Rhode Island Water Data Workplan

A Partnership to Develop a Decision Support System for Water Use and Availability

Prepared for the RI Water Resources Board in Cooperation with the US Geological Survey

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EXECUTIVE SUMMARY

The Mission

A central mission of the RI Water Resources Board (RIWRB) is to establish the quantity of water existing in every water source, the quantity that is being used or is needed for every significant purpose and the quantity that is available to support other uses in Rhode Island. However, the development of the current State water use program is, like in many other States, handicapped not so much by data quantity and quality, but by how the data is collected, organized and communicated in support of sound water resource policy and management decisions. Further complicating the situation is that water data is collected and stored by several agencies with limited connections between the various data bases. It therefore is a RIWRB priority to build a database system that improves how water use is stored, processed and shared in the State. Improving techniques, including GIS-based techniques, for estimating agricultural withdrawals, improving domestic water use coefficients as well as calculating consumptive use will be important as the state moves forward into future phases.

> *More than any other single step, modernizing water data would unleash an era of water innovation unlike anything in a century.*
>
> -The New York Times, Water Is Broken. Data Can Fix It
> By Charles Fishman, March 17, 2016

The Plan

The immediate focus of this workplan is on improving the fresh water data collection, storage and reporting efforts by the RIWRB. Priority focus areas for RIWRB water use data are public water supply, the self-supplied (domestic, commercial and industrial water use), and agricultural irrigation water uses. With the input from State and Federal stakeholders and based on the outcomes of a workshop, a plan has been formulated to:

1. Examine public domain and commercial software/hardware environments to include:
   - The cost of system acquisition (soft- and hardware)
   - Ease of use and versatility, including the need for long-term tech support and system maintenance
   - Ability for expansion and accommodation of competing data structures, type and complexity in the future (e.g. incorporation of water quality data)
   - Handling of automated data dumps, data security and accessibility
2. Evaluate other states that have successfully implemented a statewide water use database manage and organize their systems, particularly NH and WI.
3. Build a fully functional data base for RIWRB
4. Incorporate the flexibility to grow the database into a unified, user friendly platform and storage environment for providing web-based access to water data across RI agencies.

With funding, this plan can be implemented within 18 to 24 months.

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1. Introduction

One of the most urgent water resources management needs in Rhode Island is the development of decision-support tools necessary for implementing sound data-driven water resource management programs. These tools are essential to providing accurate and consistent information to decision-makers, stakeholders, and the public. Some examples for the application of such programs include consistent and uniform water use inventories, better tracking of diversions both into and outside of a watershed, assessing water availability, the development of implementable water conservation, efficiency, and allocation programs, and improving information related to consumptive water use. A critical emerging issue is the need for multi-disciplinary approaches to water resource management and the increasing need for the coordination and dissemination of information to assist and inform all levels of government, NGOs, utility managers, and the public. Currently, water resources management data and information about the status of the physical water distribution systems, water quality, and water use and availability are shared among state agencies and institutions, including the RI Department of Health, the Department of Environmental Management and the Water Resources Board. Information about Rhode Island's water resources is distributed between agencies and not necessarily available to all interested parties.

An important mission of RIWRB is *to establish the quantity of water existing in every water source, the quantity that is being used or is needed for every significant purpose…and the quantity that is available to support other uses.* (Rhode Island General Laws § 46-15.7-3 Functions of the water resources board). The immediate data priority within this overall goal is to incorporate monthly public withdrawal data and all other estimated use data on a basin scale (HUC 10 and 12) on an on-going basis. Initially the estimated data will consist of the information published in the USGS Water Use and Availability studies commissioned by the Water Resources Board. This data is compared to water availability standards and provides an important foundation for water management and water policy stakeholder efforts. Improving techniques, including GIS-based techniques, for estimating agricultural withdrawals, improving domestic water use coefficients as well as calculating consumptive use will be important as the state moves forward into future phases.

The water use data provides the foundation for water resource policy and management decisions. To fulfill the mission, the RIWRB has implemented annual reporting procedures for the large public systems that satisfy several of the U.S. Geological Survey (USGS) goals for public supply. RIWRB has collected additional water use and availability information in a series of watershed studies contracted with US Geological Survey to account for all uses and to provide information across multiple jurisdictional perspectives. RIWRB is also charged with developing a workplan for the state's water use and availability data, which needs to be aligned with the USGS goal to improve the collection, storage and quality of a national water use database. The workplan presented herein outlines the current status of RI's data collection and compilation efforts, areas where improvements can be made, including the prioritization of specific water use data needs, and suggestions about how these improvements can be accomplished in Rhode Island.

The report is organized in four parts. The first part provides a review of the status of current water use data sets by categories in Rhode Island. The second part presents an overview of USGS Water-Use Databases and components. Special considerations have been given to the USGS Site-Specific Water Use Database (SWUDS) to which RIWRB reports 5-year water-use compilations on regular basis, even though the full implementation of SWUDS in New England has not been achieved at this time. Because of its regional importance, and past involvement with RIWRB, the New England Water-Use Data System (NEWUDS) is discussed. Also provided is a review of alternative, commercial Water-Use Database systems, including a discussion of their advantages/ disadvantages. In part three, we provide a summary of the outcomes of the first Rhode Island Water Use Data Plan Workshop held in April 2016. Finally, this report provides recommendations and preliminary budget estimates to prepare the state to move forward with this important effort.

Table 1: Tiers of USGS water use data collection goals for the Public Water Supplier category. (Excerpts from USGS Water Use Data and Research Financial Assistance Guidance, 2016).

Category	BASELINE GOALS (Tier 1)	Tier 2	Tier 3
Public Supply	Monthly withdrawals reported by system, water source, and water type. Deliveries to domestic users from public-supply systems, and populations served. Report system information relevant to HUC-8 and county, and groundwater withdrawals with aquifer designation.	Site-specific annual and monthly withdrawals (by intake, well, or well field) reported by water source, and by water type. Quantity of water purchased between systems, and source(s) of purchased water. Quantity of water sold between systems. Reporting and/or verification of water deliveries for domestic, commercial, industrial, thermoelectric and other use.	Interbasin transfers. System uses (internal and other non-revenue uses) and losses. Improve estimates of populations served by site (for example, by surface-water intake, well or well field). Use of reclaimed wastewater for public or landscape irrigation.

2. Current Water Uses by Categories

In Rhode Island, the estimated population on public water supply was 939,621 in 2010 and the total estimated public water withdrawals were 108 million gallons per day (Mgal/d) in that year (Maupin et al., 2014). About 10.5% of the state's population was served by groundwater and about 89.5% percent by surface water sources (Maupin et al., 2014). Estimated water deliveries from public suppliers to domestic users are 67.5 Mgal/d (i.e. 63% of the total water withdrawals by public suppliers).

In Rhode Island, only the data for "large public suppliers" is reported to the State on a regular basis. "Large public suppliers" are defined as water suppliers that produce over 50,000,000 gallons of water per year. They report annually to the Water Resources Board. No other categories of water use are required to report quantity data on a regular basis to the state. Quantities of water withdrawn, used and discharged are gathered periodically through RIDEM wetlands and wastewater permitting programs. Rhode Island does not have withdrawal permitting or a statewide water registration or reporting program. Some entities are required to report quantity to the federal government (Thermoelectric).

Currently, quantities are estimated periodically by USGS under contract with WRB (basin studies) or in the five year national water use compilation. The basis for estimating quantities of water used include a number of sources. The Rhode Island Department of Health (RIDOH) collects information on private wells and on small public water systems that are used as the basis for estimating quantity. Recently, RIDOH has begun metering some of the 460+/-small suppliers which, over time will improve this data set. The Rhode Island Geographic Information System (RIGIS) provides data layers about geographical extent of water supply districts and groundwater recharge areas, the location of major water supply lines and wellhead protection areas, sewered areas, and other spatial information.

In addition to data not collected by the state or reported directly to the state, we also relied on data from federal and other entries. For instance, we used the 2000 through 2010 USGS water use compilations files for Rhode Island and U.S. Census data supplied by National Water Use Information Program.

The data directly reported to the RIWRB is submitted in EXCEL spreadsheet format (Appendix IV). Each spreadsheet is evaluated for completeness when it is submitted to the RIWRB. Beyond that, no other any quality assurance or quality control procedures are in place. Moving forward, water use data quality assurance and quality protocol have to be established to 1) to determine the reliability and consistency of currently collected data, 2) to develop methods to eliminate processing errors and identify basic inaccuracies within the data, and 3) to refine the consistency of water use data through development and implementation of data reporting and analysis standards.

2.1 Reported Water Use Data

2.1.1 Public Water Supply Data

The largest suppliers (over 50 million gallons/yr) submit comprehensive five-year Water Supply System Management Plans and annual reports to RIWRB. The annual reports are provided on Excel spreadsheets and include monthly water withdrawal information, purchase and sale data, usage data by category as well as system and demand management information to meet established statewide targets and goals (sample report attached). Water supplied by the largest public water systems is reported annually as required by the RI Water Resources Board. For 2010, the Water Resources Board provided USGS with the sources and volumes of water withdrawals, volumes of water delivered to residential, commercial, industrial, and governmental customers, and population served.

For the large suppliers RIWRB collects data in the annual reports that meet the Tier 1, 2 and 3 as stated by the USGS. In Rhode Island, the data is currently compiled at a HUC 10 to HUC 12 level, which exceeds the USGS guidelines (HUC 8; see Table 1).

The large suppliers plus Block Island and Richmond represent 98% of the state's public supply. The remaining 2% are small suppliers. They are licensed and tracked by the Department of Health in relation to water quality. They are mostly unmetered and the quantities of water used by these smaller suppliers are estimated based upon population served. RIWRB engaged USGS to complete a comprehensive series of basin water use and availability studies that included estimated data for these smaller suppliers (1995-1999 data). The data in these studies (published between 2003 and 2007) was housed in the New England Water Use Data System (NEWUDS). A second ACCESS database was designed to house the Water Supply System Management Plan Data (WSSMP) and it has been determined that a new structure is needed to meet the missions of RIWRB and USGS, to streamline the data that is collected and to take advantage of newer technology.

Pursuant to Safe Drinking Water Act, the Safe Drinking Water Information System (SDWIS) database referenced above is maintained by the Rhode Island Department of Health (RIDOH). The department uses SDWIS to record and analyze public water system water quality data including tracking of data and compliance determinations. Information from the database can be accessed through the Water Information System Search and the Rhode Island Geographic Information System (RIGIS). The RIGIS provides data layers for counties, public water supply reservoirs, water supply districts; water supply lines groundwater recharge areas, wellhead protection areas at community level. The RIDOH data on public water supply systems that can queried by water system type and primary source of water to verify water sources and types.

For the public supply data, a goal of a new database would be to import the name and location data from the Department of Health database (SDWIS) to calculate and maintain current quantity estimates for the remaining public water use. This would also assist RIWRB in identifying any suppliers that may be reaching the 50 Mgal/yr threshold and in assessing water supply needs and withdrawal impacts on watersheds, municipalities, etc.

A full summary about which uses are reported and which are estimated are found in Appendix I.

2.2. Estimated Water Use Data

2.2.1 Domestic and Commercial Self-Supplied Water Use

Self-supplied water users include domestic, industrial, and commercial, and it is not always straight forward to separate these sub-categories, particularly commercial and industrial. In Rhode Island, these uses are not reported and are estimated from various sources. Regarding domestic use, the USGS 2010 report (Maupin et al, 2014) shows that about 10.5% of the total population in Rhode Island relies on self-supplied water (predominantly well water). The estimated rate of withdrawal for domestic use from all these wells is 8 Mgal/d. No commercial self-supply data was collected or provided for the 2010 report. Water use for golf courses is discussed separately in this report.

A goal of the database is to update the available estimates from the basin studies (1995-99 data) to provide watershed and municipal level data related to self-supplied use. RIWRB has currently compiled this data in a statewide excel spreadsheet. For self-supplied/self-disposed data, consumptive use (15%) is assumed for domestic, and ten percent (10%) for commercial and industrial. The RIWRB data meets the USGS baseline goals but a new data structure and more frequent estimates, at a minimum, are needed to keep the data current and useful for making water management decisions at the State level. The RIDOH maintains locational data for domestic wells that can be shared to populate the new data structure as the basis for calculating domestic self-supply water quantities. A combination of data from RIDOH and RIDEM permitting programs will be needed to capture information needed for estimating use.

