AN ENVIRONMENTAL FLOWS INFORMATION SYSTEM FOR TEXAS – **FINAL REPORT**

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Distribution

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1. Executive Summary

Data describing the stream flow, water chemistry, geomorphology, and biology of streams and rivers is often contained in a variety of formats and in many geographic locations. A prototype environmental flows information system is developed for the State of Texas that incorporates relevant known available datasets from federal, state, academic, river basin, and local sources. Tools are developed to assist in the publishing, visualization, and access of data and documents via map-based, spreadsheet-based, and other methods. The information system might be used to provide: (1) rapid low-cost data integration, (2) improved data access by the public, and (3) support for the analysis and determination of environmental flow needs. The environmental flows information system represents the integration of the physical, chemical, and biological information for rivers and streams in a consistent and accessible manner in one system in one place.

Working cooperatively with the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) Hydrologic Information System (HIS) project, an NSF-supported effort to improve access to hydrologic data at the nation's universities, environmental flows data are stored in the CUAHSI Observations Data Model and web services are established for the computer-to-computer communication of data in order to extract data from disparate sources in disparate formats, to transform the data into the common language of CUAHSI WaterML, and to load the data into an end user's system. The environmental flows information system includes a linkage to a georeferenced digital archive of documents, providing for parallel access to both data and the knowledge products derived from that data. Via the Data Model and accompanying Document Model, an information system capable of managing observational data, geographic data, modeled/constructed data, and documents is offered.

2. Introduction

Stakeholders and regulators across the Texas are in the midst of a legislatively-driven process to determine the environmental flow needs of the bays, basins, and rivers of the state. As is common elsewhere, the environmental flow program in Texas includes analyses of hydrology and hydraulics, geomorphology and physical processes, water quality, and biology, and the connectivity between and among the four primary disciplines. The integration of sometimes disparate findings from these disciplines stands to be one of the most challenging and most important steps of developing instream flow recommendations.

Given the large spatial and temporal scales of analysis necessary for sufficiently detailed study of environmental flow issues, a relative paucity of data exists to support these analyses. This challenge is acutely evident in the determination of flow-biota linkages and the assessment of habitat availability and suitability.

As such, there is a pressing need for the development of tools and systems to organize, share, and synthesize information. As with many issues in the environmental arena, we are at an exciting time and a crossroads in water management: a movement is afoot to bring more and better data to the decision-making table in the recognition that better information leads to better science and thus better decisions.

The Environmental Flows Information System for Texas project seeks to provide data access and integration to aid stakeholder committees, expert science teams, and the Texas Commission on Environmental Quality in their collective efforts to determine statewide environmental flow needs.

This paper serves as a brief introduction to the project. Further information, including additional supporting documentation, may be found at: http://efis.crwr.utexas.edu. Also of note is the EFIS training presentation, available at: http://downloads.crwr.utexas.edu/EFIS/EFIS_12_14_2009.ppt.

3. INTEGRATION

To address the challenges elucidated above, this project puts forth the concept of a Water Information System comprised of three components:
Geographic Information Systems (GIS) for geographic data,
Hydrologic Information Systems (HIS) for observations data, and
Digital Libraries for digital assets (documents, images, videos).

A Geographic Information System "integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically reference information." (ESRI 2009) Geographic data are typically static in time, complex in space, and are organized in standardized formats such as geodatabases. Geographic Information Systems were first conceptualized in the 1960s and now sustain a mature commercial market.

A Hydrologic Information System is "a services-oriented architecture for water information" consisting of a repository of hydrologic time series data (HIS Server), a national water metadata catalog (HIS Central), and a desktop appliance for hydrologic data access (Hydro Desktop). These three elements are linked via web services, "automated functions that enable one computer to make appropriate requests of another computer and receive responses through the internet." (Maidment 2009) Water observations data are typically dynamic in time (time series), simple in space (sampling and gaging points), lacking in standardized formats, and potentially stored in relational databases. Hydrologic Information Systems were conceptualized in the early 2000s by the National Science Foundation-supported Consortium of Universities for the Advancement of Hydrologic Science, Inc. and are a new but rapidly maturing concept; HIS development has thus far been accomplished by the CUAHSI university partnership with limited business partners.

