to develop computer models for all major and minor aquifers in Texas. These models are used by the Board to estimate Modeled Available Groundwater for the districts and for planning purposes.

The models are by no means black boxes that are indecipherable to the public. Each model was developed in a partnership between stakeholders and scientists. The stakeholders supply local information on the aquifer such as pumping test data and groundwater demands to use as model inputs. The Texas Water Development Board conducts public meetings to communicate model assumptions and explain model results to the stakeholders.

Stakeholders may also submit petitions to the Board if they question the reasonableness of a desired future condition.

Groundwater planning does not end at the local or county level. The management policies in one district can impact another district, especially if they are using the same aquifer. For instance, a district that raises its pumping limits can draw down not only its own water table, but also that of its neighboring district.

To facilitate aquifer-level planning, the Texas Water Development Board used the boundaries of major aquifers and political regions to define 16 Groundwater Management Areas throughout Texas. The agency reviews the desired future conditions within each management area to ensure that they do not conflict each other.

Meanwhile, every five years, each of the state's 16 planning groups adopts a regional water plan, then the following year the State of Texas incorporates these plans into a State Water Plan to serve as a guide to state water policy.

The State Water Plan compiles and projects the water needs of all water user groups – homes, cities, farmers, factories, ranchers, miners, and power companies. The plan is submitted to the Governor and the Legislature of Texas and includes recommendations on water projects to meet water demands 50 years into the future. Within the Plan, all sources of water - surface, groundwater, and new technologies such as desalination - are considered as well as the effects of water conservation. Estimates of Modeled Available Groundwater form the basis for how much groundwater is available to use now and throughout the planning horizon.

Through the Groundwater Availability Modeling program, local, regional and state groups are using local knowledge, scientific know-how, and policy expertise to provide clear, in-depth, and science-based guidance for management of Texas groundwater resources.

Appendix B – Summary of responses from public preview of video modules (“Frankenstein” Cuts)

Name	**[Survey summary from showing at UT SAGE seminar series]**	Phone	
Email			
Screening Location	University of Texas at Austin Thompson Conference Center Room 3.102	Screening Date	10/21/2013

PLEASE RATE HOW MUCH YOU AGREE WITH THE FOLLOWING STATEMENTS

	Completely disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Completely agree	Don’t know or not sure
The video(s) made me more interested in groundwater issues in Texas. ***(Numbers represent total responses in each box from the survey)***	☐0	☐2	☐2	☐2	☐10	☐1
I learned new information or perspectives about groundwater resources in Texas.	☐1	☐1	☐0	☐5	☐9	☐1
The message in the video(s) is relevant to water issues to my community.	☐0	☐2	☐0	☐1	☐11	☐3
I am interested in seeing the finished video products.	☐1	☐1	☐0	☐4	☐8	☐3
I will recommend these video(s) to others.	☐1	☐1	☐2	☐3	☐8	☐2

(Below is a compilation of responses to each of the evaluation form questions)

Did you have any “a-ha” moments while watching this video? Was there something new or especially interesting that you heard?

- “Good fact: 1acre ft = enough for 2 avg. families for a year“
- “Learned what aquifers looked like“
- “yes- good description of aquifers“
- “We have been taking a 6 week course, so we already know most of the info you presented. “

- “Good video showing effect of pumping on artesian well“
- “yes- good description of aquifers“
- “The explanation of aquifers is terrific! I've heard the term but have never known too much about it. Great explanation.“
- “yes- good description of aquifers“
- “The definition of "aquifer". Voila! “
- “Every presentation should include these videos. The visuals were excellent. I know the facts, but live video, actual "bubblies", and color aquifers on actual map areas make it all much more understandable“
- “I like the depiction of aquifer. The schematics were very good. It is a very good piece of work. I have made slide shows, and appreciate the work it takes. “

Were the parts that you did not agree with?

- “Time spent on explanation of permeability, etc not useful. The video of simulation of the inside of an aquifer weren't useful“
- “2nd video too detailed“
- “That distorting music. “

What parts were unclear or need better explanation or illustration?

- “Need more graphics on how artesian wells get their pressure“
- “Like it but thought the color quality could be better“
- “Better to spend time on simulation of groundwater level impact on cities using groundwater. “
- “An "acre foot" is used often. Go slower with the explanation/definition or give it a second different time. “
- “Please speak slower“

Would you have additional suggestions for the video(s)?