2.2.2 Livestock Water Use

Livestock water use covers the water needs of livestock watering, feedlots, dairy operations, and other on-farm activities. Livestock water use estimates for RI are not reported but can be estimated at county level from the national water use information system (Maupin et al, 2014; USGS-NWIS, 2014).

At the national level, withdrawals for livestock use were an estimated 2,000 Mgal/d for 2010 or about 1 percent of the Nation’s total freshwater withdrawals. In Rhode Island, the estimated livestock water use in 2010 was 0.18 Mgal/d. About 94% of that water was groundwater (Fig 1).

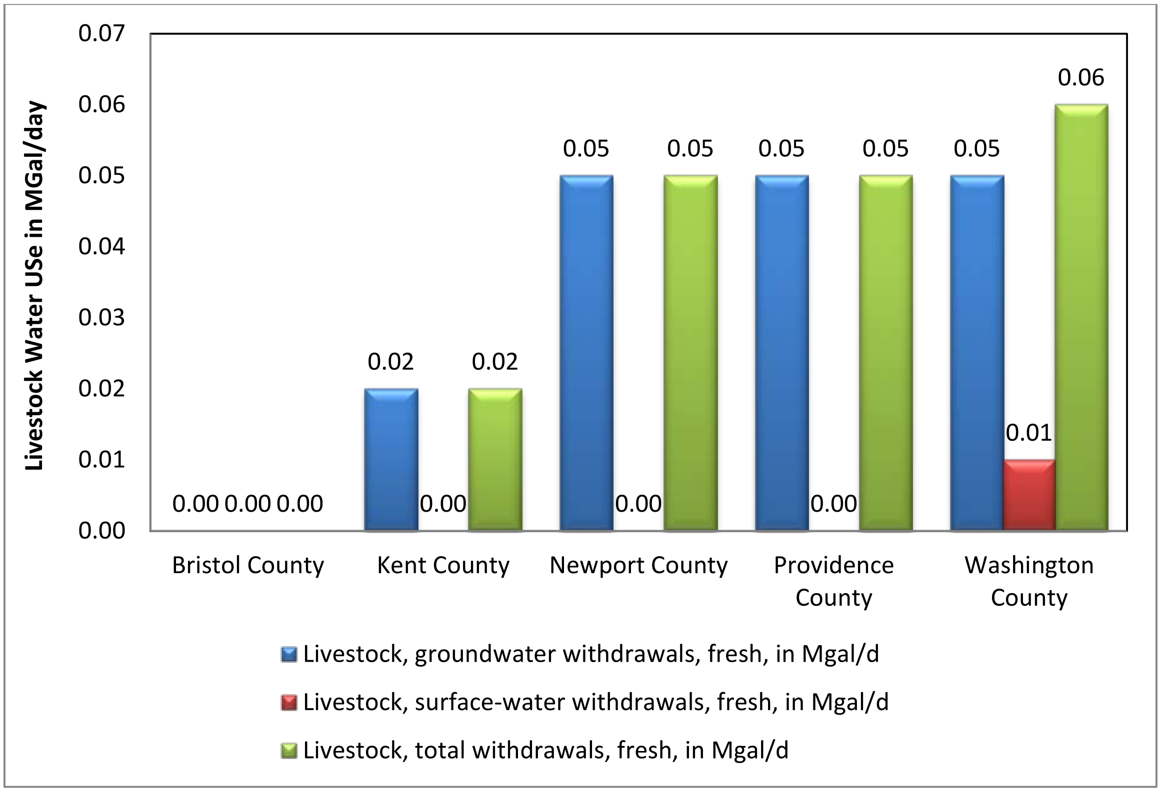

Figure 1: Livestock water use in Rhode Island in 2010 (Source: USGS - NWIS 2014).

2.2.3 Irrigation Water Use

Irrigation water use includes water that is applied by an irrigation system to sustain plant growth in all agricultural and horticultural practices. Also included in irrigation water uses are golf courses, parks, nurseries, turf farms, cemeteries, and other self-supplied landscape-watering activities. In Rhode Island, irrigation water use is not reported to the State. Therefore it is difficult to accurately identify, down to individual points of diversion, the quantity of irrigation water actually withdrawn. RIWRB and RIDEM have estimated agricultural water needs in the Chipuxet basin. In addition, the USGS basin studies commissioned by RIWRB contained estimated agricultural water use. Estimates for irrigated acreage for golf course and cropland in RI are available through the National Water Information System, USGS. Based on these estimates, about 30% of the total irrigated land accounts for golf course and 70% for cropland. Sprinkler irrigation system were used on 79.5% of the total irrigated area, whereas 20% was irrigated by low flow system and the remaining 0.5% used gravity driven irrigation. Data for reclaimed wastewater use in RI is not documented.

In the USGS 2010 report, the total water use for irrigation in RI was estimated to be 2.68 Mgal/day of which 83.5 % is applied to golf course and the remaining 16.5% to croplands. The groundwater contribution to the irrigation water use is 86% (Figure 2). No information is available on conveyance losses and system efficiencies.

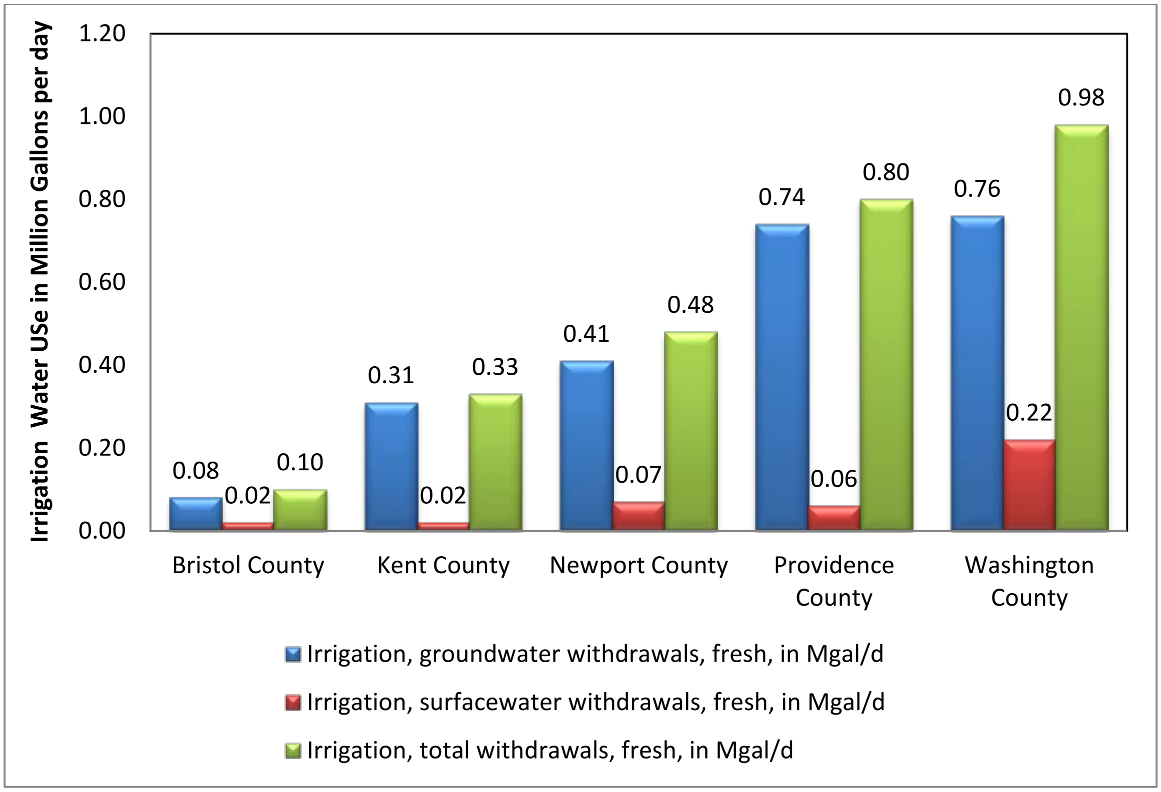

Figure 2. Irrigation water use in Rhode Island in 2010 (Source: USGS – NWIS 2014).

2.2.4 Mining Water Use

Mining water use is water used for the extraction of minerals that may be in the form of solids, liquids and gases. Mining is an extremely small part of the Rhode Island economy, contributing less than 1% of the gross state product (Netstate Report 2013). The predominant mining activities in Rhode Island are limited to the extraction of aggregate materials (sand and gravel). Similar to livestock water use, mining water uses were estimated based on county level information obtained from the National Water Use Information Program. Based on this source, mining water use was 0.92 Mgal/day (Figure 3), of which about 47% was withdrawn from groundwater.

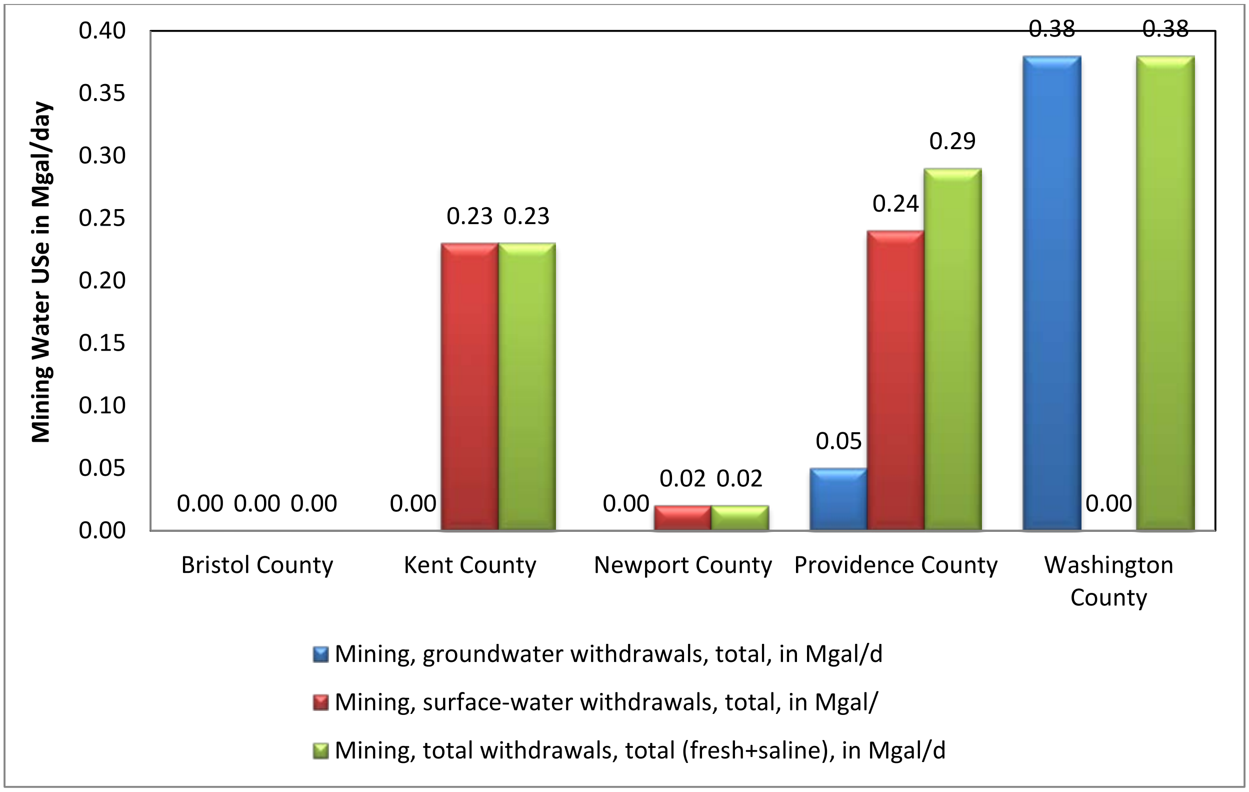

Figure 3. Mining water use in Rhode Island in 2010 (Source: USGS - NWIS 2014).