A Digital Library is a collection of digital materials (as opposed to print, microform, or other physical media) accessible via computer. Digital libraries, also known as digital repositories, provide for large-scale, stable, managed long-term storage of digital material in any format and are designed to capture, describe, distribute and preserve these materials. Digital content may include technical reports, articles, books, maps, tables, photographs, images, videos: any material which is either born-digital or digitized. Digital libraries were conceptualized in the mid-1990s, sustain a modest commercial and open-source presence, and are the focus of more widespread experimentation and development.

Implicit in the consideration of data management is the spatial and temporal complexity of the data. A hard-copy topographic map, a GIS shapefile of stream gaging stations, and a time series of daily streamflow data are examples of data with differing character and thus differing organizational needs. In the case of hydrology, data are often continuous and regular in time and from fixed locations. In the case of water quality, data are often instantaneous and irregular in time; that is, sampled at different time intervals and either sampled at the same or different locations. In the case of geomorphology and aquatic biology, data are often instantaneous, irregular in time and space, and likely to only be sampled once or a limited number of times at a particular location. In all of these cases, the particular sampling location is chosen or assumed to be representative of a larger area; examples include river reach, ocean sector, pond, or stream habitat.

Other factors affect the character of the data as well: domain, setting, sampling methodology. Physical data describe the movement of water and its properties. Chemical data describe the constituents moving with, in, and through the water. Biological data describe the organisms inhabiting the water environment. Subsets and hybrids of these broad domains exist; for example, bathymetric and geomorphic data describe the physical environment of the water but also the geochemistry and the habitat. As is often the case for hydrology, the spatial and temporal extent of data required for meaningful analysis precludes individual project-specific data collection efforts. Data collection in a freshwater or terrestrial setting is a very different experience than in a marine or offshore setting. And data from a federal sensor network is different than data from a community volunteer monitoring organization.

4. An Environmental Flow Information System for Texas

A web-based system, The Environmental Flows Information System for Texas is hosted at: http://efis.crwr.utexas.edu (Figure 1). Six information types are included in the Information System:

1. Point observations data (communicated via the WaterML web language and stored in the CUAHSI Observations Data Model) (CUAHSI 2009);
2. Geographic data (such as shapefiles, feature classes, KML, WFS/WCS/WMS);
3. Documents (stored in the DSpace digital archive);
4. Tables (such as fishes conservation status and trophic guilds);

5. Tools (such as a Microsoft Excel-based Calculator For Low Flows); and
6. Links (including the Fishes of Texas project, the Indicators of Hydrologic Alteration model, and many others).

This information may be accessed through one of four avenues:

1. Web page (Figure 1);
2. Interactive Map Viewer (Figure 2);
3. Digital Library (Figure 3); and
4. HydroPortal (Figure 4).

