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14. ABSTRACT

The Bureau of Reclamation does not own a centralized database system that tracks Reclamation-owned water rights. In the U.S., law governs the allocation, ownership, and transfer of water rights. Because of the variability between state systems across Reclamation, tracking its water rights requires flexibility when maintaining, monitoring, and protecting its water rights. Project-related water rights represent a valuable property right, but Reclamation does not have a centralized database system. As a result, Regions and Area Offices employ a variety of methods to monitor water rights, however their methods are not consistent. This water rights information management system (WRIMS) will bring consistency to this task and add GIS data tracking to provide a user-friendly visual format that shows accurate allocations, locations, ownership, and relationships to Reclamation assets.

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Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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To help test the WRIMS Pilot System, it was populated with sample water rights information gathered from a few Reclamation Area Offices and in collaboration with the Western States Data Council's WaDE system. End-user testers were notified prior to testing. The information in WRIMS is for testing the functionality of the system only. When testing is complete, all the test data will be deleted, and the data management system manager will help end-users import and input up-to-date data from their regions and areas into the system.

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Water Rights Information Management System (WRIMS)

Final Report No. ST-2022-20088-01

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Peer Review

Bureau of Reclamation
Research and Development Office
Science and Technology Program

Final Report ST-2022-Project ID(20088)- Report Number (ST-2020-20088-01)

Water Rights Information Management System (WRIMS)

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Acronyms and Abbreviations

AF	Acre-Foot
AMD	Asset Management Division
CFS	Cubic feet per second
CGB	California-Great Basin Region
CPN	Columbia-Pacific Northwest Region
DBMS	Database management system
Department	Department of the Interior
ECS	Enterprise Content System
eERDMS	Electronic Enterprise Records and Document Management System
ETL	Extract, transformation, and load
FLPMA	Federal Land Policy and Management Act of 1976
GIS	Geospatial Information System
IT	Information technology
LCB	Lower Colorado Basin Region
MB	Missouri Basin Region
ONE	Omni Networking Environment
PaaS	Platform as a service
Reclamation	Bureau of Reclamation
R&D	Research and Development Office
S&T	Science and Technology
SQL	Structured Query Language
UCB	Upper Colorado Basin Region
UI	User Interface
U.S.	United States
WaDE	Western States Water Council Water Data Exchange
WAPA	Western Area Power Administration
WestDAAT	Western States Water Data Access and Analysis Tool
WRCID	Water right core identifier
WRIMS	Water Rights Information Management System

Executive Summary

The Bureau of Reclamation (Reclamation) holds a substantial amount of water rights associated with Reclamation Authorized Projects. Water is vital with its pervasive commercial and societal impact affecting everything from health, sustenance, environment, to aesthetics. In eight Western States, more than 90% of storage water rights associated with Reclamation projects are Federally held; in only five Western States is that figure less than 50%. America's water is grouped into three systems of water law: riparian, prior appropriation, and hybrid. Western water rights are primarily made up of prior appropriation and hybrid systems. Historically, western states treat water as a public resource. However, those same states recognize private property rights for the beneficial use of water.

In the U.S. (U.S.), each state has the authority to determine and allocate water within its boundaries. In 1902, Congress passed the Reclamation Act to help the 17 Western States finance Reclamation Projects. Under the 1902 Act, all Reclamation Projects must obtain water rights based on state law. Reclamation Projects, such as the Aspinall Unit of the Colorado River Storage Project, administer water delivery to the Colorado River Basin states. Reclamation Projects must also comply with other water appropriation agreements like the Colorado River Compact that dictates water delivery requirements to the Lower Basin States from Reclamation Project assets like Navajo Dam, Glen Canyon Dam, Fontenelle Dam, and Flaming Gorge Dam. The Department of the Interior's (Department) regional boundaries and the agency's internal organizational office boundaries determine Reclamation's jurisdictional boundaries to manage water in the western states.

The Supremacy Clause of the U.S. Constitution can preempt state water law and give Reclamation additional authority to manage water in the western states. The Federal Government owns different inter- and intra-state water rights, that trigger a different management responsibility in compliance with different state laws.

Reclamation activities include collaborating with the Solicitor's Office on water rights objection settlements and litigation, pursuing administrative procedures to ensure project water rights are current, monitoring water use, applying for changes and extensions, and working with water transfers. Emphasis on the stewardship of Reclamation's water rights prompted research and development for a Reclamation-wide centralized database system that incorporates geospatial information system (GIS) visualizations that highlight the varied allocation types of Western water with spatial and temporal slicers.

Currently, each region has individual water rights databases in several different formats, including Microsoft Access™ and Excel™. Joint development of a single-source shared database has been Reclamation's vision since the 1990s, and now it has been implemented and finally developed into a fully supported project from all regions. Taking a proactive approach in maintaining Reclamation assets, the Asset Management Division (AMD) partnered with the Upper Colorado Basin (UCB) Region in establishing this agency-wide enterprise information management system to assist Reclamation to be more responsive to inquiries from Congress, federal partners, local and state governments, non-governmental organizations, public stakeholders, and Reclamation.

Additionally, an enterprise system is meant to assist with the administration, preservation, and protection of Reclamation's water rights and ensure consistency and transparency, which involved

performing research. In collaboration with the regional offices, water rights information was gathered, monitored, and recorded; how water rights documents are stored and filed was reviewed; custom and standardized water rights reports were included; a Library management system for each water rights activity was incorporated; and a standardized file naming convention and design custom user interface were synthesized to bring together the variety of water right tracking systems from the Reclamation regional and area offices.

The development of an enterprise information management system ensures Reclamation assets, in this case water rights, are stored and maintained in one centralized location. Regional and area offices dedicate substantial staff time to maintaining and protecting project-related water rights and implementing other water administration responsibilities. Once the consolidation is completed, ownership, updating, and modification of each region's dataset will become its responsibility with support from the Denver Offices.

For the first time, Reclamation has been able to create a centralized database with collaboration from all of the regional and area offices. Regional and area offices submitted their water rights datasets so the database could be tailored to incorporate the most end-users in Reclamation. It is imperative to protect Reclamation's Project-related water rights and implement a standardized, streamlined, and centralized water rights database. The Water Rights Information Management System (WRIMS) is the realization of that three-decades-old goal of centralizing Reclamation's water rights data with support from the region and area offices.

1. Introduction

Dam Safety and Infrastructure's Asset Management Division is taking a coordinated proactive approach to the management of Reclamation's water rights records and data information. Reclamation's water rights are an important source of information relating to the management of water throughout the West and supporting Reclamation's mission in conjunction with Reclamation projects. Currently, each regional office has individual water rights databases housed in several formats, including Microsoft Access™, Excel™, and obsolete legacy systems. Inconsistent systems do not always provide accurate or even relevant information which can result in unreliability.

The goal of this water rights project is to develop an integrated and enhanced centralized water rights database that helps Reclamation tracks its water rights. WRIMS is a custom water rights enterprise system used for maintaining and storing water right assets from the 17 Western States and ensuring these assets are in an accurate order. These water rights are owned, managed, or impact Reclamation projects. The research looked at the various methods of Federal water rights tracking and maintenance.

The scope of the WRIMS database was limited to one regional site focusing on the UCB Regional Office as a basis for the Test Pilot. However, the project team elicited input from all Reclamation regional and area offices. Most of them shared their water rights data and provided input during the WRIMS development process. UCB Region encompasses all or parts of Arizona, Colorado, Idaho, Nevada, New Mexico, Utah, and Wyoming. The project team considered every state's unique water rights administration and management that require different measures related to monitoring and protecting water rights. The following states were not considered in the initial development of the WRIMS database: Arizona and Nevada. Reclamation will be able to use WRIMS to respond more accurately and faster to water rights inquiries from Congress, federal partners, local and state governments, non-governmental organizations, public stakeholders, and Reclamation staff. Reclamation's current method and program of managing water rights does not capture all Reclamation managed water rights in a centralized database. The lack of a centralized database presents a need and opportunity to better manage data through an integrated system to meet Reclamation's mission to manage water for the West.

2. Federal Regulation of Western Water Development

Purpose

Congress encouraged the West's development and settlement by enacting legislation such as the Homestead Act to provide opportunity for people to own land and develop new resources. Congress's purpose in allowing settlement on the public lands was to encourage self-sufficiency. Railroads developed better western transportation systems to promote industries like mining and

were able to aggregate vast tracts of public lands under their ownership and control. But new settlers quickly realized that Western public lands were too arid to use without irrigation, but they lacked the capital to construct dams and diversion works, leading to government financing and construction projects.