2.2.5 Industrial Self-Supplied Water Withdrawals

Industrial withdrawals provide water for such purposes as fabricating, processing, washing, diluting, cooling, or transporting a product; incorporating water into a product; or for sanitation needs within the manufacturing facility. Dun and Bradstreet Hoovers establish the industrial water use database available through the National Water Use Information Program, USGS. Industrial self-supplied water withdrawals in Rhode Island were estimated to be 7.52 Mgal/day of which groundwater withdrawals accounted for 60% (Figure 4). Information on reclaimed wastewater is not available.

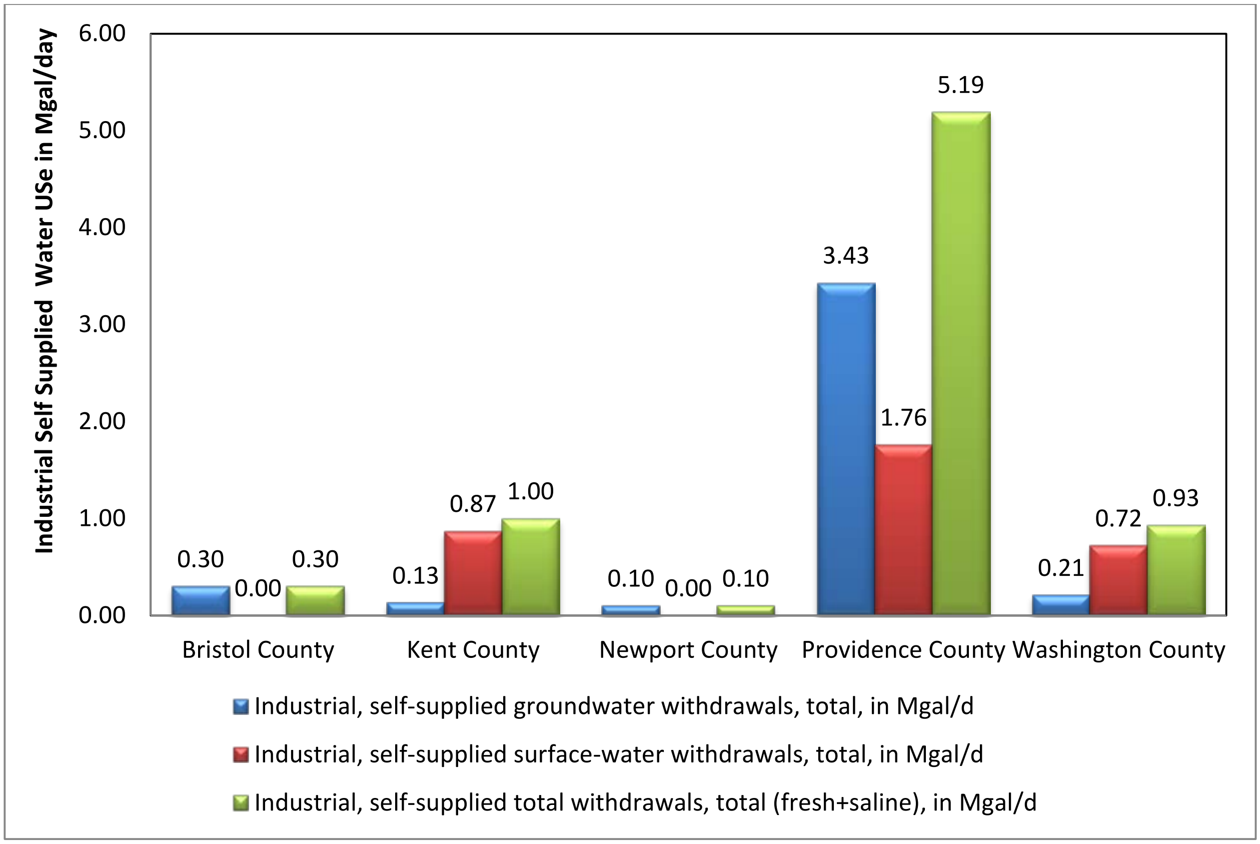

Figure 4. Industrial self-supplied water use in Rhode Island in 2010 (Source: USGS - NWIS 2014).

2.2.6 Thermoelectric and Hydroelectric Power Water Use

The U.S. Department of Energy, Energy Information Administration maintains a database on state-by-state power plants profiles which is incorporated into the USGS National Water Information Program. For 2010, Rhode Island's power plant water withdrawals were estimated to be 233.64 Mgal/day. Almost all water (232.20 Mgal/day) was saline and used for thermoelectric power production in once-through cooling systems. The remaining 1.44 Mgal/d was freshwater used in plants with closed loop cooling systems (Maupin et al, 2014).

In Rhode Island limited hydropower resources exist due to the state's flat, coastal terrain and small number of large rivers. As of December 2013, seven permitted hydroelectric facilities exist in Rhode Island, with a combined authorized capacity of 6.7 MW (RIDOP 2013).

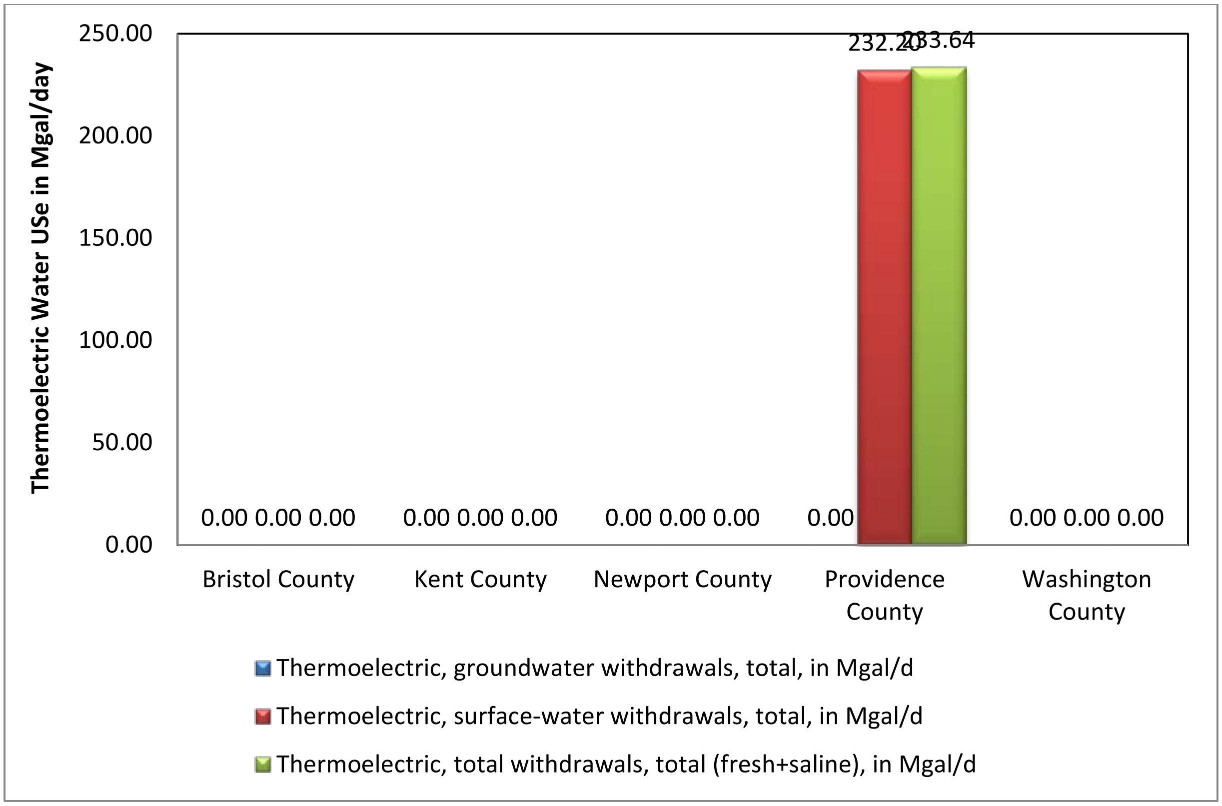

Figure 5. Thermoelectric water use in Rhode Island in 2010. All surface water withdrawals are saline and the groundwater are all freshwater withdrawals. (Source: USGS –NWIS 2014).

2.2.7 Aquaculture

In RI, aquaculture is one of the few growth industries. Aquaculture activities include shellfish aquaculture, state-owned freshwater fish hatcheries, and small private fish hatcheries. A water use database pertinent to aquaculture water use was established by Coastal Resources Management Council and can be obtained from National Water Use Information Program, USGS. Another agency providing access to aquaculture water use information is the RIDEM, Rhode Island Fish Hatcheries and Preserve Companies. In 2010 (Maupin et al., 2014) the state's estimated fresh water use for aquaculture was 5.78 Mgal/day (Table 2) and the total was 14.5Mgal/day (Figure 6).

In summary, 135 Mgal/day of combined fresh water resources (surface and groundwater) were used in Rhode Island in 2010 (Table 1). The single largest use category was public water supply. A detailed break-down of the state's water use by category is provided in Appendix II.

2.2.8 Wastewater

The RIPDES (Rhode Island Pollutant Discharge Elimination System) has monthly average flow monitoring requirements and flow monitoring results must be reported in a Discharge Monitoring Report (DMR). The monthly average flow is to be calculated by dividing the total flow discharged for a given month by the number of days in which there was a discharge during the month.

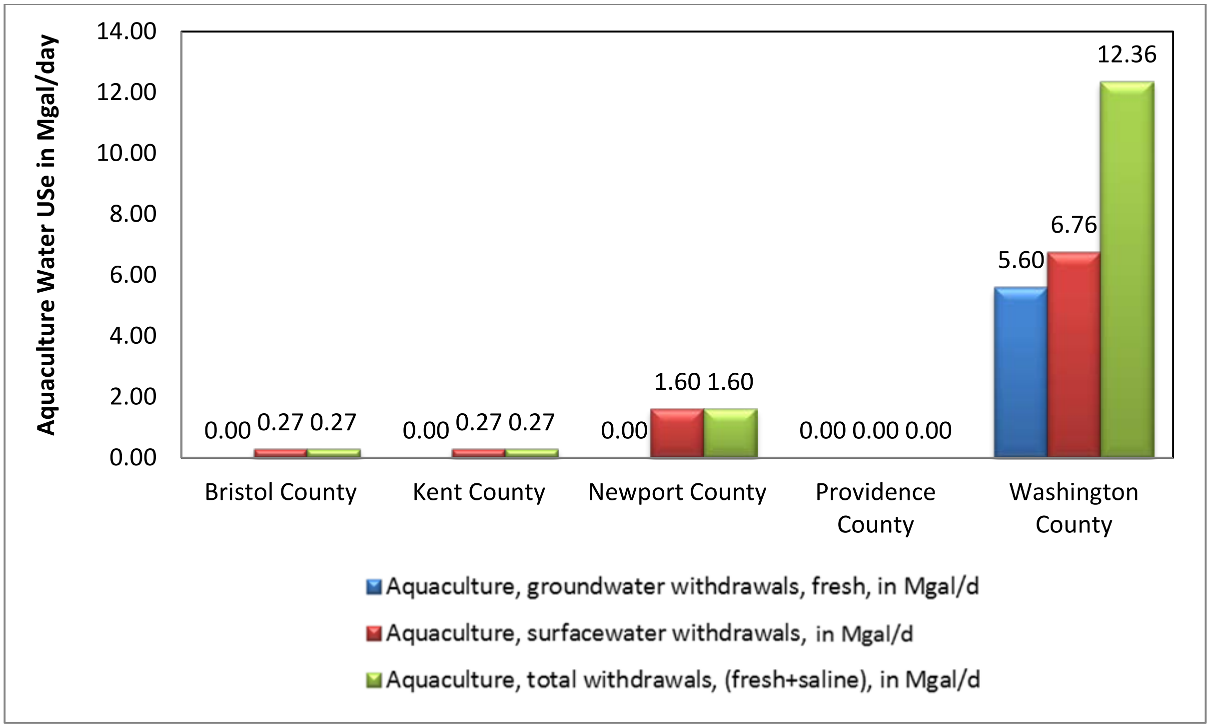

Figure 6. Aquaculture water use in Rhode Island in 2010. All surface water withdrawals are saline. (Source: Maupin et al. 2014; USGS – NWIS 2014).