- “Extremely interesting. Too much information in a short period of time. I'd recommend cutting some and rerecording with a much slower pace. “
- “Have more emphasis on what citizens can do to help conserve water. “
- “Not enough about the drought. “
- “Show what will happen to average Texas citizen if population grows as expected and nothing is done to increase water supply. “
- “A lot of info for the average person comes very quickly. Check vocabulary with people who have not had this 9-hr UTSAGE program you were in today. “
- “The first video had too many facts given too quickly. The speaker could use more "dramatic delivery".
- “The music and the narrator are too soothing - makes it easy to fall asleep. “
- “cloud seeding in Texas“
- “Print definitions into the video so that they conveyed not only in the auditory sense. “
- “Spokesman spoke too fast,. Difficult to hear. Slower is better. “
- “In 2nd video (aquifers), announcer's voice tails off at end of each sentence and sometimes is nearly inaudible. “

What issue or message emerged as the most relevant for your community?

- "It was shown how some aquifers (Edwards in particular) recharge quickly from rainwater. Need emphasis on how others (like Ogallala) won't recharge in our lifetime. "
- "Very important video. For general public viewing - consider 5 minutes max. "
- "Need to vote "yes" on "2 Billion" plan in November. "
- "Conservation, projects and ideas"
- "That a real problem exists that everyone can/should get involved, understand the options and individual actions you can take. "
- "I would hope education films are being shown to our children. That is certainly where education about conserving is most important. "
- "The importance of aquifers. "
- "Message is very important for Austin, particularly conservation"
- "overall excellent"
- " Making a video that gives info in the best possible way so that people can understand and learn.
- "The actual positioning of the aquifer and how they work.
- "Good info.

Other comments?

- "For me, the reader is reading too fast. The music is too loud compared to the man's voice. It distracts from his words and distorts his meaning. The reader's constant dropping his voice and going at the end of his sentences is distracting, confusing, redundant and becomes boring. Perhaps change the music from 1 video to another, unless the videos will be shown at different times and places. Everything he reads he uses the same emphasis. Some things deserve emphasis, others not. A bit of change up grabs interest and memory retention. I probably would have gotten more out of the videos had I just been watching and not looking at it critically. Hope my comments help. The completed videos should be very helpful to many people".

Please return completed forms to:

Ernest To, Ph.D., P.E.

RPS Espey

Email: Ernest.To@rpsgroup.com　　Fax: (512) 326-5723

Address: 4801 Southwest Parkway, Parkway 1, Suite 150 Austin, TX 78735　　Phone: 512-326-5659

Appendix C – Response to comments and suggestions on draft deliverables (received 2/25/2015)

The team received TWDB's comments and suggestions on the draft deliverables (i.e. videos, captions and reports) on 2/2/2015. The following provides a summary of the responses from the team.

Draft report comments:

General comments to be addressed

1.	Please seal the final report with a currently licensed Texas professional engineer or professional geoscientist stamp and signature, as appropriate.	Final report will be sealed by professional engineer
2.	Please do not use acronyms in the report except for TWDB (after introducing this acronym).	Addressed

Specific comments to be addressed

3.	Page 1, Section 1, Paragraph 2: please do not abbreviate "RFQ".	Addressed
4.	Page 1, Section 1, Paragraph 3, last sentence: please update sentence to reference "Appendix A".	Addressed
5.	Page 1, Section 1, Paragraph 4, Sentence 3: please update sentence to reference "Appendix B"	Addressed
6.	Page 1, Section 1, paragraph 5 (last sentence on page): please revise this sentence for clarity.	Addressed
7.	Page 2, Section 2, paragraph 1: please revise the second sentence in this paragraph for clarity.	Addressed
8.	Page 4, Section 3.1: with the final deliverable please provide supporting documentation regarding permission to use footage for the project files from the Texas Parks and Wildlife Department and the Edwards Aquifer Authority.	Addressed
9.	Page 4, Section 3.3, bullet 1: please spell out all acronyms such as groundwater conservation districts, groundwater management areas, and regional water planning areas.	Addressed
10.	Page 6, Section 4, Paragraph 4, sentence 1: for clarity, please	Addressed