Reclamation Act and Other Authorities

In 1902, Congress passed the Reclamation Act, which established an agency under the U.S. Geological Survey that would eventually become the Bureau of Reclamation in the Department of the Interior. The purpose of the Reclamation Act was to provide water for irrigation. The intent of Congress was to promote agriculture and settle new areas of the largely unpopulated West. Later legislation supplemented the purposes of Reclamation projects to include hydropower, industrial, and municipal uses. Recreation, environmental protection, flood control and navigation benefits were added to the purposes of specifically authorized Reclamation projects.

Examples of specific Congressional authorizations are the Boulder Canyon Project Act of 1928, 43 U.S.C. §617), passed in 1929, provided for construction of dams (including Hoover Dam) on the Colorado River as part of a comprehensive development plan. The Small Reclamation Projects Act, 43 U.S.C. §§422 et seq., provided for expedited approval and partial Federal funding of small projects as long as the local sponsor met certain conditions.

Limitations on Beneficiaries of Projects – Reclamation Reform Act of 1982

Overview and Policy

The 1902 Reclamation Act included provisions to prevent speculation. It restricted use to no more than 160 acres in single ownership, and the user of the water had to be a bona fide resident on or near the land to prevent absentee owners. In addition, the Reclamation Act required recipients of project waters to pay back a portion of construction costs interest free over time. Many of these provisions were amended, and some amendments allowed delayed or forgave repayment obligations in order to help water users develop western lands.

Acreage Limitation

To promote new settlements, Section 5 of the 1902 Reclamation Act prohibited the sale of Reclamation water for lands in excess of 160 acres in common ownership. The acreage limitation (or "excess land" provisions) led to unintended abuses that required Congress to pass the Omnibus Adjustment Act of 1926. Section 46 of the 1926 Act provided that excess lands could not continue to receive project water unless owners entered into a "recordable contract" to sell the lands within 10 years. The 1926 Act also delegated responsibilities for distributing water, in compliance with Federal law, to local districts. The Department entered long-term service contracts with the districts, and the districts subcontracted with water users.

Some large landowners were able to lawfully violate the acreage limitations by use of leases (since only common "ownership" was mentioned in the 1926 Act) as well as by various multiple ownership subterfuges that allowed a single operator to control thousands of acres. The Department failed to stop these abuses largely because, 160 acres was insufficient for a viable farming operation in parts of the West.

Congress provided a variety of exemptions for specific projects. For such projects, the acreage ceiling was raised beyond 160 acres (480 acres, San Luis Valley Project) or the limitation was removed altogether (Colorado-Big Thompson Project) on the rational that since the lands were already irrigated, Reclamation water was merely "supplemental," and therefore the risk of speculation was diminished. Another type of exemption allowed landowners to avoid the recordable contract provisions (limiting the resale price) by agreeing to pay interest charges on the repayment obligation for water delivered to excess lands (Washoe Project). Hardships for large landowners in the Imperial Irrigation District caused by the 160-acre limitation were also avoided by judicial interpretation. The U.S. Supreme Court held that the district was effectively exempted by the Boulder Canyon Project Act.[1]

Finally, Congress passed the 1982 Reclamation Reform Act, which increased the acreage from 160 to 960 acres and raised the charges for water. It also addressed leasing by setting a limit of 2,080 acres. Excess lands are now subject to charges for the full cost of water delivery to those lands. Districts are given a choice of amending their contracts to conform with the new limitation or to begin paying full cost for excess acreage.[2]
]

Reclamation Act and Other Authorities

In 1902, Congress passed the Act of July 17, 1902, popularly known as the Reclamation Act of 1902, which established the Bureau of Reclamation in the Department of the Interior to administer the Reclamation program. The stated purpose of the Reclamation Act was to provide water for irrigation in the arid west, and it was intended to be part of a national policy of encouraging settlement of the west by small family farms while preventing land speculation and monopolies seen during earlier public land programs. Later legislation supplemented the purposes of Reclamation projects to include hydropower, industrial, and municipal uses. Recreation, fish and wildlife protection, flood control, and navigation benefits are also provided pursuant to provisions establishing Reclamation projects.

Legislation enacted subsequent to the Reclamation Act authorized specific projects. For example, the Boulder Canyon Project Act, 43 U.S.C. §617), passed in 1928, provided for construction of dams (including Hoover Dam) on the Colorado River as part of a comprehensive development plan. The Small Reclamation Projects Act of 1956, 43 U.S.C.A §§422 et seq., provided for expedited approval and partial Federal funding of small projects, so long as the local government entity secures necessary water rights, easements, and land.

[1] Bryant v. Yellen, 447 U.S. 352 (1980).
[2] Several districts in California's Central Valley challenged this "hammer clause" as unconstitutional, arguing that it violates the due process and taking provisions of the Fifth Amendment. The Ninth Circuit ruled that there was no violation. It held that congressional silence concerning water service to lease lands conferred no vested right on the districts; such a right would be in conflict with the purpose of the Reclamation Act. Further, it held that Congress had never surrendered its sovereign right to regulate the quantity of subsidized water provided by the government Peterson v. Department of the Interior, 899 F.2d 799 (9th Cir. 1990) (per Norris, J.; the other panel members were Noonan, J. and Leavy, J.), cert. denied, 111 S. Ct. 567.

Acreage Limitations on Beneficiaries of Projects –

The Reclamation Act of 1902 included provisions to prevent land speculation by limiting single ownership to 160 acres, on which Reclamation water could be placed. The user of the water had to be a resident on or near the land to prevent absentee owners. In addition, the Reclamation Act of 1902 required recipients of Reclamation water, not project water, to repay over time a portion of the construction cost of the irrigation project that made Reclamation water available, subsidized with interest-free payments. However, many of these provisions have since been amended, and some amendments delayed or entirely forgave repayment obligations.

To help fulfill Reclamation's purpose in subsidizing small family farms, Reclamation Act of 1902 prohibited the sale of lands in excess of 160 acres to a single owner and had to be a bona fide resident on or near the land to prevent absentee owners. The acreage limitation provisions gave rise to exploitation and evasion more than any other part of the Reclamation Act of 1902. Abuses led to an attempt at reform in the Omnibus Adjustment Act of 1926. Section 46 of this Act provided that excess lands could continue to receive Reclamation water only under certain circumstances, and only if owners entered into a "recordable contract" to sell the lands within 5 years at a sale price approved by the Secretary of the Interior. The 1926 Act also delegated responsibilities for distributing water, in compliance with Federal reclamation law, to local districts. Reclamation entered long-term service contracts with the districts, and the districts subcontracted with water users.

Acreage limitations were successfully evaded by use of leases (since only common "ownership" was mentioned in the Omnibus Adjustment Act of 1926) as well as by various multiple ownership subterfuges that allowed a single operator to control thousands of acres. These evasions continued largely because, at least in parts of the West, 160 acres was insufficient for a viable farming operation.

Congress provided a variety of exemptions for specific projects. For such projects, the acreage ceiling was raised beyond 160 acres (480 acres, San Luis Valley Project) or the limitation was removed altogether (Colorado-Big Thompson Project) on the rationale that since the lands were already irrigated, Reclamation water was merely "supplemental," and therefore the risk of land speculation was diminished. Another type of exemption allowed landowners to avoid the recordable contract provisions (limiting the resale price) by agreeing to pay interest charges on the repayment obligation for water delivered to excess lands (Washoe Project). Hardships for large landowners in the Imperial Irrigation District caused by the 160-acre limitation were also avoided by judicial interpretation: the Supreme Court held that the district was effectively exempted by the Boulder Canyon Project Act.[3]

Finally, Congress passed the Reclamation Reform Act of 1982 (RRA, Public Law 97-293), which increased the limit on owned land from 160 to 960 acres for most landowners and introduced the concept of paying full cost (an unsubsidized rate) in certain circumstances for Reclamation water. Land owned in excess of the applicable ownership entitlement is ineligible to receive Reclamation water. Districts that had an existing contract with Reclamation when the RRA was enacted were given a choice of amending their contracts to conform with the new limitation or to have become

[3] See Bryant v. Yellen, Supreme Court 1980.

ineligible to receive Reclamation water if it exceeded applicable ownership entitlements specified in the RRA.[4]

3. Authorities and Environmental Legislation

Water Law Conflicts

Federal Reclamation projects and its authorizing legislation may come into conflict with a variety of state water laws (e.g., area of origin protection statues or preference statutes). Like the Federal Power Act, the Reclamation Act of 1902 contains provisions that appear to require Federal compliance with state law. Section 8 provides that the Reclamation Act is not to be construed as interfering with state laws "relating to the control, appropriation, use, or distribution of water used in irrigation […], and the Secretary of the Interior, in carrying out the provisions of this Act, shall proceed in conformity with such laws." Despite its broad language, the provision does not allow state law to override specific conflicting provisions of Reclamation law or legislation authorizing a particular project.

