

Characterization of Produced Water In New Mexico

By

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Abstract

Water produced as a byproduct of oil and gas production represents a large and almost untapped potential water source in New Mexico. In 2014, industry reported production of over 800 million barrels of water. Over 90% of that total was from the Permian Basin, with the remainder from the San Juan and Raton Basins. Although this is a significant volume of water, it is a very dispersed, largely uncharacterized, and extremely variable water source. While much of the water (>90%) is reinjected in part for pressure maintenance and improved oil recovery, a significant amount of produced water could potentially be diverted to other uses if economic, regulatory, and technological hurdles can be overcome.

Roughly 12 years ago, the Petroleum Recovery Research Center (PRRC), a division of the New Mexico Institute of Mining and Technology, began compiling data on quality and quantity of produced water into the NM WAIDS database. The project was funded through the US DOE's solicitation DE-PS26-01BC15300, Identification and Demonstration of Preferred Upstream Management Practices. This database encompassed information on water quality/quantity in various producing regions of the state and used a variety of sources including existing databases and paper documents supplied by producers. Purposes of the original database included providing online access to information regarding volume, geographical location, and quality of produced water. Such knowledge is crucial to support the design of water systems that might utilize produced water.

The original work was completed about 9 years ago and was maintained as a static online resource until late 2013 when it was taken offline due to concerns about the security of the web pages and queries that accessed the database. In the ten years that have elapsed since the database was first put online, cyber security has become an increasingly important consideration and the old interface was becoming highly vulnerable. In addition, there is a need to obtain more data. Several oil and gas plays have come to the foreground since the bulk of the data was collected, including new horizontal plays in both southeast and northwest New Mexico.

Our 2014 WRRI project undertook the update of the NM WAIDS website and database interface. The primary goal of the project was to completely recode and upgrade the web site, with secondary goals of adding new data and GIS functionality. Extensive work was done to convert old program and web code to new standards that comply with current security requirements. This revised website has been subjected to security testing and is undergoing final revisions and beta-testing for functionality prior to being made available to the general public on the GO-TECH web site. The new home page for NM WAIDS will be available at <http://gotech.nmt.edu/waterquality> by July, 2015.

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Project Description

A number of years ago, the Petroleum Recovery Research Center (PRRC), a division of the New Mexico Institute of Mining and Technology (NMT), compiled data on quality and quantity of produced water (water produced as a byproduct of oil and gas production) into the NM WAIDS database as part of a project funded by the U.S. Department of Energy.

This database encompassed information on water quality/quantity in various producing regions of the state. Purposes of the original work included assessments of the amount and quality of produced water to support the design of water treatment systems to promote the use of produced water. Work on the database ceased about 10 years ago. The database is now out of date, and in 2013 was taken offline online access due concerns about security of the entire GO-TECH web site that hosted NM WAIDS as well as several other oil and gas-related web applications. The current WRRI-funded project proposed to update the NM WAIDS database, bring the database back online, provide GIS user-friendly functionality, and identify and attempt to fill in data gaps in newly active plays in the San Juan and Permian basins.

Background

The original New Mexico Water and Infrastructure Data System (NM WAIDS) was created to alleviate a number of produced water-related issues in southeast New Mexico. This project entailed the design and implementation of a database and GIS system and integral tools to provide operators and regulators with necessary data and useful information to help them make management and regulatory decisions. The original work was funded by the U.S. Department of Energy under DOE contract DE-FC26-02NT15134. Detailed information about this project can be found in the annual and final reports submitted to the DOE¹.

NM WAIDS was a useful tool for oil and gas operators and stakeholders in the state, and was also a valuable resource for researchers. The database comprised two main datasets: Produced Water, with several thousand records of water quality from oil and gas wells throughout the state, and Groundwater, with very basic abbreviated information but

over 25,000 records, for southeast New Mexico only. In addition to the water quality data, the site also contained information concerning oilfield corrosion and scale identification, and tools that would allow users to calculate water compositions based on mixes of different types of waters and also probability and composition of any resulting precipitate. NM WAIDS received several hundred thousand visits a year at a time when the overall GO-TECH site was receiving a few million visits per year (Figs 1-3).