	reword sentence to, “After the screening, survey forms were handed to the questions [audience] to get feedback.”	
11.	Page 6, Section 4, Paragraph 4, sentence 2: please reword second sentence for clarity, possibly change “or’ to “for”.	Addressed
12.	Page 6, Section 5, Paragraph 1, Sentence 3: please reword to be consistent with final deliverable; for example, “For the draft deliverable, condensed versions of the draft video modules were provided for review and comment. For the final deliverable the following was provided on a portable hard drive: a. High definition videos (720p or 1080p) on FLASH/HDD/CD/DVD media (MP4, M4Vfiles using a high quality h264 or x264 codec), b. A copy of the Adobe Premiere Creative Cloud project files, c. Closed captions (in the form of XML files or srt files as discussed with TWDB contract manager Cindy Ridgeway) and transcripts for the hearing impaired and visually challenged, and d. A report on the project detailing approach, methods, issues, and recommendations for the future (hard copy and electronic versions in both Microsoft Word format and in Adobe Acrobat PDF compatible format).”	Addressed
13.	Per the contract, please update the report to include Acknowledgments and Reference sections.	Addressed
14.	Appendices: please either use page numbering that distinguishes the appendices from the main text and from each other, for example A1, A2, …, and B1, B2, …; or use continuous page numbering throughout the report.	Addressed
15.	Please revise the text in Appendix A to remove line breaks in the middle of sentences and add missing commas, and so forth.	Addressed
16.	Appendix A2, page 3, paragraph 7: “It may take several days … prehistoric times.” is not part of the narration and should therefore be deleted from the transcript.	Addressed
17.	Appendix A4, page 9, paragraph 1: please revise this paragraph to match the narration.	Addressed

Draft Video/caption comments to be addressed:

All modules

18. Please add credits to each video acknowledging the narrators and the sources of footage—such as Texas Parks and Wildlife, United States Geological Survey, Edwards Aquifer Authority, and TWDB, as appropriate to each video. In addition, please acknowledge project team members and/or firms. Please also add the TWDB logo along with the video title at the beginning of each video.	Addressed
19. Recommend including numbered or bulleted list of all modules either before or after title, highlighting the title of the module playing.	Addressed

Module 1

20. Video Module 1, Time 12 seconds: please slow down clip of flyover of rice fields as this may cause vertigo for some viewers	Addressed

Module 2

21. Video Module 2, Time 2 minutes 14 seconds: please consider removing clip of fast moving stream and waterfall as this visual does not support the discussion of "permeability of pumice and shale as low". Please consider replacing visual with a clip stagnant water or image of smooth surface of a lake.	Addressed. Used footage of a slow moving stream for low permeability vs. fast flowing stream for high permeability.
22. Please modify the captions file. The captions stop at 3 minutes 55 seconds on a 6 minutes 46 second video.	Addressed
23. Video Module 2, Time 5 minutes 22 seconds: please reverse the flash of "spring" and "artesian well" to match narration which mentions artesian well before spring—or flash spring, then artesian well and then back to spring to correlate with animation.	Addressed

Module 3

24. Please modify the captions file. There is a gap between 2 minutes 48 seconds and 3 minutes 1 second where captions are missing.	Addressed
25. Please modify the caption file. The timing of captions between	Addressed

	3 minutes 1 second and 4 minutes 19 seconds, and 5 minutes 58 seconds to the end is off.	

Module 4

26.	Video Module 4, Time 1 minute 24 seconds: please consider removing clip of weir along a small stream, as this visual does not support the discussion of "…pumping and limits and spacing between wells". Please consider replacing visual with possibly a clip from "SteelTape3.MTS"— after 4 seconds it appears there might be another well in the background in a small shed.	Addressed
27.	Video Module 4, Time 3 minutes 4 seconds: please change "Modelled Available Groundwater" to "Modeled Available Groundwater".	Addressed
28.	Please modify the caption file. The timing of captions is off between 4 minutes 3 seconds and 5 minutes 15 seconds.	Addressed
29.	Video Module 4, Time 5 minutes 34 seconds: please consider replacing clip of water discharging in channel with a clip of a desalination plant to match narration followed possibly with shot of Water IQ or some other image for water conservation.	Addressed

Suggestions for Draft Report:

General suggestions

30. Please check for grammar, spelling, and punctuation throughout the report.	Addressed

Specific suggestions

31.	Page 1, Section 1, Paragraph 3: please change "include" to "included".	Addressed
32.	Page 1, Section 1, Paragraph 3: please update to, "Also included in the deliverables are closed captions (in the form of XML files [and/or srt files]) and transcripts to assist the hearing impaired and visually challenged."	Addressed
33.	Page 1, Section 1, Paragraph 3: suggest expanding discussion to include TWDB screenings: a. January 27, 2014 (Draft Video Module 1): Internal TWDB staff that included staff from conservation	Addressed

	education, communications, planning, groundwater resources, and management. b. March 5, 2014 (Draft Video Module 1): Texas Groundwater Protection Committee Public Outreach and Education subcommittee members and various members of the public. c. August 13, 2014 (Draft Video Modules 2 and 3): Milam and Burleson Counties Groundwater Summit (http://www.posgcd.org/event/groundwater-summit/) that included professionals in the water industry, oil and gas industries, groundwater conservation district personnel, Texas AgriLife Extension personnel, State Representative Marsha Farney, several judges, Texas Railroad Commission personnel, Texas Water Development Board personnel, and general public. d. November 12, 2014 (Draft Video Modules 2, 3, and 4): Texas Groundwater Protection Committee Public Outreach and Education subcommittee members and various members of the public.	
34.	Page 3, bullet 5: please spell out November.	Addressed
35.	Page 4, Section 3, bullet 7: suggest rewording to,"…captions were developed in xml format."	Addressed
36.	Page 4, Section 3.2, paragraph 1: suggest rewording to," In addition, the team received additional footage from the TWDB that was incorporated into the videos. The footage included field activities by the groundwater staff, downhole video clips, photographs of various rock formations, and meetings by the Board of the TWDB.	Addressed
37.	Page 6, Section 4, Paragraph 1, 1st sentence: please remove period after Monday, please spell out October, and please remove "st" after 21.	Addressed
38.	Page 6, Section 4, Paragraph 1, 2nd sentence: please insert "was" after audience.	Addressed
39.	Page 6, Section 4, Paragraph 2, 4th sentence: please replace "what" with "the" and "e.g." with "such as".	Addressed
40.	Page 6, Section 4, Paragraph 3, bullet 1, sentence 2: please spell out November.	Addressed
41.	Page 6, Section 4, Paragraph 3, bullet 2, sentence 1: please	Addressed

	replace, "…may have had too many [much] technical detail."	
42.	Appendix A1, page 1, paragraph 1: please change "groundin …" to "ground in …".	Addressed
43.	Appendix A3, page 7, paragraph 4, Sentence 1: please change "is" to "it".	Addressed

Suggestions for Draft Videos:

44.	Video Module 1, Time 3 minutes 5 seconds: please possibly adjust resolution as the legend and text on map is indecipherable. In addition, may need to fade background color of Texas or outline Yegua-Jackson Aquifer (as it blends into the background southwest of the Brazos River Alluvium Aquifer) and outline downdip extent of the Ellenburger-San Saba Aquifer as they are hard to distinguish.	Addressed. Legend enlarged. Background faded to allow distinguishing of minor aquifers
45.	Video Module 1, Time 3 minutes 59 seconds: please possibly adjust resolution, as the text for the legend of the groundwater conservation districts is indecipherable.	Addressed. Legend enlarged.
46.	Video Module 1, Time 4 minutes 42 seconds: please possibly adjust resolution, as the text for the legend of the groundwater conservation districts is indecipherable.	Addressed
47.	Video Module 2, Time 3 minutes 30 seconds: suggest adding "Aquifer" after, "Cross Section from Edwards (Balcones Fault Zone)".	Addressed
48.	Video Module 2, Time 3 minutes 31 seconds: suggest adding	Addressed