Table 2: Water use categories and associated fresh water usages in Rhode Island. **Bold: RIWRB priorities (**Source: Maupin et al., 2014; USGS NWIS, 2010)

Water Use Category	**Millions of gallons/day**
Total Public Supply **Domestic – Public Supply (67.5)**	**108**
Domestic - Self-Supplied	**8.02**
Livestock	0.18
Irrigation	**2.69**
Mining	0.92
Industrial - Self-Supplied	**7.52**
Thermoelectric Power withdrawals (fresh water only)	1.44
Aquaculture	5.78
Total	**135**

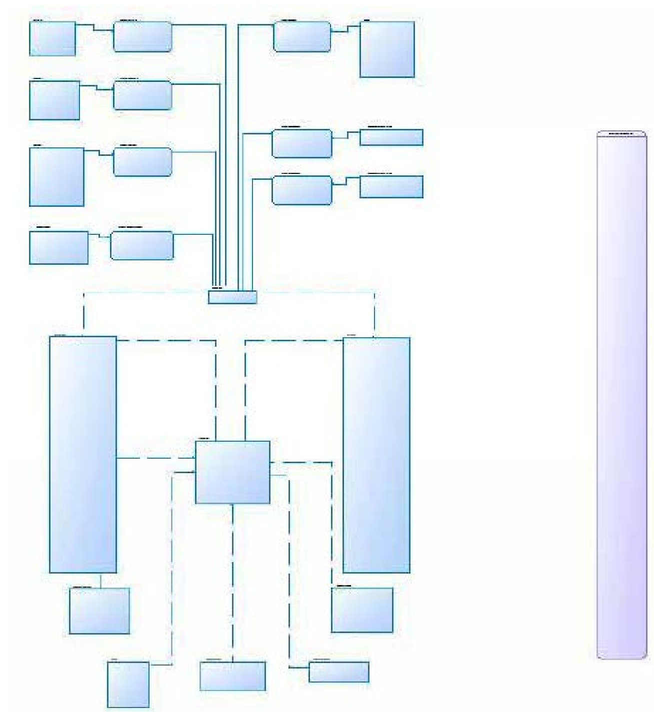

Figure 7. Data Warehouse Design-Dimensional Model. Source: Tessler 2010.

3. Overview of the USGS Water-Use Databases and its Components

Tessler (2010) defined the components of an ideal water-use database system, having the following characteristics:

1. Conveyance-based data storage in a relational database with dimensional companion data meet a predetermined level of completeness and quality. Example: A Data Warehouse dimensional model (Figure 7) permits custom queries and table extractions.

2. Accepts data for ‘one-sided conveyances’ site-specific data usually associated with a resource-interactor site

3. Flexible ‘Location’ design for partitioning of ‘area’ water quantities places of use, distribution/collection areas, land applications, etc.

4. Alias system for handling naming variations

5. Detailed associations of Sites with hydrologic Resource features resource-interaction details, allow for compound resources

6. Store related Quantities that result from the use of water, e.g. acres irrigated, kilowatts generated, population served

7. Ability to incorporate or associate with Regulatory and Permit data

Currently none of the available database systems meets all these requirements. However, there are a number of information systems developed by the USGS or in various states that provide an alternative to commercially available systems. In the following we introduce public systems first, followed by an overview of commercial software solutions.

3.1 National Water Information System (NWIS)

The National Water Information System (NWIS) is the umbrella term for the USGS Water databases. The NWIS is a distributed water database in which data can be processed over a network of workstations and file servers at USGS offices throughout the United States. The system provides access to water-resources data collected at approximately 1.5 million sites in all 50 states, the District of Columbia, and Puerto Rico. Online access to this data is organized by surface water, ground water, water quality, water use categories.

As illustrated in Figure 8, NWIS is comprised of the Groundwater Site Inventory (GWSI), the Automated Data Processing System (ADAPS), the Water-Quality System (QWDATA), and the Site-Specific Water-Use Data System (SWUDS). NWIS is an Oracle data base and presents an accumulation of over three decades of code development. Initially NWIS sites were always thought of as a point. More recently "sites" have become areal features too, like a water treatment plant, a power plant, or an orchard (Barber 2016). User interfaces exist for various components in Fortran, Visual Basic 6, .NET, Java, Perl, running in Unix, Windows desktop apps, and some web applications. Currently the system is modernized by moving Automated Data Processing System (ADAPS) to a customized version of Aquarius by Aquatic Informatics (Barber 2016).

The Aggregate Water-Use Data System (AWUDS) is under the NWIS umbrella, but not connected to the Site File because of the data stored is for area. The locations are called aggregation areas: in various national compilations such as by county, 8-digit hydrologic unit, or national aquifer systems. All work in AWUDS is organized by State, as water-use data is so dependent on State laws and data sources. In other words, for a HUC or aquifer, which crosses a State boundary, AWUDS will have entries for the pieces in each State. The State data files are developed by a person in one of the USGS Water offices, often in that State. For each aggregation area, the information available can be translated into data elements, or the actual numbers that could be reported as aggregated water-use data (Barber 2016).

Water amounts include withdrawals, returns, deliveries, consumptive use, conveyance loss, and ancillary data which may include total population, population served by public supply, power production, irrigated acres etc.

The data is compiled for the 5-year "Estimated Use of Water in the United States" circular, which has been compiled by the USGS since 1950. From 1950 to 1980, the underlying data were State totals and HUC2 or HUC4 equivalents. Watershed data moved to HUC8 in 1985 and since then water use data estimates were collected at county level, though the printed reports show State totals.

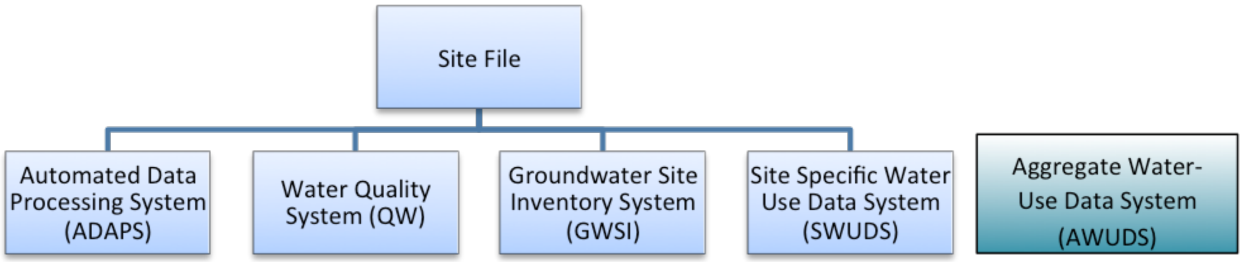

Figure 8. The National Water Information System (NWIS) structure. Source: modified after Augenstein 2012.

The GWSI System provides for entering new sites and updating existing sites within the local database. In addition, the GWSI provides for retrieving and displaying ground-water and site file data stored in the local database. Finally, the GWSI provides for routine maintenance of the local and national data records (USGS 2004).

Since 2012, a Water Quality Portal (NWISWeb) is available at www.waterqualitydata.us for downloading monitoring location information and associated water-quality results that are automatically linked and integrated from both USGS and USEPA databases. These services provide the ability to combine data from USGS's NWIS and EPA's STORET systems. The services produce data formatted according to the Water Quality Exchange (WQX) Outbound XML schema, which has been developed collaboratively by USEPA and USGS. Applications such as internet portals can use the web services to access data from both NWIS and the STORET Warehouse without needing an authorized database connection. NWISWeb does not cover well construction data, proprietary data, and most water use data. The focus of this national program has been on aggregated data. The best source for aggregated data, however, is site-specific data, and that generally means data from State water agencies that manage water resources (USGS 2012).

The NWISWeb does not show water-use codes and site names for sources and cannot indicate if they are a public supply source due to Homeland Security requirements. Further, the precise locations of treatment plants and power plants cannot be included.

3.2 Site-specific water use database (SWUDS)

The U.S. Geological Survey's site-specific water use database (SWUDS) is designed to store permitted and non-permitted surface and groundwater withdrawals from source waters, water deliveries among water suppliers, and return flows to receiving waters for individual public and private water suppliers and water-use entities. Industrial, thermoelectric, commercial, and residential water use from surface and groundwater sources can be compiled at the county and hydrologic unit levels; SWUDS also has the ability to account for inter-basin and inter-county deliveries among water suppliers (Lawrence 2013). SWUDS also includes support application for data preparation, import, and QA. Originally, it was a component of the USGS NWIS system and shared the Site file with QW, GW, and ADAPS (SW network, gages).

The SWUDS accounting capabilities permit networking the complex interdependencies of water withdrawal, treatment, distribution, finished-water deliveries, wastewater treatment, and return flows to a receiving water body for a typical public water supplier (Lawrence 2013). Point locations (sites) are connected by one-way conveyances that show how water is being moved (Figure 9).

SWUDS stores site data, owner and contacts, permit information (permit types, permitting agency, permitted average and max rate, begin/end dates), water quantities (withdrawals, returns, transfers (deliveries) between facilities, fresh vs. saline waters, consumptive use, instream use, recycled water), and ancillary data (population Served; public suppliers; Production data - identified by type and SIC/NAICS code and Production Type – acres, employees, power, production) (Barber 2016). The SWUDS has an application for the preparation of 'raw data' and also an import function similar to the New Jersey Water Transfer (NJWaTr) Data System. SWUDS also has a program that transforms a relational structure to a star-scheme Data Warehouse (DW) format for users (SWUDS Data Warehouse). Most of user interface is Visual Basic 6. Input and output uses Excel. These data are loaded in batch and communicates with excel using column headings (Figures 10 and 11). A snapshot view of SWUDS client application is presented in Figure 12.

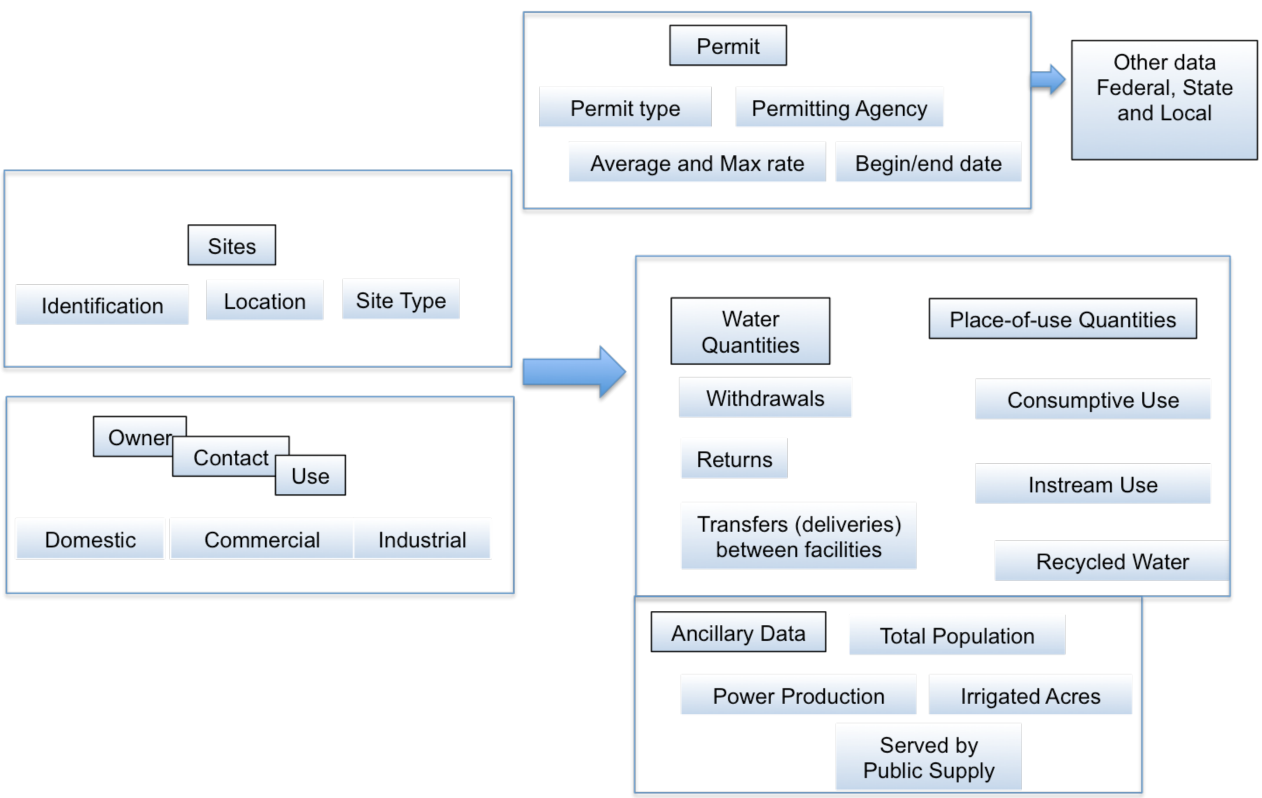

Figure 9. Conceptual model of the Site-specific water use database (SWUDS). Source: modified after Augenstein 2012.