The Clean Water Act

The Clean Water Act of 1972 replaced ineffective state regulation of pollution with a comprehensive national system involving Federal and state sharing of responsibilities (33 U.S.C. §§ 1251-1376). The goal of the Act was to eliminate discharge of pollutants by 1985 and to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" with an interim goal of swimmable, fishable waters by 1983. The Act allows enforcement by citizen suits, provides for monitoring and record keeping, and subjects violators to criminal penalties and loss of government funding.[5]

Impact on State-Created Water Rights

Wallop Amendment

Concern with the potential effect of the Clean Water Act of 1972 on water uses led to the inclusion of language protecting established water rights. The Wallop Amendment, § 101(g), is a statement of congressional policy that abrogates, supersedes, or impairs state authority over water allocation or

[4] Several districts in California's Central Valley challenged this "hammer clause" as unconstitutional, arguing that it violates the due process provided by the Fifth Amendment. The Ninth Circuit ruled that there was no violation. It held that congressional silence concerning water service to owned or leased lands conferred no vested right on the districts; such a right would be in conflict with the purpose of the Reclamation Act of 1902. Further, it held that Congress had never surrendered its sovereign right to regulate the quantity of subsidized water provided by the government (Peterson V. U.S. Department of Interior, 9th Cir.1990).

[5] Pollution control standards under the Act are of two general types. Effluent standards limit the quantity of pollutants discharged from the source; ambient water quality standards limit the concentration of pollutants in the stream. Because it is often difficult to identify the exact source of pollution in applying water quality standards, the Clean Water Act utilizes effluent standards that are based on available control technology. The program's principal control mechanism is to place limits on discharge of pollutants from "point sources." The Act leaves non-point sources subject only to minimal controls, mostly through state programs that are not subject to any Federal standards.

rights of states to water (e.g., under interstate compacts). The amendment's purpose, however, is not to prohibit "legitimate water quality measures" that affect individual water rights only "incidentally."[6]

Regulatory Takings

Federal regulations that control the timing, quantity, or manner of water use often affect the value of water rights. Since the "property" is no more than a right to use the water for a defined beneficial purpose, government interference with a water right holder's ability to make such a use requires just compensation under the Takings Clause of the Clean Water Act. Examples of Federal requirements under the Clean Water Act that may affect water use include water quality standards that demand releases of water to maintain flows to dilute pollutants or protect fisheries, conditions in the Clean Water Act § 404 permits necessary to satisfy public interest concerns of the U.S. Army Corps of Engineers, and prohibitions on diversions needed to protect critical habitat for an endangered species.

Effects on Common Law Remedies

Section 505c of the Clean Water Act shall not restrict any statutory or common law rights to enforce effluent limitations "or to seek any other relief." Thus, remedies in nuisance and trespass may still be sought in state courts.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act requires Federal agencies sponsoring or issuing permits for water projects to consult with the U.S. Fish and Wildlife Service "with a view to the conservation of wildlife resources" and requires mitigation measures to minimize adverse impacts.

Wild and Scenic Rivers Act

The purpose of the Wild and Scenic Rivers Act is to preserve, in a free-flowing condition, certain rivers possessing outstanding "scenic, recreational, geologic, fish and wildlife, historic, cultural, and other similar values." Congress may designate rivers and states may recommend rivers for inclusion in the Wild and Scenic Rivers System subject to approval by the Secretary of the Interior (or the Secretary of Agriculture if national forest lands are involved), who submits state and Federal recommendations to Congress. As of 2022, 226 rivers were included in the system and many more are under study.

The Wild and Scenic Rivers Act prohibits the Federal Energy Regulatory Commission from licensing water projects "on or directly affecting" rivers included in the system and provides interim protection for rivers under study by temporarily prohibiting project licensing on such rivers. One court has held that the prohibition applies only to Federal study recommendations, not to a state recommendation.[7]

International Treaties

Water or aquifers accessible to more than one country are of vital importance to countries who share water with the U.S.. Historically, upstream nations, e.g., the U.S., have sought to control waters originating in their territory. The doctrine of "absolute territorial sovereignty," however, has given

[6] Riverside Irrigation District v. Andres, 10th Cir. 1985.
[7] North Carolina v. Federal Power Commission, 533 R.2d 702 (D.C. Circuit 1976).

way to collaboration with neighboring nations in the interest of global cooperation. Today, treaties and doctrines of limited territorial sovereignty and equitable apportionment govern the resolution of international water disputes, but the U.S. recognizes its role as a global leader in promoting community interests regardless of national origin.

The U.S. has several water treaties with Canada, including the 1909 Boundary Water Treaty, the Lake of the Woods Treaty, the Saint Lawrence Treaty, and the Columbia River Treaty. Also, Treaties with Mexico include the 1906 Irrigation Convention and the 1944 Colorado River Treaty. Once the Federal government enters into a treaty with another nation, it is the "Supreme Law of the Land" under the Constitution and any inconsistent state laws are preempted. Thus, treaties affect the manner and extent to which state-defined rights may be exercised.

Treaties and Minutes with Mexico

The U.S. and Mexico entered into the Mexican Treaty of 1944 to allocate the waters of the Lower Colorado River. The U.S., an upstream nation, initially relied on the "Harmon Doctrine," which is based on the theory of absolute territorial sovereignty. However, pressures from Mexico to receive a share of water from the river grew as uses in Mexico increased. The 1922 Colorado River Compact between the seven states diverting water from the Colorado River for beneficial use requires the upper and lower basin states to contribute equally to supplying any future obligation to deliver water to Mexico.

The 1944 treaty with Mexico allocated a guaranteed annual flow of 1.5 million acre feet of Colorado River water to Mexico; although, in the event of severe drought in the U.S., the amount delivered can be reduced. The treaty is administered by an international commission. Notably, the treaty had no language regarding water quality. Over time, upstream development caused the river's salinity to increase as more water was consumed and large dams and storage reservoirs were created. Less water in the river meant greater evaporation from storage reservoirs and increased concentrations of salinity. Irrigators added to the problem by returning waters with high concentrations of dissolved solids.

It was not until 1967 when the Wellton-Mohawk Irrigation District in Arizona began pumping drainage water from beneath its lands, thereby releasing highly concentrated salt water into the Colorado River just north of Mexico, that Mexico protested the U.S. To address the problem, the U.S. and Mexico negotiated a series of interim agreements where the U.S. consented to undertake salinity abatement measures. The final agreement, Minute 242 of the International Boundary Waters Commission, places a ceiling on the increase in the river's salinity below Imperial Dam.

The Federal government assumed responsibility for meeting the salinity obligations of Minute 242. This is addressed by Federal salinity abatement projects such as bypassing the Wellton-Mohawk return flows, a huge desalination plant, and construction projects that intercept various natural and humanmade sources of salt. These Federal projects are, in effect, an "insurance policy" against development constraints being imposed on the Colorado River basin states by the salinity control obligation.[8]

[8] However, many water problems with Mexico remain unsettled. For instance, there is currently no system for dividing transboundary groundwater. As unregulated pumping continues, border cities such as El Paso and Juarez find themselves competing for dwindling supplies. Minute 261 was negotiated to give the International Boundary Waters commission increased authority over water quality in the border region.

Supremacy of Treaties Over State Water Law

Article 1, Sections 8 and 9 of the U.S. Constitution gives the President power to enter into treaties with the advice and consent of the Senate. State water law cannot supersede international treaties. For example, in Sanitary District of Chicago v. U.S., 266 U.S. 405 (1925). the Court enjoined the City of Chicago from diverting water out of Lake Michigan because the diversions lowered the water level of the lake and were in excess of that allowed under the 1909 Boundary Waters Treaty with Canada.

4. Water Service and Supply Organizations

The public water supplier who provides water for domestic, municipal, and industrial uses is the most widely known entity involved in supplying water. These can include privately held corporations. Most private water corporations are investor owned, and a few are "mutuals" owned by the water users who own shares in the water company and receive an equal distribution of the water held by the mutual. Water companies are usually public utilities regulated by a state agency. The water utility companies, and not their customers, are holders of the water rights. In the Eastern States, where riparian rights prevail, it was necessary to pass special laws granting authority to companies and even municipalities selling water to their residents to take water for use on non-riparian lands.

Although nearly 350 million people reside and are served by domestic water service utilities, the organizations and agencies that distribute the largest quantity of water are those supplying agricultural irrigation water in the West. Some also l supply water for municipal and industrial purposes.