In 2013, the GO-TECH server (octane.nmt.edu) was identified as compromised and deemed a security risk by federal agencies; the server was taken out of service by NMT. As a result of this, the entire GO-TECH website, including NM WAIDS, was subjected a series of web application tests in a separately funded project to identify vulnerabilities with the site. This testing was conducted by CAaNES LLC (now RiskSense, Inc.), a company devoted to Internet threat and vulnerability management. Testing identified and validated 1028 security vulnerabilities that were classified by risk posed by each vulnerability to the organization. Out of the total 1028 vulnerabilities, 439 belong to high threat class, 23 belong to medium threat class and 566 belong to low threat class. The vast majority of threats were due to either cross-site scripting or injection. Cross-site scripting can allow malicious content to be delivered to a web application user, while injection (in particular SQL injection) can allow malicious content or code to infect the server database system. The entire web site was taken down at the request of NMT.

In the ten years elapsed since the database was first put online, cyber security has become an increasingly important consideration and the old interface was revealed as highly vulnerable. All of the hardware and software components of the system required updating; and much of the old code simply would not work well with the updated programs and systems. This upgrade was labor intensive and required significant resources; thus it was prioritized as to relative importance within the client base. Two other parts of GO-TECH were deemed more important: the New Mexico Production Data Access pages, and the State Land Office Data Access pages. Aside from upgrades, the NM WAIDS database was first constructed in 2001-2003; since that time, several oil and gas plays have come to the foreground including new horizontal plays in both southeast and northwest New Mexico. Updates to the database to include new information would be desirable. Because of the scarcity of funding and other resources, and the perceived

lower priority given the water databases, upgrades to NM WAIDS of any type were very unlikely without the addition project funding provided by WRRI.

Project Objectives

The first priority for the 2014 WRRI-funded project was to get the NM WAIDS water databases back online. To achieve this, several steps were required

In addition to the high priority objective, secondary objectives were identified; these were to be addressed if time permitted.

2) Examine the existing produced water database to identify data gaps and make efforts to fill in those gaps,

3) Provide data access via an online GIS based system if possible. Sufficient location information will be provided to enable users to map data in their own systems via a common format such as GIS shapefiles.

Project Methodology

The original project was created using the Integrated Development Environment (IDE) Microsoft Visual Studios, using C# as a programming language. The project utilized ASPX pages for the user interface. The website was complex and difficult to revise. All of the old code had security flaws that could be exploited to hack servers, change data, or even infect client computers with malware. Also, the look and feel of the interface had to be integrated with the new look developed for the GO-TECH main site.

The following steps have been followed to achieve our primary objective:

- Review all existing code that pertained to the NM WAIDS web site, including client and server side as well as any database procedures that would be relevant.
- Document functionality of all code
- Identify security issues, poor coding practice, inconsistencies, and broken links or procedures, and determine appropriate fixes

- Identify an optimum IDE and programming language
- Convert all code and procedures to updated platforms and languages
- Configure server to handle different operating environments that are needed by various components of the web site including a legacy system requested by one of our state agency clients
- Run security testing on web site
- Beta-test revised web site and make needed changes
- Publish new version of web site

Results and Discussion

The following has been completed to date: PRRC has created a new project based on a different IDE and language, structured the project to have a Model View Controller (MVC) layout, converted ASPX files to Thymeleaf .html files, recycled and reformatted old Javascript code, and connected and tested the various database connections with more secure coding. Most of the web tools, with the exception of the GIS mapping capabilities, have been recoded. Data download functions have been recoded and enabled. The revised design layout for the entire site, including NM WAIDS is almost complete at this point. Internal beta testing is underway. It is anticipated that a beta version of this web site will be available for roll-out by September 1. Figures 4-7 show some of the redesigned web pages; note that results screens are likely to undergo further modification but all do function correctly. The web site access to the produced water database will be available from our main home page and directly at <http://gotech.nmt.edu/waterquality>.

Also, an effort has begun to digitize some recently-rediscovered unpublished data that was collected by the USGS from wells in southeast New Mexico. This data is primarily produced water samples from wells that were sampled in the mid-1950's to 1960's.

Efforts have also been underway to begin redeployment of the online GIS mapping service to both oil and gas production wells and produced water sample data. Initial work using one particular software solution did not work well on the large production well dataset so we are now focusing on using Google Maps as a programming interface. A beta product is now available but will require some modification before it can be useful to a general audience. Geospatial data will be provided to WRRI for inclusion in the general GIS that they are compiling for the overall water inventory.

Recommendations for Additional Work

There are three areas of work that are recommended for additional efforts:

1) Web site testing, maintenance, and upgrades: Although the preliminary web site is complete, it is expected that the early weeks of use will bring requests and comments from users. Responding to some of these will certainly improve functionality; what our developers find to be best for information display and download may not correspond to what the client audience would find to be ideal.