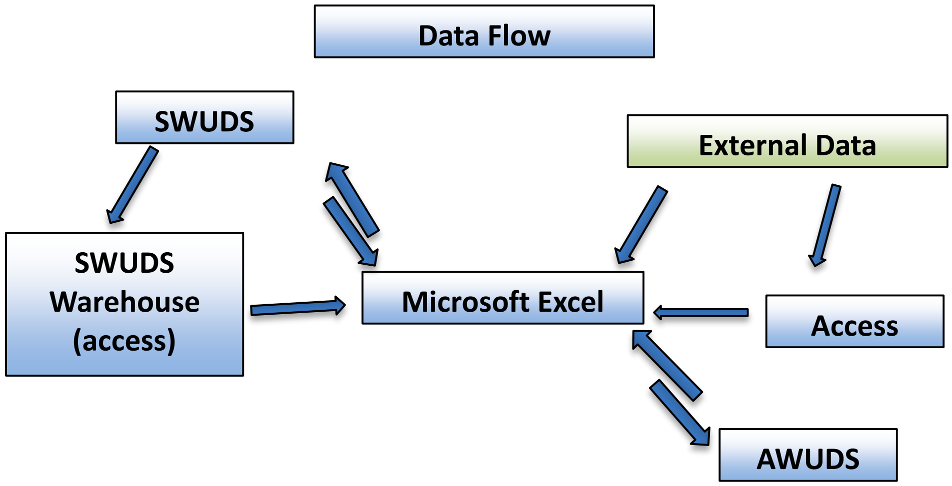

Figure 10. SWUDS data flow chart. Source: modified after Augenstein 2012.

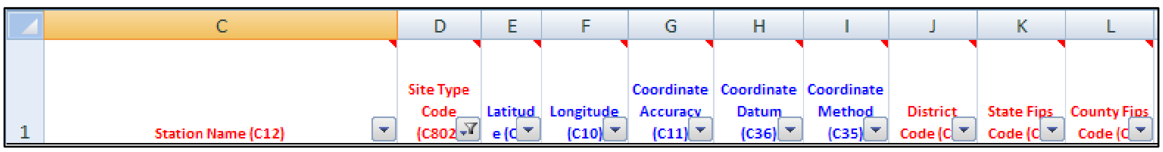

Figure 11: SWUDS interaction with Microsoft Excel through spreadsheet header. Source: modified after Augenstein 2012.

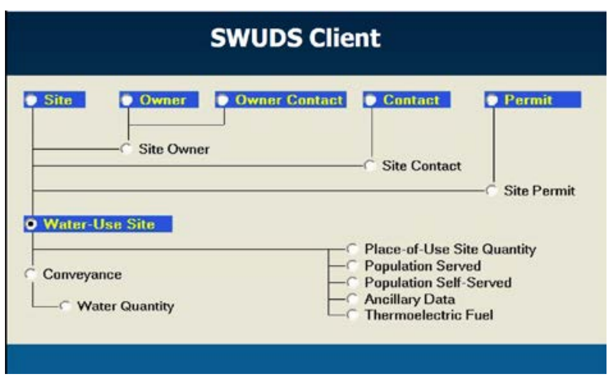

Figure 12. A snapshot of SWUDS client application. Source: Augenstein 2012.

3.3 New Jersey Water Transfer (NJWaTr) Data System

As part of a water-use database project for the USGS Districts in New England, the New England Water-Use Data System (NEWUDS) data model and database were created to provide a tool to better organize, store, and share water-use data in the region (Tessler, 2002). To support water-budget analyses at the watershed scale for the State of New Jersey, the NJWaTr was developed, in cooperation with the New Jersey Department of Environmental Protection, as a modification and extension of NEWUDS. The NJWaTr is a database design for the storage and retrieval of water-use data. NJWaTr can manage water use data, including (1) the tracking of various types of water-use activities (withdrawals, returns, transfers, distributions, consumptive-use, wastewater collection, and treatment); (2) the storage of descriptions, classifications and locations of places and organizations involved in water-use activities; (3) the storage of details about measured or estimated volumes of water associated with water-use activities; and (4) the storage of information about data sources and water resources associated with water use (Tessler, 2010). Similar to what SWUDs does, the New Jersey Water Transfer (NJWaTr) core model consist of sites that are paired to form unidirectional conveyances for which transfer volumes are recorded. Sites have locations and owners, and some interact with water resources such as surface water and ground water. The full relational data model shown in Figures 13 and 14. This flowchart shows the arrangement of 76 tables, having 95 relationships, 319 fields and more than 6,500 lookup values.

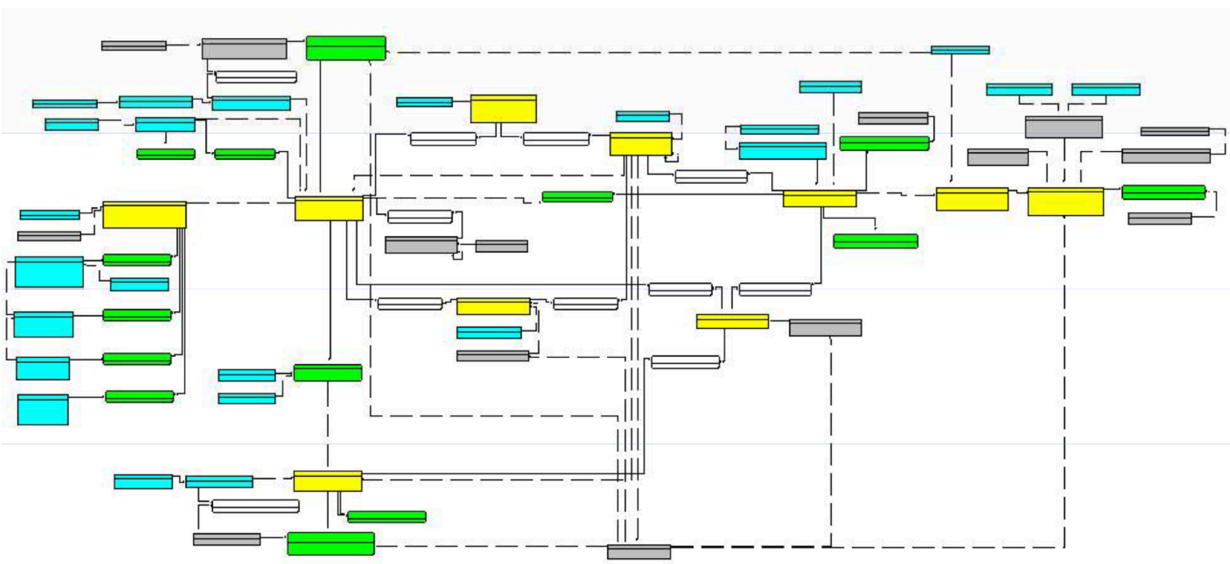

Figure 13. NJWaTr Full Relational Data Model (Source: Tessler 2010)

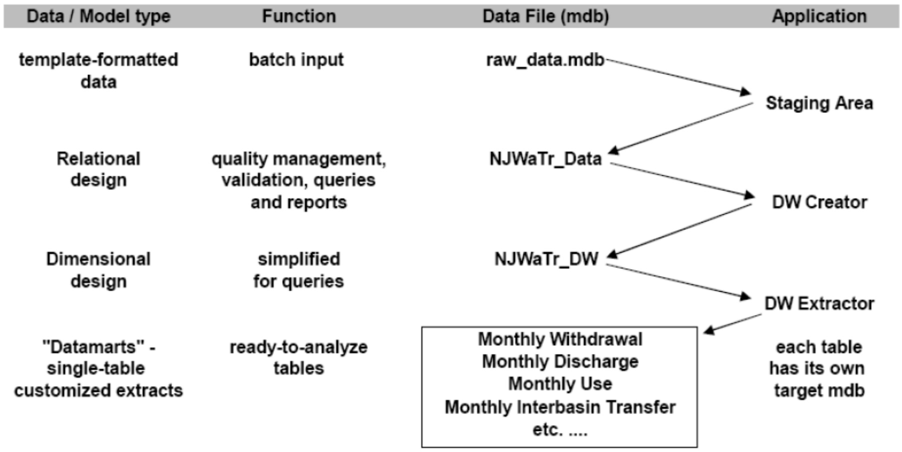

Figure 14. New Jersey Water-Transfer (NJWaTr) Data System. Source: Tessler 2010.

Table 3: Commonly used commercial water quantity and quality database applications.

Software	**Description**
Aquatic Informatics (Aquarius Time series)	AQUARIUS Time-Series is platform for managing continuous water data. It allows centralizing vast amounts of hydrologic time series data, discrete measurement data, and complex river gauging measurements from various sources. It was developed by Aquatic Informatics. http://aquaticinformatics.com/products/aquarius-time-series/
WISKI (Water Information Systems KISTERS)	WISKI was developed by KISTERS (http://www.kisters.net) and allows users to manage water data by automatically importing, processing, computing as well as storing and reporting the time series and metadata. This commercial package can work with different types of databases (e.g. MySQL and Postgres) and supports OGC standards.
Hach WIMS Water information Management Solution	This water data management software secures data collection, streamlined reporting, user-defined alerts, and powerful charting, graphing and mapping tools all make this possible. It permits maintaining a central, secure database, offers built-in equations to manage complex calculations, has troubleshooting tools for data verification, provides access to regulatory and internal report templates and features customizable dashboards. According to the manufacturer, WIMS is ideal for managing and reporting data to the EPA, state, and other regulatory agencies (http://www.hach.com/hach-wims-water-information-management-solution/product?id=7640602680).
EIM (Environmental Information Management) by Locus Tech.	EIM optimizes how field and laboratory water data is organized and tracked by consolidating data collection and field measurement workflow. Whether it is during the treatment process or after discharge, the program automates the data collection and validation process (http://locustec.com/applications/environmental-information-management).
SWIMS - Soil & Water Information Management System	The Soil and Water Information Management System (SWIMS) is an integrated, 100% web based administrative, operational, and decision making system that supports all conservation business functions and practices, across multiple Soil & Water Conservation Districts (SWCD) and administrative units. SWIMS has been designed to meet the demands of multiple decentralized computing environments and the needs of diverse stakeholders and conservation program participants.

3.4 New England Water-Use Data System (NEWUDS)

The New England Water-Use Data System (NEWUDS) has its origin in the database needs for preparing the USGS 5-year water resources data (WRD) aggregation. The NEWUDS design was based on a conveyance-based model and it was used in several USGS Projects in RI and NH to replace ad hoc district files and methods. The data was published in a series of basin studies referenced earlier in this report. According to Tessler (2010), RI developed a customized NEWUDS version as its state water-use database. USGS also designed a web interface to assist in the collection and reporting of the data. This legacy database and interface have been evaluated by RIWRB and RIDOIT and it is determined that a new data structure is needed moving forward.

3.5 Other Database Systems

In addition to those database systems developed by the USGS or by different states, there are a number of commonly used water quantity and quality database applications – many of them commercial. These systems have been tabulated in Table 3, together with a brief description of their capabilities.

4. Rhode Island Water Use Data Plan Workshop

With WUDR funding, a stakeholder's workshop on the development of a water use data base work plan was held on the URI Campus in Kingston, Friday April 1, 2016 (8:30 AM to12: 30 PM). Attendees: Clayton Commons (RIDOH) , Alan Dias (DOA), Deb Merrill (DOA), Tomas Smieszek (USGS-MA), Martha Nielsen (USGS), Jon Morrison (CT-DEEP) (TIRIWRB), Kathleen Crawley (RIWRB), Kenneth Burke (RIWRB), Chandu Dondeti (URI-CELS), Britta Anderson (URI-CELS), Marzia Tamanna (URI-CELS), Dawn Cardace (URI-CELS), Vinka Craver (URI-CE), Thomas Boving (URI-CELS), and Soni Pradhanang (URI-CELS).