The scarcity of available water was a barrier to settlement of the arid West. The first public lands colonized were near streams where water was readily accessible for mining and agriculture. The 1886 Mining Act validated the use of public land facilities to transport water to more distant lands. However, the construction, operation, and maintenance costs became unsustainable, leading to crude, inefficient ditches unable to support increased uses. Bringing water over considerable distances required cooperative effort for those unable to pay the cost of building their own ditches. A main canal could be constructed with lateral ditches to distribute water to several farmers, and storage facilities assured availability of water during times of limited supply and high demand.

The early settlers' enterprises evolved into a variety of organizations that deliver water.[9] The earliest settlers to accept and use cooperative methods were the Mormon pioneers in Utah; their strong social organization facilitated successful irrigated agriculture in the dry Utah Territory.

Water users' organizations can be divided into public and private entities. Private water distribution companies include for-profit "carrier ditch companies" and water utilities and non-profit "mutual

[9] For example, the Pueblo Indians and the early Spanish settlements of the Southwest used communal ditches to irrigate their lands, providing models for cooperative irrigation efforts. Some of these ancient community ditches, known as "acequias," still operate today in New Mexico. At first, many individualistic settlers resisted organizing sufficiently to build large facilities, and such efforts failed.

companies." Private companies are usually organized as corporations but may take other business forms. Few irrigation water supply organizations are totally private for-profit companies.

Public water organizations are divided into regulatory bodies, such as groundwater management districts, that engage in administration of water laws and conservation planning; or water supply organizations, such as irrigation and conservancy districts, who formed primarily to raise revenue to construct and operate irrigation projects. Some public water suppliers' contract with the Federal government to administer government-financed Reclamation projects.

Private Organizations

Water Utilities

Water utilities are private companies having rights to take water and divert, store, and distribute it to customers by means of owned facilities. They may be corporations, partnerships, or sole proprietorships. The water is usually sold as a commodity. Many Western States (e.g., Colorado) consider the water to be the property of the state and the company's charges to be for the service of water delivery. Water companies are made public water suppliers by statute in nearly every state. In exchange for an exclusive franchise or monopoly to serve an area, they are subjected to public regulation by a state commission, board, or municipal government. Typical regulations require delivery of water to all within a defined service area, non-discrimination among users, and submission of major transactions (e.g., sale of assets, mergers, dissolutions, or acquisitions) for approval. The most significant form of control is rate regulation. As with other types of utilities (e.g., electric, telephone, gas), rates are fixed to allow a reasonable profit. A consumer owns no water right as such, but has rights defined under state public utility law (Getches, 420-421).

Mutual Water Companies

Mutual water companies exist to serve their shareholders. Some states regulate them as public utilities, but most do not. As nonprofit corporations or associations owned by the water users themselves, regulation is less necessary. Mutuals are not usually permitted to sell water to other than their own shareholders themselves, the distribution of water being proportional to the shareholders' share(s) of stock (Getches, 421).

Carrier Ditch Companies

Private, for-profit companies, known as carrier ditch companies, achieved an early popularity during settlement of the West. Carrier ditch companies backed by profit seeking investors financed construction of irrigation works to deliver water to which individual users held rights. Nearly all such companies failed either because of infeasibility or because projected uses did not materialize as farmers opted for "free" groundwater or chose to do dry-land farming rather than pay for water delivery. Many of these companies were subsequently reorganized as irrigation districts or non-profit mutual ditch companies. Investors recouped some of their money by selling their ownership interests to these entities. A few carrier ditch companies still operate in Arizona and Texas. elsewhere (Getches, 421-422).

Mutual Ditch and Irrigation Companies

Irrigation companies provided a means for organizing water users, usually as corporations, to finance and maintain facilities to transport, store, and distribute water to shareholders. As nonprofit organizations, the companies are typically tax exempt (Getches, 422).

Formation of mutual ditch (or irrigation) companies was authorized by special state laws as early as the 1860s.[10] Mutuals were formed in several ways, including: by holders of water rights who transferred their rights to the newly formed companies in exchange for stock; by joint owners of the ditch who traded their interest for stock, expanded the facilities, and sold stock to others; by land developers who conveyed a share of stock along with each acre sold; and by local water users after bankruptcy of for-profit companies serving the area. Thus, shares of mutuals may not be considered subject to state securities laws since they are essentially a contractual arrangement among shareholders for distribution and use of jointly owned water rather than a medium of investment in an entity organized for profit (Getches, 422).[11]

Financing

Irrigation companies secure revenue almost exclusively from water users (i.e., by user fees and stock assessments), but some issue bonds secured by irrigation works or shareholders' lands. Assessments of stock (to pay operating costs and bond amortization) may be enforced by withholding water for non-payment (Getches, 422).[12]

Ownership of Rights

Irrigation companies typically issue shares of stock that represent the quantum of the shareholder's right to review water. There is no obligation to serve members of the public in the service area that are not shareholders in the company. The company holds legal title to the water rights and represents its users against other appropriators, but each shareholder is beneficial owner of the individual water rights evidenced by the shares (Getches, 422).

Transfers

Holding water rights as shares of ditch company stock facilitates transfers. Stock issuance may have to comply with Federal securities laws and state blue-sky laws. The Uniform Stock Transfer Act provides that transfer of title to shares requires either personal delivery by the owner or a written power of attorney. Stock in mutual companies is commonly considered appurtenant to the land described on the face of the stock certificate. In fact, no paper shares exist in some small companies because "shares" simply pass with the land. Contrary presumptions may be imposed statute.[13]

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[10] A number of private irrigation corporations were formed under the 1894 Carey Act, 43 U.S.C.A.SS 641, which awarded one million acres of arid Federal lands to any Western state that would cause the land to be irrigated and settled. Often this was done by encouraging formation of companies to build irrigation works. The lands were then sold by the state to individuals who bought shares in a mutual ditch or irrigation company formed to operate the irrigation works. Like carrier companies, many Carey Act corporations failed because they could not repay capital costs; some reorganized as irrigation districts (Getches, 422).

[11] Bylaws usually restrict the shareholders to asserting and changing their water rights though the company (East Jordan Irrigation Co. v. Morgan, Utah 1993).

[12] See Henderson v. Kirby Ditch Co., Wyo. 1962.

[13] Recently, the Utah Supreme Court determined that in the absence of explicit severance of the water share, it is presumed to transfer with the land based upon the requirement that water must be put to beneficial use.

Priorities

As a rule, no priorities exist among shareholders with a proportionate interest in the same water supply even when supplies are insufficient for all users. But if users convey rights to a mutual company with different priority dates, the company can issue different classes of stock related to the priorities and with different burdens and privileges.[14]

Regulation

A company may be treated as a public utility subject to regulation. This usually results if water service is provided to those other than shareholders (Getches, 422).[15]

Public Organizations

Regulatory and Planning Bodies

Limited public entities regulate present water uses and others plan for future uses. Types and activities of such regulatory bodies vary from state to state (Getches, 422).[16]

Municipalities

Laws of most states recognize the authority of cities to distribute water to their residents. State statutes or constitutions often authorize municipalities to avoid certain restraints in water law to carry out their water service responsibilities. For example, riparian states may allow municipalities (which are not riparian) to obtain and use rights to water on non-riparian lands; in appropriation jurisdictions, municipalities may be able to appropriate water in ways and for purposes not available to other users. A municipality that serves its citizens generally may be considered a public utility subject to regulation.[17] A city can deny or withhold water service on grounds reasonably related to public health and safety. Refusal to serve must not be arbitrary or malicious (Getches, 422).[18]

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[14] A holder of shares evidencing a high priority may be assessed at a higher rate because the high priority confers greater benefits (Robinson v. Booth-Orchard Grove Ditch Co., Colo. 1934) (Getches, 422).

[15]As an example, Yucaipa Water Co. No. 1 V. Public Utilities Comm'n (Cal. 1960) (company delivered water to lessees of shares of stock).

[16] As an example, the Colorado Water Quality Control Commission promulgates water quality standards under the Colorado Water Pollution Control Act and assists in administering water pollution control measures. The Water Conservation Board engages in joint Federal-state water project and water use planning and engages in financing public and private irrigation projects. The Groundwater Commission determines rights and regulates water use in designated basins. Groundwater management districts may be formed (having both use-regulation and taxing powers) to assist the Groundwater Commission in regulating groundwater use.

[17] Under many state laws, however, municipalities are exempted from public utility regulation, even when they may be serving consumers beyond municipal boundaries (Board of County Comm'rs of Arapahoe County v. Denver Bd. Of Water Comm'rs, Colo. 1986) (city is a public utility but is statutorily exempt from Public Utilities Commission regulation) (Getches, 422).