2) Database updates and enhancements: This database is static and all additions ceased in 2003. Since then, there have been updates to public datasets such as those compiled by the DOE and other agencies that should be incorporated into the database². In addition, small amounts of older data have been located. These are paper data sets and have not been digitized. Also, several plays have shown increased activity in New Mexico. Data from these plays should be identified through outreach efforts to operators and if possible, new data should be acquired and added to the database.

3) GIS Implementation: Initial efforts at reviving the old ArcIMS maps have not been successful. However, almost all the data does have a geospatial reference and could be utilized as part of an overall GIS interface as envisioned by WRRI. To this end, our data should be made compliant with WRRI requirements. If possible, efforts will continue to create online GIS access to the database via the NM WAIDS web site, and at a very minimum, shapefiles of data suitable for download will be made available.

4) Inclusion of reference materials developed for and derived from previous NM WAIDS work. An online manual of corrosion information was developed for the NM WAIDS project, and a student Master's Thesis was written based on the water data collected for the produced and groundwater databases. This information still has some use and should be included in the redesigned web site. Currently we are in the process of rewriting the code for the online corrosion manual to integrate with the rest of the web site.

5) Closer integration of the water quality database with the produced water volumes information. The Go-Tech web site has production and injection volumes for oil and gas wells in New Mexico as reported by the NM Oil Conservation Division, and users can easily find the information. However it could be made even easier to integrate volume and quality information without requiring additional searches from the user.

Summary

The work completed during the past year has served to completely upgrade and revise the NM WAIDS web site. This site, originally completed as part of a DOE-funded project that terminated in 2005, was taken offline because of cybersecurity vulnerabilities identified in 2013, and since that time there was no public access to the thousands of water quality records for produced and groundwater data that were contained in the databases. The new web site will be available by September 2015 and will have much of the functionality of the old site, including links to produced water information such as volumes produced and water quality analyses. The information could be made even more useful and accessible by carrying out some of the recommended future work.

References

- 1) Cather, M.E.: "NM WAIDS: A Produced Water Quality and Infrastructure GIS Database for New Mexico Oil Producers," final report, Contract No. DE-FC26-02NT 15134, U.S. DOE, Washington, DC (June 2005).
- 2) USGS Produced Waters Database:
<http://energy.usgs.gov/GeneralInfo/EnergyNewsroomAll/TabId/770/ArtMID/3941/ArticleID/1051/USGS-Updates-the-National-Produced-Waters-Geochemical-Database-and-Map-Viewer.aspx>