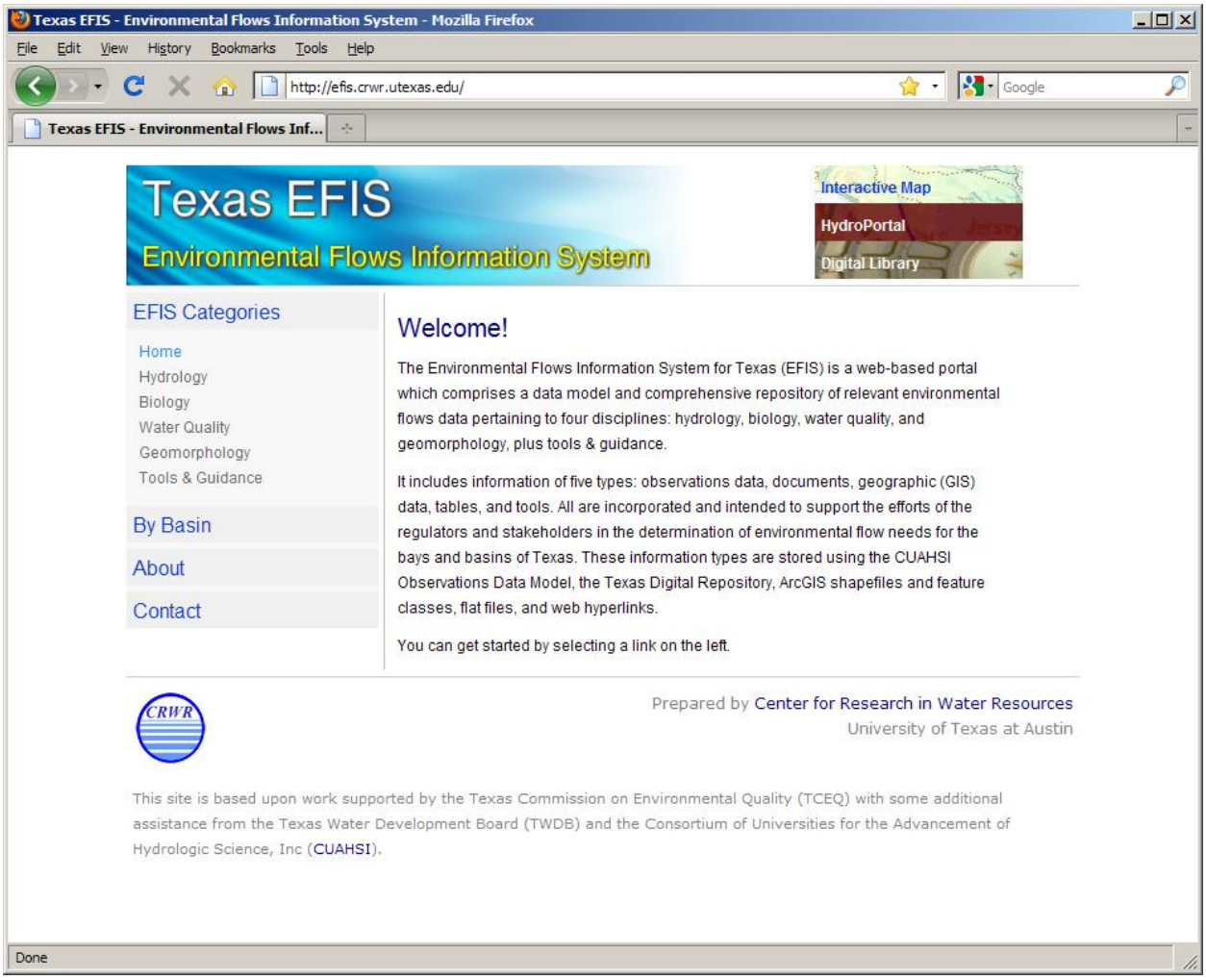

Figure 1. Environmental Flows Information System for Texas site homepage: http://efis.crwr.utexas.edu.

Altogether, the Information System contains nearly 100 components from over 25 contributors, including: state sources (e.g.: Texas Commission on Environmental Quality, Texas Water Development Board, Texas Parks and Wildlife Department, Texas Coastal Ocean Observation Network, and Texas Natural Resource Information System); federal sources (e.g.: United States Geological Survey, US

Environmental Protection Agency, National Weather Service, National Oceanographic and Atmospheric Administration, and US Fish and Wildlife Service); academic (e.g.: University of Texas, Texas A&M University, Texas State University, University of New Orleans, and CUAHSI); non-governmental organization sources (e.g.: World Wildlife Fund and The Nature Conservancy); and river authorities (e.g.: San Antonio River Authority, Sabine River Authority of Texas.