	“Aquifer” after, “Cross Section A-A’ from Edwards (Balcones Fault Zone)”.	
49.	Video Module 2, Time 4 minutes 30 seconds: please possibly adjust resolution, as the text on animation is indecipherable; for example, “spring”, “aquitard”, “aquifer”, and “confined aquifer”.	Addressed
50.	Video Module 2, Time 5 minutes 22 seconds: please possibly adjust resolution, as the text on animation is indecipherable; for example, spring, artesian well, and pumping well.	Addressed
51.	Video Module 2, Time 5 minutes 48 seconds: please possibly adjust resolution, as the text on animation is indecipherable; for example, unconfined aquifer and pumping well.	Addressed. Graphic and text enlarged.
52.	Video Module 3, Time 3 minutes 28 seconds: please possibly adjust resolution, as the text on legend and on contours is difficult to read.	Addressed
53.	Video Module 3, Time 4 minutes 20 seconds: please consider replacing image of person in boat measuring surface water levels with an animation or image of a hydrograph or repeat animation from 2 minutes and 11 seconds.	Addressed
54.	Video Module 3, Time 4 minutes 29 seconds: please consider replacing image of water flowing in a ditch with an image of related to groundwater (measuring a well, drill rig, model, or group meeting).	Addressed
55.	Video Module 4, 27 seconds: please possibly adjust resolution, as the text on animation is indecipherable; for example, dry well, and well owner A, B, and C.	(see #45)
56.	Video Module 4, Time 1 minutes 56 seconds: please possibly adjust resolution, as the text for the legend of the groundwater conservation districts is indecipherable.	

Appendix D – Accessing the portable drive contents

The portable drive contains two main folders (see Figure 3).

1. "!START_HERE" contains the project deliverables.
    a. The final high resolution videos along with transcripts and captions
    b. The final report
    c. The Adobe Premiere project used to make the videos.
2. "TWDB Water" contains the footage, graphics and audio files associated with the video modules.

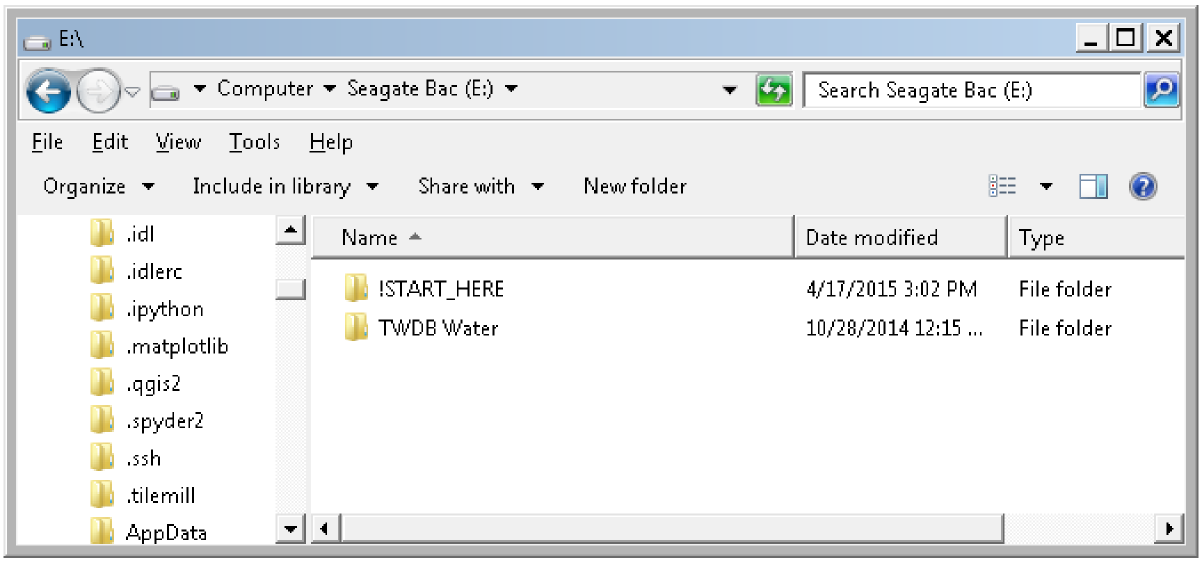

Figure 3. Main folders in the portable drive.

Clicking open the "START HERE!" folder reveals the location of the deliverables (see Figure 4).