Figures

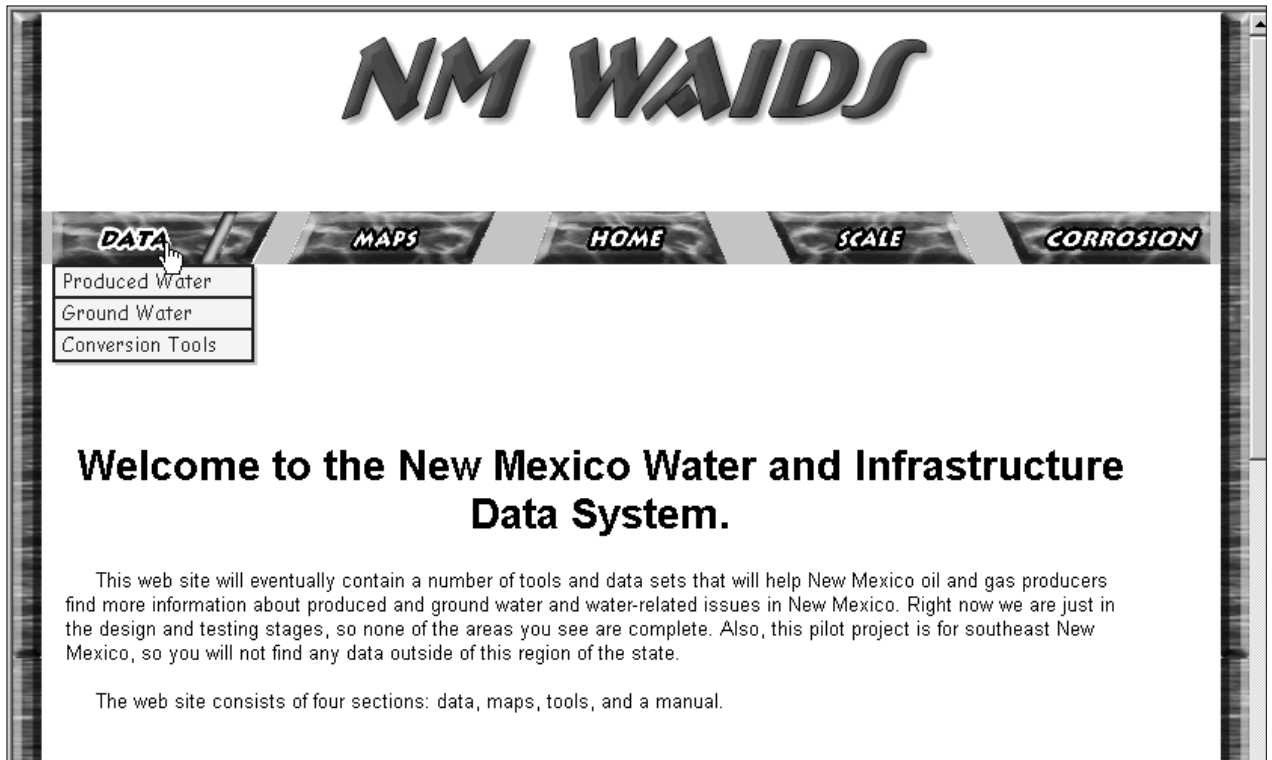


Figure 1 Home page for original NM WAIDS web site. Interface included links to produced and groundwater databases and query pages, a GIS map server, various tools for predicting corrosion and scale, an online corrosion manual, and reference materials.

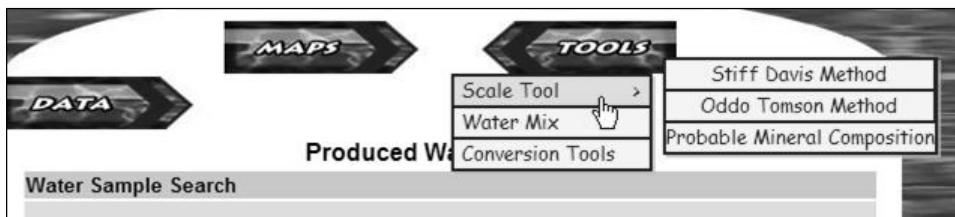


Figure 2 Tools included two scale calculation tools, a mineral composition tool, one to determine the composition of mixing of two waters, and unit conversion calculators.