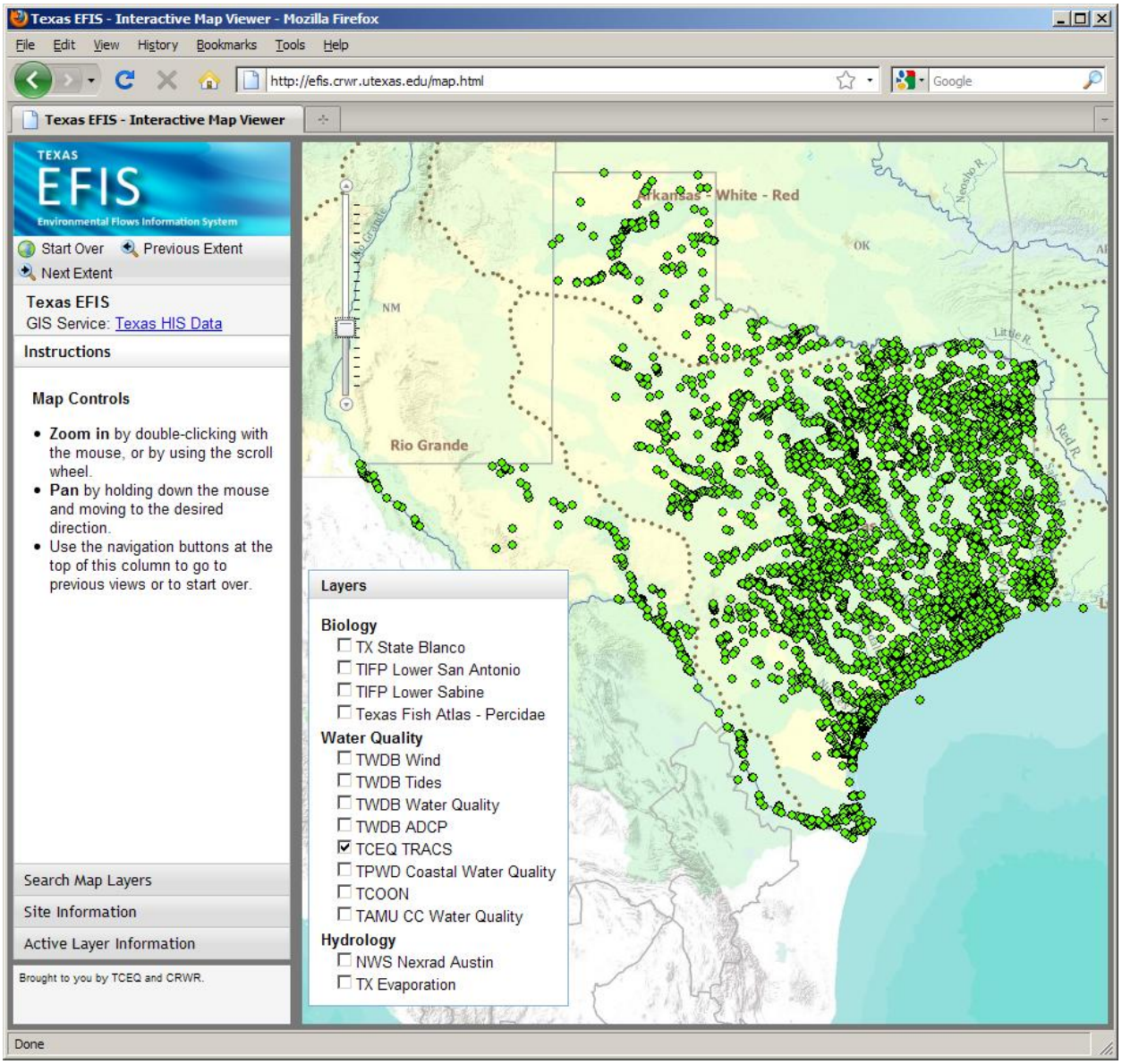

Figure 2. Environmental Flows Information System for Texas Interactive Map: http://efis.crwr.utexas.edu/map.html.

An Interactive Map Viewer was developed which incorporates hydrologic basemap data for the United States developed and hosted by ESRI, overlain by observations data developed and hosted by the Center for Research in Water Resources at the University of Texas at Austin (Figure 2). Geographic and

observations data is also available via the HydroPortal, a customization of the ESRI Geoportal Toolkit extension (Figure 3). Finally, a Digital Repository was developed in conjunction with the University of Texas Library system based on the open-source DSpace digital archive system (Figure 4) (DSpace 2009).