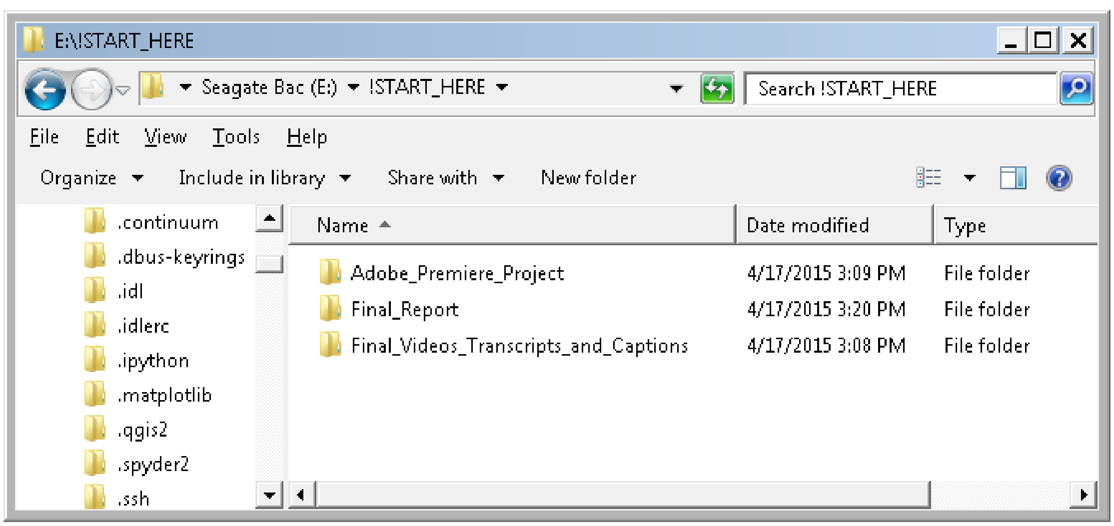

Figure 4. Location of the deliverables under the "!START HERE" subfolder.

To edit the videos, make sure you have Adobe Premier Creative Cloud installed. Go to the "Adobe_Premiere_Project" folder and double-click on "TWDB Groundwater Education Video Project_Final_20150417_1503.prproj". It should bring up the premiere editor interface (see Figure 5) and the program will start loading the associated media into each of the module sequences.

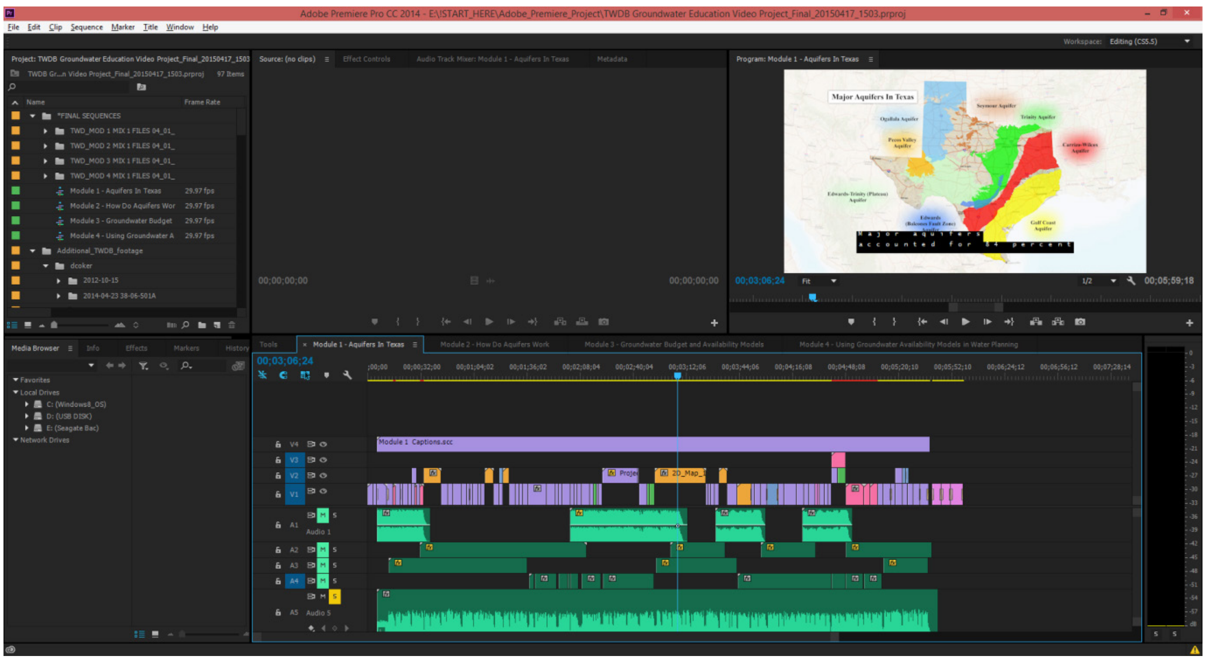

Figure 5. The Adobe Premiere interface.