In preparation for the workshop, a questionnaire survey (See Appendix III) was circulated. The purpose of the survey was to collect information about how individual agencies collect, manage and report water use and availability data. In summary, the four agencies that responded to the survey indicated that:

- Database management tool(s) that are currently in use include SQL, Oracle, and MS Office Access.
- Of all agencies that responded to the survey, only one is part of a state data network.
- All but one agency is involved in the data collection process, but none of the data are dumped automatically.
- Data is received in various formats, EXCEL and PDF files, paper copies or XML stored in SQL data base.
- Some state agencies have data reporting templates.
- State agencies report to federal agencies, such as EPA and USGS.
- Some federal data recipients require data to be submitted in a defined data architecture or offer tools to communicate EXCEL files into an Oracle database (e.g. USGS).

- Moderate amounts of data are collected, i.e. <5 GB.
- Data management tools include EXCEL, Advantage Gen (SDWIS), .Net, and Access.
- Database management and QA/QC protocol are used by only half the responding agencies. Similarly, one half of the agencies have a person in charge of the data (base).
- All agencies have plans to modify or improve data collection, storage and reporting processes and capabilities (e.g. CTDEEP is working with the USGS to populate SWUDS).

When asked about data considered important but currently not collected, the responses include (1) irrigation applications; self-supplied industrial, thermoelectric, and other category usage at sites below the state minimum reporting thresholds, including establishment of coefficients for consumptive use for the above categories (2) annual data from registered (grandfathered) diverters and (3) and basin data on a HUC 12 basis.

The results of the survey were discussed during the April 1, 2016 workshop. The principle outcomes of that discussion were:

- Regarding differences in water data structures within New England, there was a general consensus about the need for a standardized data structure and format both at the collection and the reporting end. The difficulties receiving data from certain stakeholders is primarily due to the mismatch of fiscal and hydrologic years and the data source formats.
- The estimation of water use and availability data has to be linked to with the policy and management process. Currently, most of the agencies have a five year water supply system management plan.
- There is a need for more and better collaboration among the State agencies and the USGS.
- The database that Ohio uses was presented as an example for a well-functioning database management and reporting system. A notable example of a good water data reporting structure is New Hampshire where ground and surface water is treated as a single public resource. States without any data reporting structures or exempt from reporting include Maine and Vermont.

Workshop outcomes specifically pertinent to Rhode Island:

- RIWRB receives the water use data in various formats, such as EXCEL files reported on templates developed by RIWRB in case of the large public suppliers (see sample annual data report attached, Appendix IV), or PDF files or even paper copies (previous to 2009).
- Data on irrigation water use is difficult to collect and therefore not reported. Farmers do not want to report irrigation use in fear of losing their water rights.
- Lack of information regarding the industrial classification code and industrial usage. Information on water demand is available only in snapshots of 2005, 2010 and 2015. But all data is estimated annually.
- RIWRB tracks more than 3000 connections and uses water usage estimating techniques developed by the USGS to estimate water use of entities, such as assisted living facilities.

- RIWRB receives information only from larger water sector users but not from small community water systems.

Part of the workshop was a presentation on Database Management System Software by Mr. Chandu Dondeti, communications manager for the College of the Environment and Life Sciences at the URI. The presentation highlighted some of the currently used water database management system applications. It was pointed out that there is typically a need for a programmer to initially setting up of a database software.

The workshop participants expressed a willingness to participate in water use data management meetings in future, including a continued discussion of the direction for the integration of water data and building a water use database management system.

5. Recommendations

In Rhode Island, water data is collected and stored by several agencies, including RIDOH, RIDEM and RIWRB. The data systems have evolved separately to support important, independent state and federal agency missions. Although the systems are separate, there are opportunities to share data in order to build the RIWRB data system and to develop and to improve estimating techniques for the water use data that is not metered and/or reported. A long term vision should include a statewide unified water data structure. The software and design structures selected for the water use data effort should contemplate potential expansion in the future. Furthermore, the approach proposed to build the RIWRB water use data system can be replicated.

For the purpose of this workplan, the immediate focus is on improving the fresh water data collection, storage and reporting efforts by the RIWRB. The RIWRB monitors where and how much (groundwater, surface) water is withdrawn and where that water eventually ends up, including tracking out-of-basin transfers. Of equal importance to RIWRB is monitoring the purposes that water is being used for. Overall, this data is crucial for assessing water availability in towns and watersheds and tracking the progress of water conservation and demand management initiatives in Rhode Island. Priority focus areas for RIWRB data are public water supply, the self-supplied (domestic, commercial and industrial water use), and agricultural irrigation.

It is important to note that progress has been made on how water use data is collected and stored in the State. Yet a critical element is still missing: a unified, user friendly platform and storage environment for providing web-based access to the water data across agencies. As part of this workplan, a review of commercial and public domain water database software systems was conducted. The review suggests that presently, there is not a single off-the-shelf system available that would satisfy all demands and specifications sought by RIWRB. Selecting a particular software system therefore will require compromises, taking into consideration the cost of system acquisition (soft- and hardware), its ease of use and versatility, including the need for long-term tech support and system maintenance, ability for expansion and accommodation of competing data structures, type and complexity in the future (e.g. incorporation of water quality data), handling of automated data dumps, data security and accessibility.

Most states in the New England region rely on Microsoft products for data collection and operate non-proprietary water database software systems, particularly SWUDS, which currently is being considered for adaptation in CT. In Rhode Island, RIWRB already has a rudimentary SWUDS system in place that will be examined for possible adaptation. However, it is strongly recommended to also examine proprietary, commercial software systems, such as Hach WIMS *Water information Management Solution* (Table 3). The rationale for not excluding commercial products is to weight their expense versus advertised versatility in relation to SWUDS. The evaluation would include an evaluation of the cost of buying into one of these systems and maintaining it.

Because of the complexity of these considerations, it is recommended to create a training data set built from priority data. The rationales for purposefully limiting the data complexity initially are:

- Entice RI WRB to evaluate and prioritize their data needs.
- Ease communication between data generators and IT specialist.
- Use priority data to test and train the data base system.
- Train the RI WRB database operators.
- Apply lessons learned to gradually phase-in other data sets.

After the most appropriate water use data base system has been chosen and users have become familiar with it, more data will be fed into the system which gradually enhances the system capacities. This phased approach ensures that the users will not be overwhelmed navigating the new data base, which is a common pit-fall when transitioning to a new software environment.

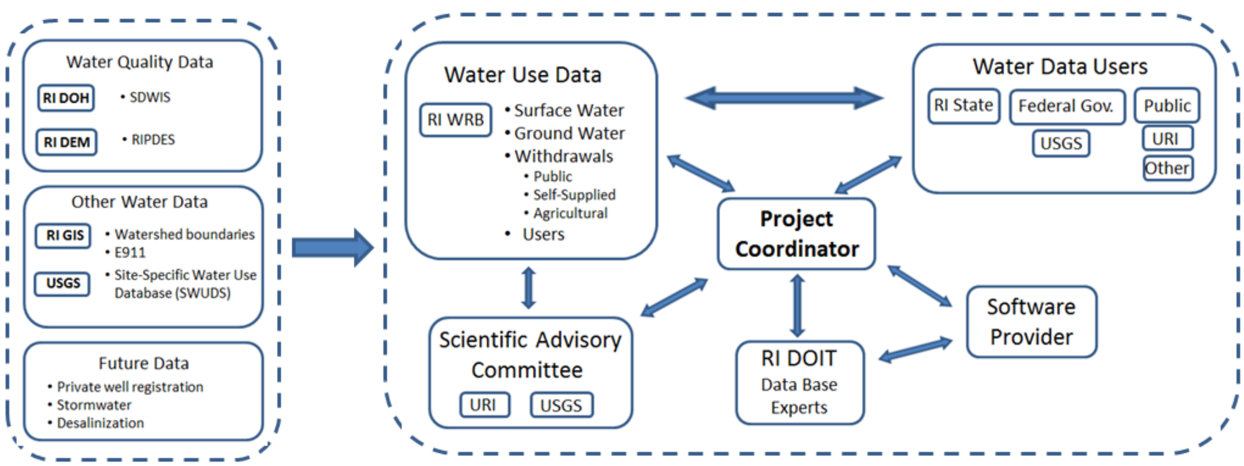

Figure 15: The water use data maintained by RI WRB will serve as a model for developing a water database.

Figure 15 depicts the suggested organizational structure to support the evaluation of water database systems. As recommended, the water use data maintained by RI WRB will "test" the process and software for a future, unified system. Because RIWRB relies on data from other state agencies, such as RIDOH, the early involvement of these agencies will ensure that other stakeholders are aware of this effort.

As shown in Figure 15, a central role falls to the Project Coordinator. It is recommended to identify and hire full-time, for the 18 to 24 months of the project duration, an individual who is experienced in developing state-wide water use data base systems. The Project Coordinator will be the intermediate between the water data collectors and users, the software providers and the RIDOIT experts. An external scientific advisory committee will aid the water data collectors and project coordinator in developing a test data set and in the evaluation of the data base performance.

5.1 Timeline

The unique water data sets collected across state agencies will be an invaluable resource for the State but also poses a great challenge for the professionals that have to synthesize reliable reports for decision makers. In order to provide the information in a format that will be usable in multiple formats and for multiple end-users, the state needs a robust, unified data system that is easily accessible to state planners and an interactive data base that can be grown to meet the demands of the future. Such a data base system must be expandable over time to accommodate, at minimum, past and future data, variable data sources, formats and structures, or data that the state agencies may be required to collect in the coming years.

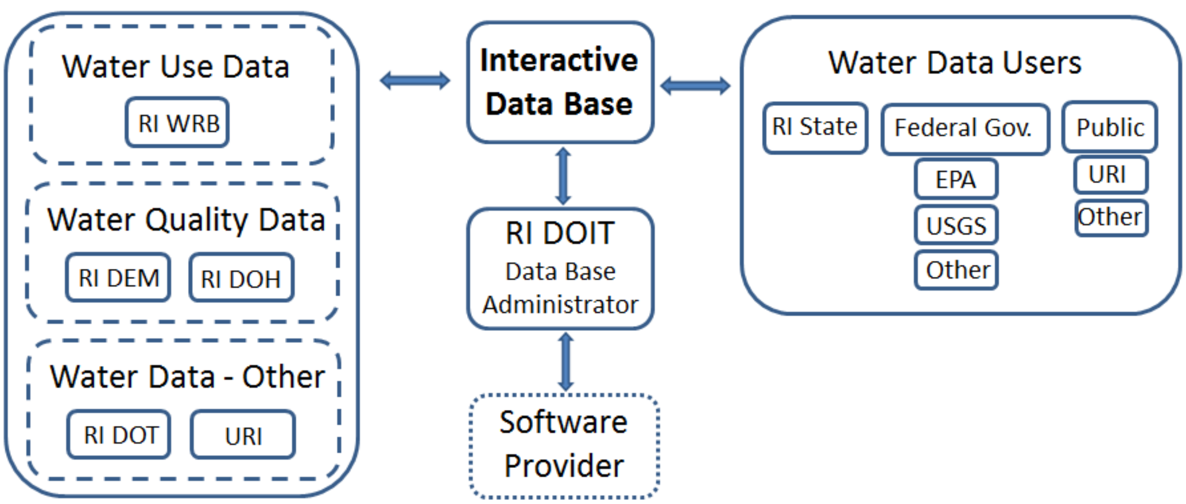

Figure 16: Possible stakeholders and their inter-relations in a future state-wide, unified water data base.

The task of examining existing state database systems and preparing for a future in which data is shared across state agencies in a unified database environment will be a challenging task. Choosing an appropriate and affordable state-wide water data base management system cannot be addressed by the various data generators in insolation, but requires the collaboration of the state's information technology specialists, extramural software designers, and the involvement of water data experts (Hydrologist, Engineers) that advise the data generators, users, and IT personnel. The ultimate goal is to identify a water use data base management system that has a state-wide web interface and comes with built-in common queries functions and reporting tools, and which can easily be adopted to meet the future needs of Rhode Island's water stakeholders. Also, it has to be decided where the new data base will be housed and which agency will have the ultimate responsibility for operating it (excluding the data maintenance). It is suggested to house the database at RIDOIT and, with the possible assistance by the software provider, task the agency with operating it (Figure 16).