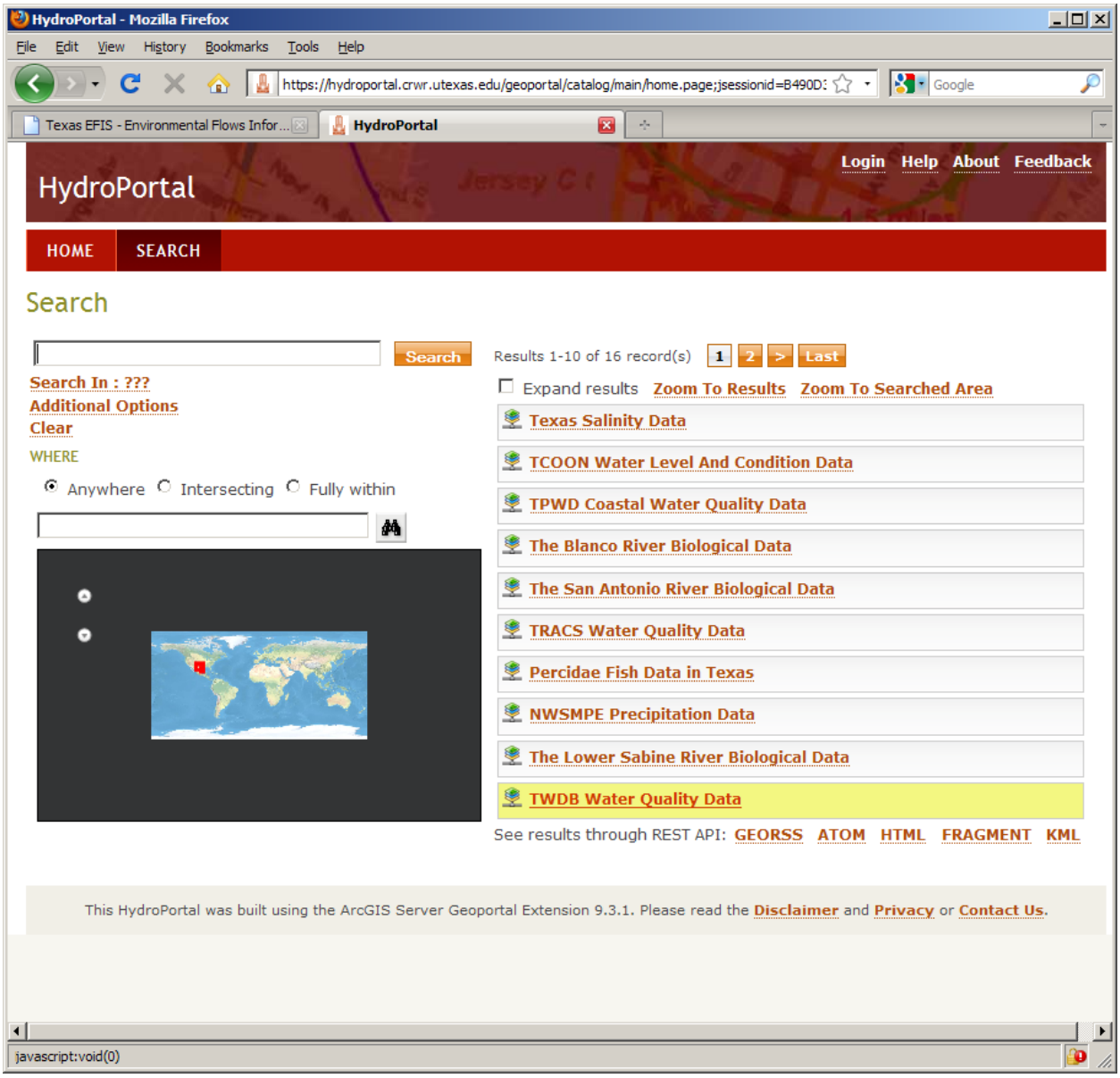

Figure 3. Center for Research in Water Resources HydroPortal.