[18] If it is not rationally related to the public entity's legitimate interests (such as limited supply), denial of service that leaves land with no economically viable use could theoretically result in a regulatory taking of property that is compensable under the Constitution (Lockary v. Kayfetz, 9th Circuit 1990; State legislation could not limit city's constitutional powers by restricting condemnation of water rights to those needed for 15 years in the future) (Thornton v. Farmers Reservoir & irrigation Co., Colorado 1978).

Irrigation Districts

Irrigation districts exist under several names, including conservancy district, conservation district, reclamation district, water control district, and fresh water supply district. Although they have many different organizational forms and powers, the distribution of irrigation water is common to each. Some also perform functions such as electric power generation, drainage, and flood control. Irrigation districts are formed under special provisions of state law and enjoy a governmental or quasi-governmental status (Getches, 422).[19]

Formation of Districts

Beginning with California's Wright Act in 1887, all Western States passed laws authorizing formation of irrigation districts. The statutes define the organizational form, powers, and purposes of the districts. Typically, they provide for formation upon petition of local landowners or electors. The petition sometimes can be acted upon by a state court after a hearing; often, an election is required. Some types of districts may be formed by acts of legislature without voter or landowner consent (Getches, 422).

Benefits of Districts

Possessing power to levy assessments against all property within their boundaries, irrigation districts historically provided an effective way to finance irrigation works. They helped solve problems of capital formation that had beset agriculture in much of the arid West. However, where a district is formed for a governmental purpose such as irrigation supply and then engages in other economic activities, it may lose tax exempt status. A water district (or city) may also lack governmental immunity from suit on the ground that water supply is essentially a proprietary role (Getches, 422).

Ownership of Water Rights

Irrigation districts, not their constituents, own the water rights they exercise. The water rights are property rights. The users' rights are essentially contractual (Getches, 422).[20]

Financial Details

Irrigation districts may be empowered to raise revenues by assessing property, imposing taxes, charging users for water, and marketing other services. Revenue raising powers of districts depend on the state laws that authorize their creation.[21] State laws may allow assessments to be levied upon all land or upon land classifications (e.g., tract size or type of soil). Bonds may be issued by virtually all irrigation districts. It is this governmental authority that led to the formation of most early districts (Getches, 422).[22]

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[19] Irrigation districts distribute about half of all water used in the West, giving them economic power and political influence.

[20] See Bryant v. Yellen, Supreme Court 1980, Boulder Canyon Project Act requiring satisfaction of "present perfected rights" preserved individual users' rights under state law.

[21] For instance, in Colorado "conservancy districts" may tax all lands in their boundaries, but "irrigation districts" are limited to taxing irrigable lands. It is not necessary that taxes be in proportion to the benefits received (Millis v. Board of County Commissioners of Larimer County, Colorado 1981).

[22] See Sullivan v. Blakesley, Wyoming 1926)

Functions

Although irrigation districts began as rather simple organizations whose sole purpose was to deliver irrigation water, many districts today are involved in other activities such as hydroelectric power generation, operation of recreation facilities, draining, flood control, sanitation, and municipal and industrial water supply. An example is the Salt River Project Agricultural Improvement and Power District, which serves metropolitan Phoenix, Arizona, and derives 98 percent of its total revenue from power sales. Mixed and multiple use purposes complicate administration of irrigation districts and may lead to conflicts among different constituencies (Getches, 422).

Municipal Water Districts

Some states authorize creation of several special types of districts that deal with problems of procuring water supply not necessarily related to irrigation. They are akin to "irrigation districts" that develop and transport to several water companies, municipalities, and large consumers. California has passed enabling legislation for the creation of special districts, known as municipal water districts and replenishment districts, to manage imported surface waters and local groundwater resources by administrating rights determined in basin-wide adjudications, controlling pumping to safe annual yield rates, importing supplies, and preventing saltwater intrusion (Getches, 422).

5. Water Rights and Data

Administrative/Legal Details

Every state has unique procedures for recognizing and administering water rights that require different measures from one state to the next for monitoring and protecting those rights. A water right or permit is a right to divert (remove from its natural source) and beneficially use water. Reclamation water rights or permits core table data elements only include the original state-assigned identification symbol, priority date, filing date, legal status, and original type of record.[23] To perfect a legal right in the water, the user must show that the use amounted to an appropriation. The three elements – diversion, intent, beneficial use – were designed to prevent fraud. A water right once manifested in a permit or decree is rarely disturbed. Change of place or purpose of use or of point of diversion requires permission by an agency or court. No change in use may be made if it results in harm to other appropriators.

Water User (Owner) Data

Appropriation of water began several years before statehood in most Western states. Miners developed customs and rules for water appropriation, which led to procedural customs of the prior appropriation doctrine later incorporated into the common law of water rights by the early territorial and state court systems. A miner's right to get water depended upon two acts: posting notice at the point of diversion and diverting the water to apply it to a beneficial use.

[23] See Data Card Appendix – Water Right Core, for more information on the data.

Reclamation water users' data is captured in the entity and business tables, where various metadata points are collected. The user's data helps support the water owners table where ownership as a percentage for a specific timeframe with a start and termination date is tracked for a specific user and water right. This design allows for multiple owners/entities to be associated with a single water rights or permit.[24] The general contact information collected is not personal identifiable information and is public record.[25]

Appropriations as Water Allocation Background Information

Typically, a water user only uses a portion of the total water diverted and returns the rest to the stream. Water rights are usually expressed as a maximum amount or rate of flow that may be diverted for a certain use on specific land. A right may also be limited by the amount that may be consumed. Within these limits, consumption may be increased by reuse so long as nothing occurs that constitutes a change of use – a change in the place, purpose, or time of use or the means or point of diversion.[26]

Therefore, an allocation is the amount or portion of water assigned to a particular owner who has diverted water for beneficial use. Water allocation is defined as the quantity of water allowed for diversion by flow rate cubic feet per second (CFS) and/or by volume acre-feet per year (AF) and the name of the source from which the appropriation is to be made.[27]

Diversion

A diversion is an alteration of part or all of a stream's flow away from its natural course. A common method of diversion is to build a dam across a stream, directing water into a canal or ditch. Water may be channeled farther into smaller ditches, each with a "headgate" that controls when and how much water is used in each of several parcels of land, often by several appropriators. Other methods of diverting water include reservoirs, flumes, pipes, pumps, and even water wheels (Getches, 93).[28,29]

Some state statutes set maximum time periods, often five years, for construction of facilities and application of water to beneficial use, subject to extension for good cause (e.g., Arizona, Idaho, Nevada, Oregon, Wyoming, and New Mexico allow four additional years after construction to use the water) (Getches, 93).[30]

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[24] See Data Card Appendix – Water Users Management for "Business Organization," for more information on the data.
[25] See Data Card Appendix – Water Rights User (Owner) Group, for more information on the data.
[26] An appropriator ordinarily may "recycle" irrigation return flows or capture seepage and use it within limits imposed by state law.
[27] See data card Appendix – Water Rights Allocation for table and field descriptions.
[28] Traditionally, a diversion had to be human made, but courts have forged numerous exceptions. Even in states adhering to a strict physical diversion requirement (e.g., California, Montana, New Mexico), exceptions are allowed for various water uses (Getches, 93).
[29] See data card Appendix Water Rights Allocation – Diversion for table and field descriptions.
[30] In Colorado, which does not have a permit system, an appropriator's priority date is generally the date of an application for a conditional right. But priorities can relate back to the first, open physical act toward appropriating water such as the date construction of diversion facilities commenced (City and County of Denver v. Sheriff, Colo. 1939) (Getches, 94).

Exceptions to the Diversion Requirement

Several states no longer require an actual, physical diversion from the stream; exceptions have been fashioned to meet policy considerations. A physical diversion from a stream may not be required if intent to appropriate to a beneficial use, notice to others, and actual application to a beneficial use are clearly established (Getches, 95).

Several states have embraced a trend allowing instream (in situ) appropriations of water.[31] In stream flows generally may be appropriated or reserved only by a state agency; although, the agency may act upon requests of private individuals, other state and local agencies, or the Federal government (Getches, 96).[32]

Priority and Dates

Priority is the essential feature of the doctrine of prior appropriation. A person whose appropriation is first in time (the prior appropriator) has the highest priority and hence a right to make beneficial use of water superior to all others. An appropriator with an earlier priority date is known as the senior when compared to a later appropriator, who is the junior. All water rights holders are ranked according to the dates of their appropriations. When there is not enough water for both senior and junior appropriators, the doctrine of priority allows the full senior right to be exercised before the junior can use any water. The first user to be limited is the most junior on the list of priorities; juniors must abate their use until everyone senior to them has been served.