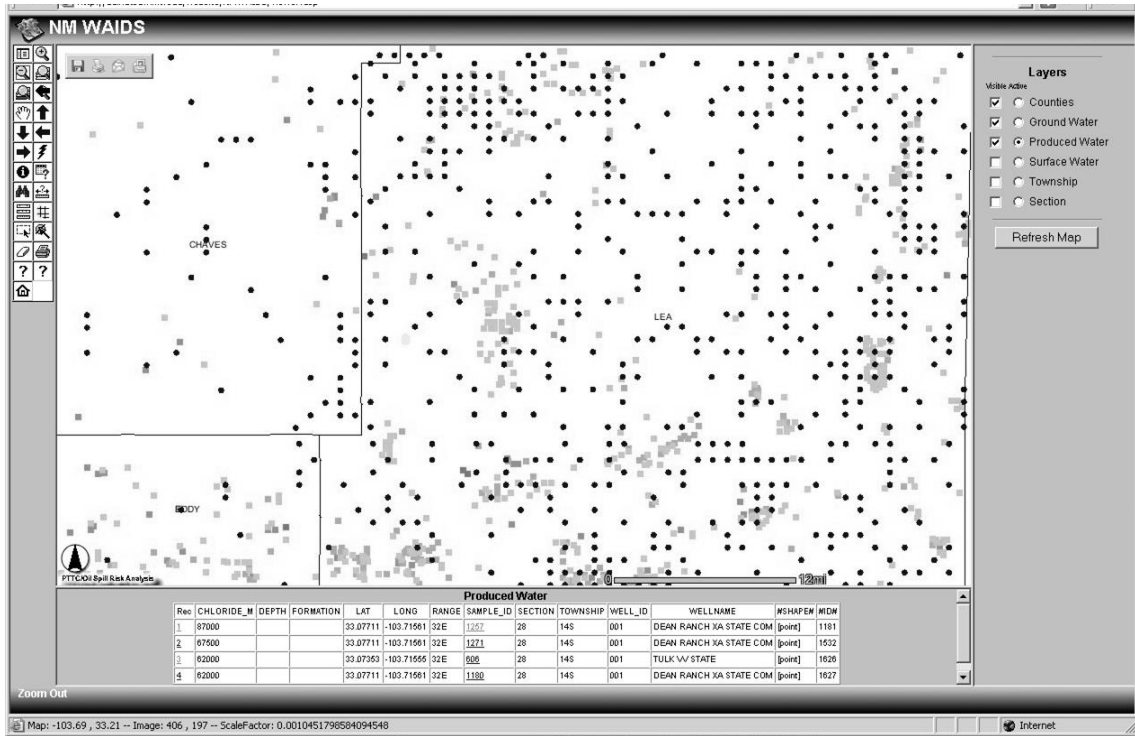


Figure 3 The original NM WAIDS site had an online GIS map server, here zoomed to Lea County. Produced and Groundwater data shown as darker and lighter gray, with darker colors having higher chloride content.

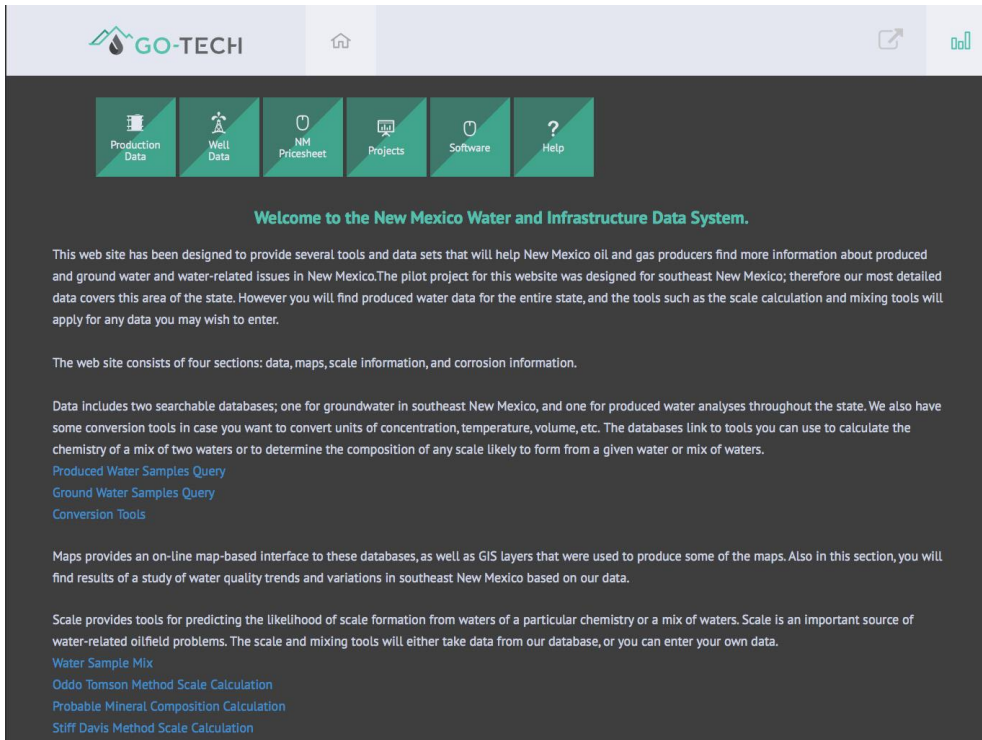


Figure 4 New NM WAIDS Interface.

Production Data Well Data NM Pricsheet Projects Software Help

Produced Water :: Samples Query

Water Sample Search

API Number

County

Township

Range

Section

Well Name

Formation

Field

Search

72 matching results found

Show 25 records per page

Download Selected

Filter:

ID	API	Well_Name	Section	Town	Range	Field	Formation	Collected
2873	3001500076	GOVERNMENT 134 001	12	26S	24E	WASHINGTON RANCH	MOR	
2830	3001500076	GOVERNMENT 134 001	12	26S	24E	WASHINGTON RANCH	MOR	
643	3001500079	FED HARRIS DE001	15	26S	24E	Wildcat		01/01/1900
2102	3001500078	FED HARRIS DE 001	15	26S	24E			
4061	3001500079	FED HARRIS DE001	15	26S	24E	Wildcat		01/01/1900
2403	3001501159	WELCH ABV FEDERAL 001	21	26S	27E	EDDY UNDESIGNATED		
2273	3001504776	USA 001	20	26S	30E		DEL MTN	
2236	3001504776	USA 001	20	26S	30E		DEL MTN	
6341	3001504776	USA 001	20	26S	30E		DEL MTN	
6499	3001505886	E D WHITE FEDERAL NCT 1 003	26	26S	31E	MASON NORTH	DEL	
3432	3001511411	FED J 001	06	26S	27E		DEL MTN	07/31/1978
6957	3001522473	FED J 001	06	26S	27E		DEL MTN	

Figure 5 Screen shot showing query request and basic results list.