A complex project like this one should be organized around clearly defined milestones. It is suggested that reaching a consensus on the most appropriate data base software environment serves as the first milestone. The second milestone would be procuring the necessary funding for the purchase of the software/hardware database system (must include funding for training and maintenance). The ultimate milestone is defined by the implementation and acceptance of the new data base by all stakeholders.

In depth testing of the most appropriate data base software environment (Milestone I) will require 18 to 24 months and would address the following goals:

Milestone I - Appropriate water database software has been tested on RI WRB water use data

- Learn about how other states that have successfully implemented a statewide water use database manage and organize their systems, particularly NH and WI.
- Examine capacity and user friendliness of SWUDS data base environment
- Obtain examination copies of commercial water use data base software.
- Create a test data base
    - Develop a common data structure
    - Include placeholders for future expansion of data (e.g. water quality)
- Use test data base to examine software for ease of:
    - Date entry
    - Data pre- and post-processing
    - Date query
    - Adding new data layers and formats
    - Linking with existing data bases, especially USGS and EPA
- Pricing of software
- Pricing of hardware
- Estimating maintenance needs and associated cost
- Consensus building
    - Organize workshop to communicate results to other state agencies
    - Housing the database
    - Defining database operating requirements
- Draft RFP for procuring the data base software/hardware (must include funding for training and maintenance).

When reaching Milestone I, RIWRB will have a working water use data base. But, the project team will likely rely on software examination copies for evaluating different commercial software. If ultimately a commercial software is identified as the most appropriate system, it is probable that RI WRB would need to purchase a full license at that point.

6. References

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Appendix 1. Sources and Status of Water Use Data in Rhode Island

Note: When a 'total use' category is calculated using a combination of reported and estimated data, it is designated with an E.

Data Element	**Availability Status (Yellow: available, Red: not available)**	**Data Type (R) Reported (E) Estimated**	**Sources and Methods**
Total population of county, in thousands	Yellow	R	U.S Census Bureau
Public Supply, population served by groundwater, in thousands	Yellow	R	RIWRB, RIDOH, USEPA, RIGIS, USGS, URI Primary Sources are –RIWRB and RIDOH. Primary Source of Water Use data (quantities) is RIWRB
Public Supply, population served by surface water, in thousands	Yellow	R	
Public Supply, total population served, in thousands	Yellow	R	
Public Supply, groundwater withdrawals, fresh, in Mgal/d	Yellow	R	
Public Supply, groundwater withdrawals, saline, in Mgal/d	Red	R	
Public Supply, groundwater withdrawals, total, in Mgal/d	Yellow	R	
Public Supply, surface-water withdrawals, fresh, in Mgal/d	Yellow	R	
Public Supply, surface-water withdrawals, saline, in Mgal/d	Red	R	
Public Supply, surface-water withdrawals, total, in Mgal/d	Yellow	R	
Public Supply, total withdrawals, fresh, in Mgal/d	Yellow	R	
Public Supply, total withdrawals, saline, in Mgal/d	NA		
Public Supply, total withdrawals, total (fresh+saline), in Mgal/d	Yellow	R	
Domestic, self-supplied population, in thousands	Yellow	E	RIWRB, RIDOH, USEPA, RIGIS, USGS, URI
Domestic, self-supplied groundwater withdrawals, fresh, in Mgal/d	Yellow	E	
Domestic, self-supplied surface-water withdrawals, fresh, in Mgal/d	Red	E	

Domestic, total self-supplied withdrawals, fresh, in Mgal/d		E	
Domestic self-supplied per capita use, in gallons/day [DO-WFrTo/DO-SSPop*1000]		E	
Domestic, deliveries from Public Supply, in Mgal/d		R	
Domestic, publicly supplied per capita use, in gallons/day [DO-PSDel/PS-TOPop]		R	
Domestic, total use (withdrawals + deliveries)		E	
Industrial, self-supplied groundwater withdrawals, fresh, in Mgal/d		E	Dun and Bradstreet Hoover Database, National Water Use Information Program, USGS, NAICS Association for SIC codes.
Industrial, self-supplied groundwater withdrawals, saline, in Mgal/d		E	
Industrial, self-supplied groundwater withdrawals, total, in Mgal/d		E	
Industrial, self-supplied surface-water withdrawals, fresh, in Mgal/d		E	
Industrial, self-supplied surface-water withdrawals, saline, in Mgal/d		E	
Industrial, self-supplied surface-water withdrawals, total, in Mgal/d		E	
Industrial, self-supplied total withdrawals, fresh, in Mgal/d		E	
Industrial, self-supplied total withdrawals, saline, in Mgal/d		E	
Industrial, self-supplied total withdrawals, total (fresh+saline), in Mgal/d		E	
Irrigation, groundwater withdrawals, fresh, in Mgal/d		E	NCDC for climate data, USDA Ag Census data, Farm and Ranch Irrigation Survey, USGS, Internet websites for golf courses. Water withdrawals for all golf facilities were based on yardage coefficient depending on number of holes. Crop irrigation is based on assumption that an application of 1 inch of water per week would be required over the total crop irrigated area (USDA- AgCensus, 2007).
Irrigation, surface-water withdrawals, fresh, in Mgal/d		E	
Irrigation, total withdrawals, fresh, in Mgal/d		E	
Irrigation, acres irrigated, sprinkler, in thousands		E	
Irrigation, acres irrigated, micro irrigation, in thousands		E	
Irrigation, acres irrigated, surface (flood), in thousands		E	
Irrigation, acres irrigated, total, in thousands		E	

Irrigation-Crop, groundwater withdrawals, fresh, in Mgal/d		E	
Irrigation-Crop, surface-water withdrawals, fresh, in Mgal/d		E	
Irrigation-Crop, total withdrawals, fresh, in Mgal/d		E	
Irrigation-Crop, acres irrigated, sprinkler, in thousands		E	
Irrigation-Crop, acres irrigated, microirrigation, in thousands		E	
Irrigation-Crop, acres irrigated, surface (flood), in thousands		E	
Irrigation-Crop, acres irrigated, total, in thousands		E	
Irrigation-Golf, groundwater withdrawals, fresh, in Mgal/d		E	
Irrigation-Golf, surface-water withdrawals, fresh, in Mgal/d		E	
Irrigation-Golf, total withdrawals, fresh, in Mgal/d		E	
Irrigation-Golf, acres irrigated, sprinkler, in thousands		E	
Irrigation-Golf, acres irrigated, microirrigation, in thousands		E	
Irrigation-Golf, acres irrigated, surface (flood), in thousands		E	
Irrigation-Golf, acres irrigated, total, in thousands		E	
Livestock, groundwater withdrawals, fresh, in Mgal/d		E	National Water Use Information Program, USGS; USDA-NAAS Census of Agriculture and State level per animal water use coefficients. Estimated based on NWUIP as no data are reported.
Livestock, surface-water withdrawals, fresh, in Mgal/d		E	
Livestock, total withdrawals, fresh, in Mgal/d		E	
Aquaculture, groundwater withdrawals, fresh, in Mgal/d		E	
Aquaculture, groundwater withdrawals, saline, in Mgal/d		E	
Aquaculture, groundwater withdrawals, total, in Mgal/d		E	
Aquaculture, surface-water withdrawals, fresh, in Mgal/d		E	

Aquaculture, surface-water withdrawals, saline, in Mgal/d		E	
Aquaculture, surface-water withdrawals, total, in Mgal/d		E	
Aquaculture, total withdrawals, fresh, in Mgal/d		E	
Aquaculture, total withdrawals, saline, in Mgal/d		E	
Aquaculture, total withdrawals, total (fresh+saline), in Mgal/d		E	
Mining, groundwater withdrawals, fresh, in Mgal/d		E	NWUIP-USGS, NMA, Netstate.com Mining water use is estimated based on coefficients, crude ore production data (USGS GD Mineral Information Team), DOE Energy Information Administration, Bureau of Census, Bureau of Mines. Estimates are based on NWUIP and no data pertinent to mining are reported.
Mining, groundwater withdrawals, saline, in Mgal/d		E	
Mining, groundwater withdrawals, total, in Mgal/d		E	
Mining, surface-water withdrawals, fresh, in Mgal/d		E	
Mining, surface-water withdrawals, saline, in Mgal/d		E	
Mining, surface-water withdrawals, total, in Mgal/d		E	
Mining, total withdrawals, fresh, in Mgal/d		E	
Mining, total withdrawals, saline, in Mgal/d		E	
Mining, total withdrawals, total (fresh+saline), in Mgal/d		E	
Thermoelectric, groundwater withdrawals, fresh, in Mgal/d		E	USDOE-EIA, The Energy Justice Network, USGS NWUIP. Water withdrawal volumes are estimated based on the USDOE-EIA data spreadsheet from USGS-NWUIP.
Thermoelectric, groundwater withdrawals, saline, in Mgal/d		E	
Thermoelectric, groundwater withdrawals, total, in Mgal/d		E	
Thermoelectric, surface-water withdrawals, fresh, in Mgal/d		E	
Thermoelectric, surface-water withdrawals, saline, in Mgal/d		E	
Thermoelectric, surface-water withdrawals, total, in Mgal/d		E	
Thermoelectric, total withdrawals, fresh, in Mgal/d		E	

Thermoelectric, total withdrawals, saline, in Mgal/d		E	
Thermoelectric, total withdrawals, total (fresh+saline), in Mgal/d		E	
Thermoelectric, power generated, in gigawatt-hours		E	
Thermoelectric once-through, groundwater withdrawals, fresh, in Mgal/d		E	
Thermoelectric once-through, groundwater withdrawals, saline, in Mgal/d		E	
Thermoelectric once-through, groundwater withdrawals, total, in Mgal/d		E	
Thermoelectric once-through, surface-water withdrawals, fresh, in Mgal/d		E	
Thermoelectric once-through, surface-water withdrawals, saline, in Mgal/d		E	
Thermoelectric once-through, surface-water withdrawals, total, in Mgal/d		E	
Thermoelectric once-through, total withdrawals, fresh, in Mgal/d		E	
Thermoelectric once-through, total withdrawals, saline, in Mgal/d		E	
Thermoelectric once-through, total withdrawals, total, in Mgal/d		E	
Thermoelectric once-through, power generated, in gigawatt-hours		E	
Thermoelectric recirculation, groundwater withdrawals, fresh, in Mgal/d		E	
Thermoelectric recirculation, groundwater withdrawals, saline, in Mgal/d		E	
Thermoelectric recirculation, groundwater withdrawals, total, in Mgal/d		E	
Thermoelectric recirculation, surface-water withdrawals, fresh, in Mgal/d		E	
Thermoelectric recirculation, surface-water withdrawals, saline, in Mgal/d		E	
Thermoelectric recirculation, surface-water withdrawals, total, in Mgal/d		E	
Thermoelectric recirculation, total withdrawals, fresh, in Mgal/d		E	
Thermoelectric recirculation, total withdrawals, saline, in Mgal/d		E	

Thermoelectric recirculation, total withdrawals, total (fresh+saline), in Mgal/d		E	
Thermoelectric recirculation, power generated, in gigawatt-hours		E	
Total groundwater withdrawals, fresh, in Mgal/d		E	
Total groundwater withdrawals, saline, in Mgal/d		E	
Total groundwater withdrawals, total (fresh+saline), in Mgal/d		E	
Total surface-water withdrawals, fresh, in Mgal/d		E	
Total surface-water withdrawals, saline, in Mgal/d		E	
Total surface-water withdrawals, total (fresh+saline), in Mgal/d		E	
Total withdrawals, fresh, in Mgal/d		E	
Total withdrawals, saline, in Mgal/d		E	
Total withdrawals, total (fresh+saline), in Mgal/d		E	

Appendix II: Summary table of water use by different sectors in RI in 2010.