The priority date may relate back to an earlier date when one first formulated the intent to appropriate or received a permit or decree for a planned future use. Thus, the doctrine protects priorities of early appropriators, providing an incentive for water users to invest in expensive diversion works by assuring them of legal protection for their water supply against juniors in times of shortage. Appropriators may build diversion works prematurely or unnecessarily.[33]

Enforcement of Priorities

Juniors may not deprive seniors of water in quantities, at times, at place, or of a quality necessary to support the seniors' use. However, this does not mean a senior can force the junior to stop taking water out of turn under all circumstances. A senior cannot enforce a water right if a junior can prove that the water would not be put to beneficial use by the senior or that water would not reach the senior in usual quantities.

Preferences

Many states have statutes or constitutional provisions that express a preference for certain types of water use over others. Typically, they rank uses according to the prevailing view of the relative importance of various uses at the time the preferences were established. Almost all reserve the highest use for domestic or municipal purposes. Although there are many variations, most put agricultural use second and industrial and mining third.

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[31] Even where the state constitution refers to water rights as "the right to divert," such state legislation has been upheld (Nebraska Game and Parks Commission v. 25 Corporation, Inc., Nebraska 1990).

[32] The Colorado statute allows rights to instream flow to be appropriated only by the state board, but others can obtain a water right that effectively protects flowing water by constructing facilities to control the stream without removing water (e.g., boat chute and fish ladder) (City of Thornton v. City of Fort Collins, Colorado 1992).

[33] See data card Appendix – Water Rights Core for table and field descriptions.

Water Subject to Appropriation and Water Sources

Private rights to use water cannot be acquired in all types of water. A state's constitution or statutes may define water subject to state jurisdiction and control in a way that excludes certain waters within the state from allocation of water rights to private parties.[34]

Watercourses

Once water joins a watercourse, it becomes subject to state control. A watercourse could be defined to include not only rivers and lakes, but every tiny brook flowing into them, all the gullies through which water flows to the brooks, the snowpack and rainfall that feed them, and the evaporating or transpiring water in the process of forming clouds.[35] The courts often define "watercourse" as a body of water flowing in a defined channel with a bed and banks.

Streams

A definite bed, bank, and channel are universal. The more arid the area, the more important a small flow will be and the greater the likelihood it will be found to be a watercourse in a close case.

Lakes and Ponds

The water of natural lakes and ponds ordinarily is subject to appropriation by state law. The right to appropriate water from such sources may be qualified by rights to use the surface (as distinguished from rights to consume water) that are recognized in littoral (lakeshore) landowners appurtenant to riparian land, even in prior appropriation states.

Springs

The treatment of spring water varies with the state in question and with the type of spring. The laws of some states (e.g., Oklahoma) consider a spring subject to appropriation even if the water would remain entirely on private property.

Waters Made Available by Human Effort

Sometimes water is in a natural stream at times and places in quantities other than what would occur in nature. This may be simply because irrigation return flows delay the seasonal decline of natural streamflow, or it may be the result of massive diversion from one watershed to another. The general rule is that water that would never be available in the stream except for human efforts can be used without restriction by the person responsible for its being there, and it is not subject to appropriation until that person abandons it.

Foreign and Developed Water

Imported or foreign water, e.g., from transbasin diversions, is not part of the stream and thus not subject to appropriation.[36]

Foreign water, unlike water subject to appropriation, is not subject to restrictions on recapture and reuse.[37]

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[34] See data card Appendix – Water Rights Water Source for table and field descriptions.
[35] Legal definitions are intended to define a point beyond which a state does not regulate water use.
[36] See City and County of Denver v. Fulton Irrigating Ditch Company, Colorado 1972.
[37] See Water Supply and Storage Company v. Curtis, Colorado 1987.

Salvaged Water Distinguished

Foreign or developed water would not naturally be in a stream but for human intervention. Salvaged water is recovered from existing uses or losses within the watershed. For instance, if seepage or evaporative losses are prevented by human effort, fuller use could be made of it. But it is not "new" to the stream as imported water is.

Withdrawals from Appropriation

Water in a natural water course can be removed from availability for some or all forms of appropriation by state action or Federal law to preserve it for some future use or for instream flows.[38]

Maintenance of Instream Flows

Protection of stream flows or lake levels for fish and wildlife, recreation, water quality, and scenic beauty is accomplished in two ways. The waters can be appropriated for instream uses or can be considered withdrawn from appropriation so that the instream flows are preserved from depletion by private appropriators.[39]

Beneficial Use

Beneficial use is said to be the basis, the measure, and the limit of the appropriator's right to use water.[40] Once an appropriator puts water to a use considered beneficial by state law, the right is perfected. The right becomes absolute and its priority in times of shortage will not be defeated by even more socially important, economically more valuable, or more efficient uses by a junior appropriator (Getches, 101).[41,42]

Table 1. Beneficial Uses Generalized by State Law.

	Domestic	Municipal	Irrigation / Agricultural	Industrial	Stock watering	Power	Mining	Recreation	Fish & Wildlife	Other
Alaska	X	X	X	X		X	X	X	X	Manufacturing, navigation, water quality
Arizona	X	X	X		X	X	X	X	X	Groundwater recharge
California	X	X	X	X	X	X	X	X	X	Water quality
Colorado	X	X	X	X				X	X	
Idaho*										

[38] See data card Appendix – Water Rights – Allocation Water Use for table and field descriptions.
[39] Statutes that remove waters from appropriation usually preserve all appropriations existing on the date of enactment. Extinguishing private rights would amount to the taking of private property for a public use and would require just compensation.
[40] Before development of modern administrative systems, an appropriator claimed a right to use a certain quantity of water. Usually, the only limit on the claim was the capacity of their diversion facilities (Fort Morgan Land & Canal Co. v. South Platte Ditch Co., Colo. 1892) (Getches, 118).
[41] Thus, a senior user applying vast quantities of water to the unprofitable production of rice in the desert might prevent a city with a junior right from receiving desperately needed water for domestic purposes (i.e., a highly profitable industry from taking the water that it requires).
[42] See data card Appendix – Water Rights – Beneficial Uses for table and field descriptions.

Kansas	X	X	X	X		X		X	X	
Montana	X	X	X	X	X	X	X	X	X	
Nebraska*										
Nevada*			X				X	X	X	State conservation purposes
New Mexico**										
North Dakota	X	X	X	X	X			X	X	
Oklahoma*										Not limited to these
Oregon	X	X	X	X		X	X	X	X	Pollution abatement
South Dakota***										
Texas	X	X	X	X	X	X	X	X	X	Parks, aquifer recharge, "any other beneficial use"
Utah*			X		X					
Washington*	X		X	X	X	X	X	X	X	Frost protection
Wyoming	X	X	X							

* No comprehensive definition by statute or case law.
** Case law defines beneficial use as the "the use of such water as may be necessary for some useful and beneficial purpose in connection with the land from which it is taken" (Erickson v. Mclean, 62 N.M. 264, 308 P2.d 983, 1957).
***Statute defines beneficial use as "any use of water within or outside of the state, that is reasonable and useful and beneficial to the appropriator, and at the same time is consistent with the interest of the public" (South Dakota Code Laws §46-1-6, 3).

Although in the past overclaimed use of water claims on a stream amounted to many times its total flow,[43] today the statutory systems of all states include administrative mechanisms for verifying amounts of water that are to be put to a beneficial use before rights are embodied in a permit or decree. Many systems provided for review of old rights and required persons claiming water rights to justify their claims before recognizing the rights in a new permit or decree (Getches, 119).[44]

Beneficial Use as a Limit

Appropriative rights extend only to beneficial use, and therefore there is no right to use water wastefully. State laws and court decisions interpret "beneficial use" as requiring that water use be "reasonable" or "reasonably efficient." Standards for reasonableness or efficiency change as the demand for scarce Western water grows and conservation technology improves, leading to stricter regulation (Getches, 120).

Permit Systems as Core Rights Type

All Western States have statutory systems to allocate and administer rights to use water. Every state but Colorado has vested authority in an administrative agency (Getches, 138).[45,]

[43] Only in extreme cases did a court find that an appropriator right exceeded beneficial use (State ex rel. Erickson v. McLean, N.m.1957; uncontrolled flooding of grazing lands for 24 hours a day is not a beneficial use).
[44] Adjudications of all existing rights throughout large watersheds are now underway in Arizona, Idaho, Montana, and Washington. They typically require holders of existing rights to prove their existing uses, and they apply standards intended to check inefficient use. All competing users may participate before the responsible agency or court and object to appropriations of excessive quantities of water (Getches, 119).
[45] Colorado has a judicial system whose function is similar to agencies in other states. See data card Appendix – Water Rights Core and Attribute Rights Type for table and field descriptions.