General Well Information

ID: 6269	Well Name: BERGER	API: 3004505792
Latitude: 36.47849	Longitude: -107.99331	Section: 22
Township: 26	Range: 11	FTGNS: 790
FTGEW: 1800	Unit: C	County: San Juan
State: NM	Company: XTO ENERGY, INC.	Field: BASIN DAKOTA (PRORAT)
Formation: GAL/DAK	Depth: 6372	Lab Number:
Sample Number:	Sample Source:	Water Type:
Sample Date: 2000-07-18 00:00:00	Analysis Date:	General Info Remarks:

Produced Water Analysis Data

ph:	ph Temperature (F):	Specific Gravity: 1.0
Specific Gravity Temperature (F):	tds (mgL): 354.0	tds (mgL @ 180C):
Alkalinity as CaCO3 (mgL):	Hardness as CaCO3 (mgL):	Hardness (mgL): 40.0
Resistivity (ohm cm):	Resistivity (ohm cm) Temperature (F):	Conductivity:
Conductivity Temperature (F):	Sodium (mgL):	Calcium (mgL): 240.48
Iron (mgL):	Barium (mgL):	Magnesium (mgL): 24.305
Potassium (mgL):	Strontium mgL:	Manganese (mgL):
Chloride (mgL): 3545.3	Carbonate (mgL):	Bicarbonate (mgL): 7442.98
Sulfate (mgL):	Hydroxide (mgL):	H2S (mgL):
CO2 (mgL):	O2 (mgL):	Anion Remarks:

Figure 6 Detailed results page for a specific well. Typically produced water data only has a few data fields completed.

Water Sample Mix

API	Well Name	ID	Date Collected	
No well selected				
Water Sample 1: Ions & Dissolved Gases (mg/L)				
Ca ⁺⁺	5000	Mg ⁺⁺	2200	
CO ₃ ⁼	30000	HCO ₃ ⁻	2000	
H ₂ S		O ₂		
Na ⁺	10000	SO ₄ ⁼	2000	
Ba ⁺⁺		Cl ⁻		
Fe ⁺⁺		OH ⁻		
Sr ⁺⁺				
pH	6	Temperature (F)	150	
		Ratio 1 / Volume	6	
<input type="button" value="Clear"/>				
Water Sample 2: Ions & Dissolved Gases (mg/L)				
Ca ⁺⁺	500	Mg ⁺⁺	2200	
CO ₃ ⁼	126	HCO ₃ ⁻	777	
H ₂ S		O ₂		
Na ⁺	30000	SO ₄ ⁼		
Ba ⁺⁺		Cl ⁻		
Fe ⁺⁺		OH ⁻		
Sr ⁺⁺				
pH	7	Temperature (F)	159	
		Ratio 2 / Volume	4	
<input type="button" value="Clear"/>				
Instructions:				
There are two types of mixing available:				
Mix by Ratio: Insert temperatures and Ratios for each sample and the Total Volume				
Mix by Volume: Insert temperatures and Volumes for each sample.				
Then click Mix.				
Mix Water by Ratio*	<input type="radio"/>	Total Volume (L)	30	
<small>This must enter a 0000 volume to use this method.</small>				
Mix Water By Volume	<input type="radio"/>			
<input type="button" value="Mix"/>				
This will give you a mixed sample, which you can then use to calculate scaling tendencies by clicking the Calculate Scale button. You will be taken to the Calculate Scale page and can choose the method you want.				
Mixing Water				
Ca ⁺⁺	3200	Mg ⁺⁺	2200	
CO ₃ ⁼	18050.4	HCO ₃ ⁻	1510.8	
H ₂ S	0	O ₂	0	
Na ⁺	18000	SO ₄ ⁼	1200	
Ba ⁺⁺	0	Cl ⁻	0	
Fe ⁺⁺	0	OH ⁻	0	
Sr ⁺⁺	0			
Temperature	153.56		Ionic Strength	1.37
			pH	6.19
<input type="button" value="Calculate Scale"/>				

Figure 7. Sample mixing tool will calculate composition of a mix of two waters, using either sample data or user-entered data.