Data Element	**Values**
Total population of county, in thousands	1052.56
Public Supply, total population served, in thousands	939.63
Public Supply, total withdrawals, fresh, in Mgal/d	108.03
Domestic, total self-supplied withdrawals, fresh, in Mgal/d	8.02
Domestic self-supplied per capita use, in gallons/day [DO-WFrTo/DO-SSPop*1000]	342
Domestic, deliveries from Public Supply, in Mgal/d	67.65
Domestic, publicly supplied per capita use, in gallons/day [DO-PSDel/PS-TOPop]	360
Domestic, total use (withdrawals + deliveries)	75.67
Industrial, self-supplied groundwater withdrawals, fresh, in Mgal/d	4.17
Industrial, self-supplied total withdrawals, fresh, in Mgal/d	7.52
Irrigation, total withdrawals, fresh, in Mgal/d	2.69
Irrigation, acres irrigated, total, in thousands	6.19
Livestock, total withdrawals, fresh, in Mgal/d	0.18
Aquaculture, total withdrawals, fresh, in Mgal/d	5.7
Aquaculture, total withdrawals, saline, in Mgal/d	8.8
Aquaculture, total withdrawals, total (fresh+saline), in Mgal/d	14.5
Mining, groundwater withdrawals, total, in Mgal/d	0.43
Mining, total withdrawals, fresh, in Mgal/d	0.92
Thermoelectric, total withdrawals, fresh, in Mgal/d	1.44
Thermoelectric, total withdrawals, total (fresh+saline), in Mgal/d	233.64
Thermoelectric, power generated, in gigawatt-hours	1138.3
Thermoelectric once-through, total withdrawals, total, in Mgal/d	232.2
Thermoelectric once-through, power generated, in gigawatt-hours	639.26
Thermoelectric recirculation, total withdrawals, fresh, in Mgal/d	1.44
Thermoelectric recirculation, power generated, in gigawatt-hours	499.04
Total groundwater withdrawals, fresh, in Mgal/d	36.5
Total surface-water withdrawals, fresh, in Mgal/d	98
Total surface-water withdrawals, saline, in Mgal/d	241
Total surface-water withdrawals, total (fresh+saline), in Mgal/d	339
Total withdrawals, fresh, in Mgal/d	134.5
Total withdrawals, saline, in Mgal/d	241
Total withdrawals, total (fresh+saline), in Mgal/d	375.5

Appendix III: Survey Questionnaire

Purpose of the survey

A primary mission of the RI Water Resources Board (RIWRB) is the collection, storage and sharing of statewide water use information. This mission is shared with the US Geological Survey's (USGS) National Water Use Information Program. The RIWRB seeks to develop a work plan for the state's water use and availability data needs that is aligned with the USGS and their goals to improve the collection, storage and quality of the national water use data. Ideally, the data base will be useful and accessible to other state stakeholders. In the first phase of working towards a water use and availability data base, the RIWRB is collaborating with the URI Geosciences Drs. Pradhanang and Boving to research options for data base design and develop. On this background, this survey is intended to

1. Discover what water use data is collected that may be relevant to the current effort to build a statewide water use database.
2. Share information about the data structures that are currently in use or planned for the state to facilitate discussion at a workshop on April 01, 2016.

Please kindly complete following survey by March 17, 2016, 11:59 PM EST.

Contact: Dr. Pradhanang (spradhanang@uri.edu) or Dr. Boving (boving@uri.edu), University of Rhode Island

Name:

Agency:

<u>Data collection, storage and reporting</u>

1. Please name the database management tool(s) that are currently in place and used in regular basis.
2. Is the data part of the state network? ☐ Yes ☐ No

3. Is the data required by a federal agency? ? ☐ Yes ☐ No

   If yes, which one;

- ☐ USGS
- ☐ EPA
- ☐ Other ________________________________

4. How is data collected?
   a. Collect our own data? ☐ Yes ☐ No
   b. Automatic data dump? ☐ Yes ☐ No
   c. Periodic data request to data generators? ☐ Yes ☐ No
   d. Other (please specify)

If you answered “b” “c” and/or “d”,

i) Please describe in what format is data received and stored? (For e.g., text file, excel, oracle etc.)
ii) Do you provide a data reporting template? ☐ Yes ☐ No
iii) How much data is received (megabytes, gigabytes, terabytes) and how often (every day, weekly, monthly, quarterly, annually)
iv) How much data is stored? (megabytes, gigabytes, terabytes)

5. What application do you use to manage your data? (for e.g., Excel, Access, SQL etc.,)

6. What application do you use to report your data? (for e.g., Word, Excel, pre-described format/templates form the agency to which you have to report, etc.,)

7. Do you have a database management protocol? ☐ Yes ☐ No

8. Does your data undergo quality assurance/quality check evaluation? ☐ Yes ☐ No

9. Do you have a person in-charge of data? ☐ Yes ☐ No

10. Is the person managing the data the same as the person

    a. collecting your data, in case you generate your own data ☐ Yes ☐ No
    b. reporting your data? ☐ Yes ☐ No

<u>Water Use Data</u>

11. Do you provide any data to the USGS National Water Use Information Program?

☐ Yes

☐ No

12. Do you collect any data listed in the appendix (check all that apply- see attached appendix)?

Data Gaps

1. Within the next twelve months. Do you have any plans to modify or improve data collection, storage and reporting processes and capabilities? □ Yes □ No
   If Yes, please specify.

2. Are there any data above and beyond your current data inventory that you would like to collect? (please provide examples)

3. Is there water use data that you would like to see the RI Water Resources Board collect?

Continued Involvement

1. Are you interested to being part of the ongoing discussions about the State wide water use database? □ Yes □ No

Please check all that apply.

1) Please identify which, if any, categories of water use data apply
   - □ Public Supply
     - □ Domestic
     - □ Commercial
     - □ Industrial
     - □ Agriculture
     - □ Government
     - □ Other
   - □ Self-Suppliers
     - □ Domestic
     - □ Commercial
     - □ Industrial
     - □ Agriculture
     - □ Government
     - □ Other
   - □ Irrigation
   - □ Livestock
   - □ Aquaculture
   - □ Thermoelectric
   - □ Mining
2) Please identify any other water information you collect:
   - □ Consumptive use
   - □ Return flow
   - □ Conveyance loss
   - □ Evaporation
   - □ Transpiration
   - □ Water source(s)
     - □ Groundwater
     - □ Surface Water
   - □ Water quantity
     - □ Metered
     - □ Estimated
   - □ Water quality
     - □ Physical parameters (e.g. temperature, pH, TDS, or electric conductivity)
     - □ Major anions/cation
     - □ Organic compounds
     - □ Heavy Metals
     - □ Nutrients
     - □ Pathogens
     - □ Others (please specify): __________________________

Appendix IV

WATER SUPPLY SYSTEM MANAGEMENT PLAN PROGRAM
STATE FISCAL 2016 REPORTING - July 1, 2015 - June 30, 2016

Return completed form no later than August 1, 2016
Report all water volumes in gallons

WATER SUPPLIER: **CONTACT NAME & PHONE:**

SECTION #1: Service Connections (July 1, 2015 through June 30, 2016) and Population Served - Historic, Current, and Projected (Section 8.02 (f)) (Worksheet #8)

Residential # Service Connections	Commercial # Service Connections	Industrial # Service Connections	Governmental # Service Connections	Other # Service Connections	Total # Service Connections	Number of Metered Services	Total Current Population Served	5-Year Projected Population Served*	20-Year Projected Population Served	Population Eligible to be Served
					0					

Instructions: Provide service connection data by type of connection. Please note if the breakdowns are estimated. The total number of connections will be calculated automatically. Note the method used to calculate total population served. Provide data and time periods for projections from most recent Water Supply System Management Plan if more recent data is not available. Provide data and note the time periods (5 and 20 year). Use the most recent Water Supply System Management Plan if more recent data is not available. Note the method used to calculate total population served.

SECTION #2: Current Volumes of Water (Gallons) Withdrawn from Each Supply Source and Total System (Section 8.02 (h) (Worksheet #12)
LAST COMPLETED FISCAL YEAR (July 1, 2015 through June 30, 2016)

Source Name	J	A	S	O	N	D	J	F	M	A	M	J	TOT
													0
													0
													0
Totals	0	0	0	0	0	0	0	0	0	0	0	0	0

List all sources active and inactive. Provide data in gallons. Totals are calculated automatically.

Section #3: Current Monthly Wholesale Water Purchases (Gallons) (Section 8.02 (h) (Worksheet #14)
LAST COMPLETED FISCAL YEAR (July 1, 2015 through June 30, 2016)

Source Name	J	A	S	O	N	D	J	F	M	A	M	J	TOT
													0
													0
													0
													0
Totals	0	0	0	0	0	0	0	0	0	0	0	0	0

Section #4: Current Monthly Wholesale Water Sales (Gallons) (Section 8.02 (h) (Worksheet #16)
LAST COMPLETED FISCAL YEAR (July 1, 2015 through June 30, 2016)

Source Name	J	A	S	O	N	D	J	F	M	A	M	J	TOT
													0
													0
													0
													0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0

SECTION #5: Current Water Use (Gallons) by User Category * (NAICS) (Section 8.02 (i)(2)) (WORKSHEET #20)
LAST COMPLETED FISCAL YEAR (July 1, 2015 through June 30, 2016)

User Category	J_{31}	A_{31}	S_{30}	O_{31}	N_{30}	D_{31}	J_{31}	F_{28}	M_{31}	A_{30}	M_{31}	J_{30}	Total
Residential (Total)	0	0	0	0	0	0	0	0	0	0	0	0	0
Single													0
Multi													0
Residential Demand Per Capita Per Day-note1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Commercial (Total)	0	0	0	0	0	0	0	0	0	0	0	0	0
1 Commercial													
2 Motel/Hotel													
3 Medical													
4 Nursing Home													
5 Restaurant													
6													
7													
Industrial (Total)	0	0	0	0	0	0	0	0	0	0	0	0	0
1													
2													
3													
Government (Total)	0	0	0	0	0	0	0	0	0	0	0	0	0
Other (Total)	0	0	0	0	0	0	0	0	0	0	0	0	0
1													
2													
3													
Totals	0	0	0	0	0	0	0	0	0	0	0	0	0
System ADD (Gallons) -note 2	0	0	0	0	0	0	0	0	0	0	0	0	0
System ADD (MG) Gallons/1,000,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
System ADD/Capita (Gallons)- note 3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Fill in the above data in total gallons based on billing (monthly, quarterly, etc.). Provide explanation as needed. Totals will be automatically calculated.
Notes:
* Section 8.02 (i)(2) of the Regulations requires water use analyzed by user category utilizing the North American Industry Classification System
1. Average Day Residential Demand per capita is Daily Residential Water Use/Total Current Population Served (cell H13) above.
2. Based on Monthly Production, Purchase, and Storage Data (to be provided separately if available) - (Withdrawals + Purchased) / # of Days in Month).
3. System ADD / Total Current Population Served (cell H10 above).

SECTION #6: FY 2016 Water Rates
Please attach information explaining your current billing system and customer types. Attach a copy of the current water rate schedule as approved by your local governing body, water board or the public utilities commission including effective date and schedule for the next update. Include all charges, fees, surcharges and taxes as well as scale, if any, used to calculate rate for different size connections.

SECTION #7: Current Non-Billed and Non-Metered Water Use Estimates (Gallons) (July 1, 2015 through June 30, 2016)

	FY 2016(Gallons)
Total Water Produced/Purchased (Total Sections 2 and 3)	0
Less Total Metered (Sold/Billed) Water (Total Sections 4 and 5)	0
Less Non-Billed Water Use (Total Section 7 below)	0
Total Non-Metered (Not Sold) Water Use	0
% Non-Metered Water (Total Non-Metered/Total Water)	#DIV/0!

Section 7 is calculated automatically based on previous sections and data entered below.

Non Billed Water Use	FY 2016 Gallons
Fire Fighting Allowance	
Main Flushing/System Maintenance	
Storm Drain Flushing	
Sewer Cleaning	
Street Cleaning	
Schools and Other Public Buildings	
Landscaping in Public Areas	
Swimming Pools	
Construction Sites	
Water Quality and Other Testing	
Process Water at Treatment Plants	
Leakage	
Theft, meter error	
Other Non Billed Water	
Total	0

Instructions: All non-billed water must be included in Section 7 above. Leakage (actual or estimated) must be provided. If individual categories other than leakage are not known, provide the information in the "Other Non-Billed Water" category.

SECTION #8: Top Ten Major Users FY 2016
Provide the legal names of the top ten major water users, the amount of water used (Gallons), and telephone

COMPANY NAME	CONTACT	FY 2016 (Gallons)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		