Source of Authority

The authority to enact and enforce permit systems is rooted in the broad police power of the state. Water is usually subjected to public control by state statues or constitution. Water users have challenged the mixed executive and judicial role of agencies. Although the state's interest may be expressed in property terms, it is not one of ownership but of sovereignty.

Permitting Procedures

The first permit system was adopted by Wyoming in 1890. All appropriation states except Colorado have statutes requiring permits to appropriate water (Getches, 141).[46]

Filing

In all permit states, a formal written application for a permit to take appropriated water must be made to the state engineer or an administrative body.[47] The time of filing generally becomes the priority date if all later requirements are met (Getches, 142).

Notice

Typically, a notice of filing the application must be published and efforts must be made to contact all affected parties, who have a fixed time in which to file objections. Objections are to be based on an allegation that statutory criteria for issuance of a permit are lacking (Getches, 142).[48]

Hearing

The administrative agency holds a public hearing on properly file objections, serving notice of the hearing to the applicant and objector. The state engineer or equivalent official investigates factual data upon which the agency relies and reports to the agency on whether the statutory criteria were satisfied. The agency then approves, disapproves, or approves with modification the permit application. The applicant has a right to due process, i.e., to present any pertinent evidence. The agency's findings may then be appealed to the courts (Getches, 142).

Issuance of Permit

The next stage of the process is issuance of a permit. A permit is not a water right but will ripen into one if all conditions are met. During a stipulated time period, the permittee is required to construct diversion works, make a diversion, and apply water to a beneficial use. The application to beneficial use is the act that causes a water right to vest; the priority will then relate back to the act of filing. Typical permit conditions include compliance with the time periods stipulated and "due diligence" in completing a diversion project. All states allow extensions of time limits for cause.

Statutory Criteria

The permit procedures discussed above are to determine whether certain criteria set forth in the statute have been satisfied. In Montana, the criteria require evidence of:

a) A beneficial use;

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[46] The Wyoming Act divided the state into four water divisions and established the Office of State Engineer to collect stream records, make surveys, and provide staff support to the Board of Control.

[47] This is almost always the exclusive way to obtain a water right and must be done before any physical act such as digging a diversion ditch.

[48] See data card Appendix – Water Rights Folio and Attribute Document Type for table and field descriptions.

b) Availability of unappropriated water at the time and period of use;
c) No harm to prior appropriators;
d) Adequate diversion facilities; and
e) No interference with reservations of water for future use or other planned uses.

On many streams, rights to divert water far exceed the quantity of water flowing in the stream. This is a result of two phenomena: (1) many users depend on the same water, as downstream users divert water that has already been diverted and returned by upstream users; and (2) the most junior rights may be exercisable only in years of heavy flow or low senior usage.

Public Interest Considerations

The laws of most states authorize the agency to reject or condition applications not consistent with the public interest or public welfare.[49]

Adjudication

There are three general types of judicial procedures affecting water rights.

General Stream Adjudications

All states have adopted procedures for adjudicating the competing rights of all water users in a particular stream system. All persons claiming water rights in the system typically must be joined as parties.[50]

Validation or Review of Agency Permit Decisions

Once an official or agency makes a determination, it is final unless someone appeals. Appeals first go to another level before proceeding to court. In most states, the court engages in a trial de novo, but most appeals are based on the administrative record. Decisions of an administrative agency are subject to judicial review either on appeal or as a required step in the process.

Conflicts Among Water Users

One or more water users may sue other water users who allegedly violate their water rights. The decision generally binds only those who are parties. Administrative bodies in some states may have authority to resolve conflicts between individual water users.

Regulation of Water Distribution

An administrative agency usually enforces established rights based on the relative priorities of appropriations. The manner in which appropriators use water is also subject to regulatory and administrative controls (Getches, 151).

Transfers and Exchanges of Water Rights

Appropriative water rights may be transferred among water users subject to certain state law limitations. Transfer of water rights along with land is a routine matter. Water rights in most states

[49] Example, the New Mexico state engineer rejected an application for a proposed irrigation project that seemed too large for the available water supply and thus might result in high costs and uncertain supplies for those who bought land and the accompanying water rights. (Getches, 150)

[50] In some states, judicial proceedings may be initiated by the users, in others by a state agency and in some states by either users or an agency.

pass with the land upon its conveyance, unless otherwise provided in the conveyance.[51] Water rights, however, may effectively be made non-severable by statute or severance may be allowed with conditions to protect other users (Getches, 155).[52]

Transfers for uses in locations, for different purposes, at different times, or involving changes in the points of diversion or return are more complicated, requiring protection of junior water rights under the "no harm" rule (Getches, 155). Agriculture requires vastly larger quantities of water than municipal and industrial uses. Typically, early priority of irrigation rights makes them especially desirable. Municipalities can temporarily lease rights they hold for anticipated future needs to others.

Transfers Generally

A transfer of water rights may be made by sale, lease, or exchange. A transfer, of course, may not exceed the quantity of rights held by the transferor. It may or may not be accompanied by a change of use (e.g., a different place or purpose of use).[53]

State Restrictions on Transfers Apart from the Land

Some states restrict transfers for uses away from the land (Montana, Oklahoma, Nebraska, Nevada, South Dakota, and Wyoming). Arizona, Kansas, and North Dakota experimented with non-severance statutes but later repealed them. Laws restraining transfers apart from the land are based on the riparian-type notion that a water right is appurtenant. A likely motive for the laws was to prevent appropriators from making claims to water in amounts well beyond the quantity that could be used beneficially on theirs lands and then selling the early priority water right to others.

Restrictions on Transbasin Diversions

Removing water from one watershed to be used in another, variously known as transbasin diversion or interbasin transfer, is generally permitted under the prior appropriation doctrine.[54] A variety of state laws limit transbasin diversions by placing certain requirements on the diverter to protect the equities and interests of the area of origin.

Changes in Use

No Harm Rule

Whenever one seeks to change the point of diversion or the place, purpose, or time of using a water right, whether a transfer of the rights is involved, special protections against harm to other appropriators apply.

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[51] And when land is divided, a pro rata portion of water rights may accompany each parcel (Stephens v. Burton, 1976). In Colorado, the intention of grantor determines whether water rights pass with the deed to land (Bessemer Irrigating Ditch Co. V. Woolley, Colorado 1904).

[52] See data card Appendix – Water Rights Associated and Superseding Water Rights and Owners Group for table and field descriptions.

[53] For example, if farmland is conveyed along with appurtenant water rights, there may be no change in the purpose, time, or place of use, or in the point of diversion or return. However, when water rights are converted separately (or where the original owner intends a different use), any or all of the above use characteristics may change, thus affecting the rights of other stream appropriators and triggering procedures for determining whether harm to others is sufficient to disallow a change of use.

[54] The seminal case of Coffin v. Left Hand Ditch Co. (Colorado 1882) involved a diversion of water out of the basin of its origin. The recognized appropriation doctrine is fundamentally different from the doctrine of riparian rights in that it allows such diversions.

An appropriator who seeks to change a use or to transfer a right to another for a changed use must apply to the appropriate administrative body or court for approval.[55]

Procedures

An appropriator who wishes to make a change in use or transfer a water right to another who will use the right differently must seek permission for the change. In permit jurisdictions, the decision whether a change in use will be allowed rests with a state administrative agency such as the office of the state engineer. Administrative decisions are subject to review by state courts.[56]

Type of Changes

A change in use may take several forms, each with its own potential for harm to other appropriators. Changes may be made in the point of diversion (or point of return), in the place of use (or place of storage), in the purpose of use (e.g., irrigation or municipal), or in the time of use (e.g., seasonal or intermittent or continuous).

Change in Point of Diversion

One of the most common types of changes in use is a change in the point of diversion (which may be accompanied by a change in the place of water use). An irrigator may want to divert through a new ditch or use a surface diversion instead of a well drawing on the same water source.[57]

Change in Place of Use

A change in place of use must not increase consumptive use even if the amount diverted remains the same. Changes in place of use often change the place or timing of return flows from irrigation. Changing to out of basin uses will yield no return flows, making the new use 100% consumptive.[58]

Change in Place of Storage

A change in the place of storage, such as an alternative reservoir site, is a type of change in the place of use.[59] Uses that involve a change from direct use to storage may affect both the timing of usage and amount of consumptive use.[60]

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[55] Changes in use may affect stream conditions upon which other appropriators depend for their beneficial uses. Of course, a junior appropriator may do nothing to impair a senior appropriator's prior rights to water, but juniors are also protected from changes made by seniors. The doctrine of prior appropriation recognizes a right of junior appropriators "in the continuation of stream conditions as they existed at time of their respective appropriations" (Farmers Highline Canal & Reservoir Co. v. City of Golden, Colorado 1954).