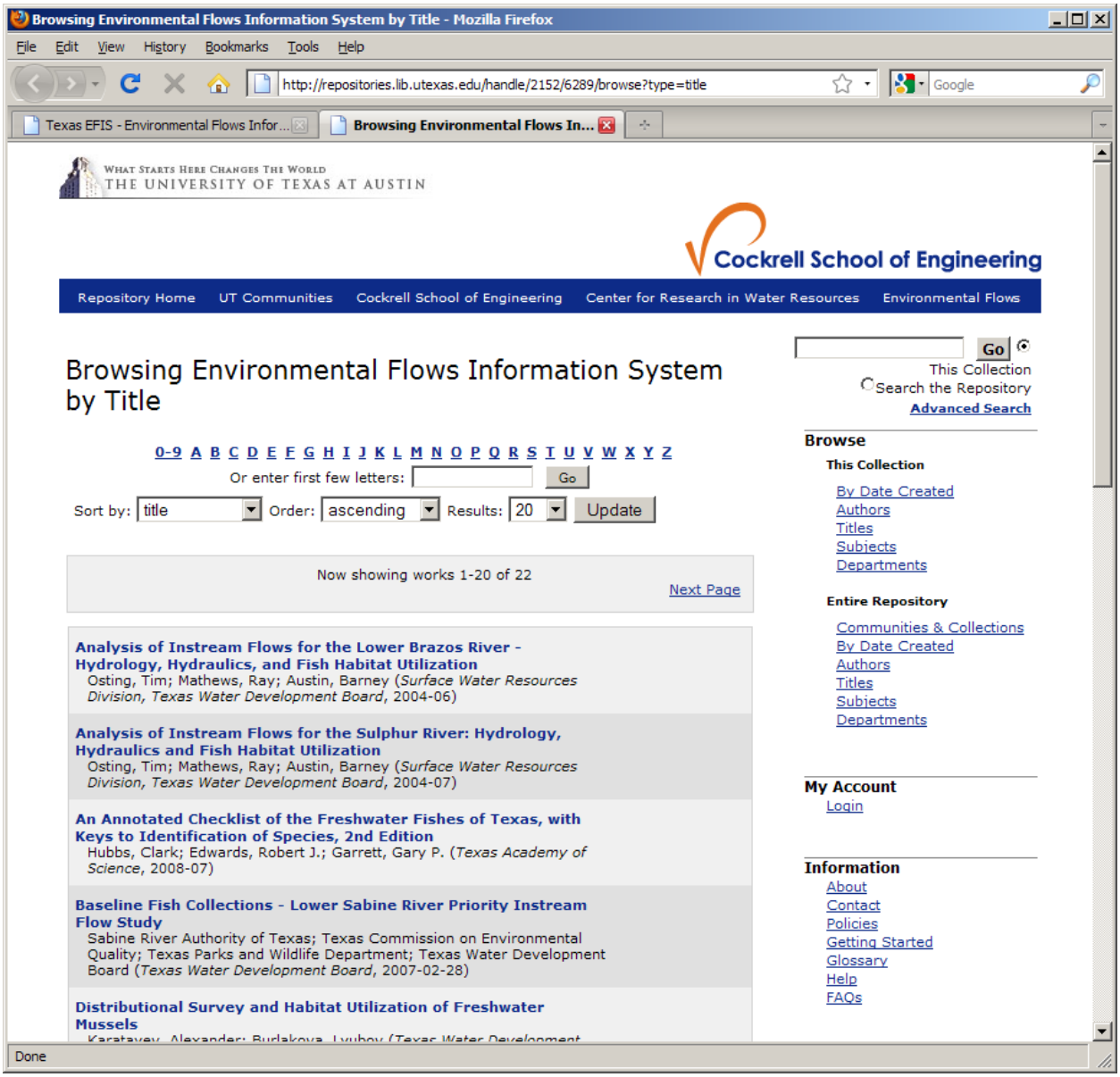

Figure 4. Center for Research in Water Resources Digital Repository.

5. The Calculator for Low Flows

As part of the EFIS project, a Microsoft Excel-based application called the Calculator for Low Flows was developed. CaLF is a tool for: (1) downloading USGS daily streamflow data; (2) calculating the seven-day two-year low flow (7Q2); (3) calculating and plotting the flow duration curve; (4) calculating the harmonic mean; (5) calculating the Lyons' method monthly minimum streamflow and the modified Lyons' method streamflow and adjusting them via a Drainage Area Ratio (DAR) if desired; and (6)

graphing these two minimum flows. The tool uses web services to download U.S. Geological Survey (USGS) mean daily streamflow data over an internet connection. This data is imported to the CaLF tool and manipulated through Visual Basic programming.

More information on the 7Q2 can be found here: http://info.sos.state.tx.us/fids/30_0307_0010-7.html. More on the Lyons' method here: https://repositories.lib.utexas.edu/handle/2152/6714. A current User's Manual for the latest version of CaLF may be found on the EFIS Tools & Guidance page: http://efis.crwr.utexas.edu/tools_guidance.html.

6. Conclusion

It is hoped that the information system might be used to provide: (1) rapid low-cost data integration, (2) improved data access by the public, and (3) support for the analysis and determination of environmental flow needs. The environmental flows information system represents the integration of the physical, chemical, and biological information for rivers and streams in a consistent and accessible manner in one system in one place.

7. References

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