[56] In either type of jurisdiction, the main substantive issue in the change of use proceeding is whether the change violates the no harm rule.

[57] See data card Appendix – Water Rights Allocation – Diversion for table and field descriptions.

[58] See data card Appendix – Water Rights Allocation – Water Use for table and field descriptions.

[59] The change may be permitted if the new reservoir is at a higher elevation with lower losses than the original site (Lindsey v. McClure, 10th Circuit 1943). But increased seepage and evaporation loss could harm juniors. Uses that involve a ration loss could also harm juniors.

[60] See data card Appendix – Water Rights Allocation – Storage for table and field descriptions.

Exchange Statutes in several Western states (including New Mexico, Colorado, and Utah) authorize agreements between water users (i.e., to furnish water at one point in the stream and withdraw at another).[61]

Change in Purpose of Use

A change in purpose of use typically involves change from irrigation use to municipal or industrial uses. Municipal uses are among the most consumptive since returns (usually sewage effluent) are a small percentage of the quantity diverted. Hydroelectric power generation and cooling are less consumptive than irrigation.[62]

The purpose of use (e.g., agriculture) is not changed if water is used in a new manner for the same purpose in the same place. Planting crops that consume more water or using different facilities to irrigate (e.g., sprinklers instead of flood irrigation) are not usually considered changes in the purpose, although the manner of use is different and others may be harmed (e.g., by a reduction in seepage or elimination of return flows resulting from reduced application or increased consumption).[63] The prevailing rule remains changes in the purpose of use that necessitate permission of an administrative agency or court and invocation of the no harm rule occur only when water is put to a different type of beneficial use.

Priority of Reserved Rights is how the Federal Government obtains a water right with a priority as of the date a reservation is established by the date of the statute, executive order, agreement, or treaty setting aside the reservation. Private rights existing on a stream when a reservation is established are superior to the reserved rights of the Federal government; Federal reserved rights are superior only to subsequently established private rights.[64,65]

Change in Time of Use

A change in the timing of use can harm others. For example, irrigation water rights are seasonal (used only during the irrigation season), although municipal and industrial uses are typically year-round uses. Similarly, a storage water right may permit constant diversion into the reservoir although actual uses are intermittent. A direct flow right is occasional, occurring only when there are present uses. A change in the timing of return flows is also a possible source of harm. The slow-moving character of seepage returning to the stream provides a form of "transient storage" that may furnish last season return flows to juniors (thus extending the irrigation season).

Change in Point of Return

The quantity of water subject to Federal or Indian reserved rights is limited to the quantity necessary to fulfil the purposes of reserved rights. However special base cases exist like once Indian Reserved

[61] Exchanges are changes in the manner and place of use that are subject to the no harm rule (Almo Water Company v. Darrington, Idaho 1972.

[62] Thus, changes from irrigation to municipal use (City of Westminster v. Church, Colorado 1968) or from power generation to irrigation use (Hutchinson v. Stricklin, Oregon 1933) may increase consumption.

[63] This seems like a loophole in the no harm rule, but it is built on traditional assumptions of water users, especially irrigators, that they should be able to plant whatever they want and irrigate as necessary so long as the amount used does not exceed the amount allowed by a permit or decree.

[64] This greatly limits the Federal government's rights for newer reservations on heavily or fully appropriated streams.

[65] See data card Appendix – Water Rights Allocation and Beneficial Use for table and field descriptions.

water rights have been quantified, the water may be put to use for other purposes than the original intended purpose and use that the water was quantified under.[66]

Limits on Changed Use

A change in use will not be denied or enjoined if conditions can be imposed sufficient to protect junior appropriators from harm. To assure maintenance of stream conditions on which others are entitled may necessitate restricting the new use.

Historical Consumptive Use

A common restriction placed on a change in use is that the new use must be limited to historical consumptive use or as reasonably necessary. Actual historical use may be shown by records of the amount of water diverted and the amount of water returned if they exist.

Permitted or Decrees Diversion Right

The amount diverted can never exceed the diversion right stated in a permit or decree. This is true even if a change in use would result in no greater consumption. If the historical consumptive use of a decreed right of 200 cfs was 100 cfs (50% consumptive), the new use is only 40% efficient; however, the new user will, in fact, only be able to use 80 cfs (200 cfs x 40% consumption).

Other Restrictions

It may be necessary to restrict a new use to less than historical consumptive use. For instance, in a change in point of diversion, the no harm rule may dictate further curtailment to assure that the same amount of water reaches those who depend on it.

Loss of Water Rights

Water rights acquired by prior appropriation may be lost if they are not used. The statutes or applicable doctrines in most states provide that nonuse for a time coupled with intent to relinquish constitutes abandonment.[67] Appropriative water rights generally may not be lost by prescription because any water not used by appropriators in priority belongs to the stream, to be used for the satisfaction of rights of existing appropriators and for new appropriations.[68]

Abandonment

Rights to use water established by prior appropriation will be abandoned and lost if they are not used for an extended time. However, simple nonuse is not enough for abandonment. One must intend to abandon the rights (Beaver Park Water, Inc. v. Victor, Colorado 1982).

Forfeiture

Forfeiture, unlike abandonment, does not require that the appropriator intend to abandon water rights by nonuse. Involuntary loss of all or a portion of one's water rights is triggered simply by nonuse for a period set by statute. Statutes that declare water rights "abandoned" without any requirement of intent are effectively forfeiture statutes. The burden of proving nonuse is on the state

[66] For example, the Indian reservations along the Colorado River are entitled to certain quantities of water based upon their irrigable acreage. But the tribes may apply the water allocated to them to industrial purposes (Arizona v. California Supreme Court., 1979).
[67] Some states require forfeiture of rights for nonuse in spite of the appropriator's contrary intent.
[68] See data card Appendix – Water Rights Core and Attribute Status for table and field descriptions.

(or other party) asserting forfeiture and may be found where evidence is inadequate to prove intent to abandon (Jenkins v. State Department of Water Resources, Idaho 1982).[69] Generally, forfeiture requires a party file in a court who has jurisdiction to order a forfeiture and the case progresses like any other civil case. Self-help is not available to any party to claim forfeited water.

Adverse Possession

One may obtain another's rights in real property by taking actual, open, notorious, and hostile exclusive possession of the property. A few courts have ruled that a junior appropriator could adversely possess a senior's priority (e.g., Idaho, Montana, and Utah). However, rights held by prior appropriation generally cannot be lost to others by adverse possession.

A junior appropriator who takes water to the detriment of a senior appropriator for an extended period may build a case for the senior's abandonment of the right. If nothing is done to prevent the junior's use, a court might find that the senior intended to give up the right. But the better view is that the junior would not take the senior's priority; at best, the junior could establish a new appropriation in the abandonment water with a priority date no earlier than commencement of the junior's use. Adverse possession does not always apply, such as in Utah, where it only applies to water rights acquired by adverse possession where the seven-year possession period was completed prior to 1939. See Otter Creek Reservoir Co. v. New Escalante Irrigation Co., 203 P.3d 1015 (2009).

Access to Water Sources

Rights of ways for ditches, canals, and pipelines are of critical importance to both individual and corporate water users. Because most irrigated land does not border on a stream, bringing water to a tract may require building facilities on the land of one or more property owners. Even if land is adjacent to a stream, some use of another's land may be necessary in order to use a gravity flow pipe or ditch that must follow contours of the terrain. Both Federal and state governments have acted to facilitate acquisition of rights-of-way across public and private lands.

Across Public Lands

At first, virtually all lands in the West were public lands. Congress provided for ditch and canal rights-of-way across public lands in the 1866 Mining Act. In addition to recognizing the right of trespassers to establish water rights by prior appropriation on Federal lands, the Act stated, "the right of way for the construction of ditches and canals for the purposes aforesaid is hereby acknowledged and confirmed." The 1870 Amendment to the Act made all patents of public lands and all homesteads "subject to any vested and accrued water rights."

In the Canal Act of 1890, August 30, 1890, Congress preserved perpetually to the Government an easement and right of way through and over any and all lands west of the one hundredth meridian so the government might grant to settlers and purchasers subsequent to the passage of the Act, and reserved the easement and right of way for the construction, maintenance and operation of any ditches and canals the government may construct at any time in the future for the irrigation of arid lands.

[69] Forfeiture claims are usually initiated by statutory procedures but also can be decided in private litigation. Courts may defer to the primary jurisdiction of an administrative agency to decide whether there has been a forfeiture.

Across Private Lands

Status of Trespassing Appropriators

Under the appropriation doctrine, use (not land ownership on a waterbody) is the basis of a water right; appropriators may thus take waters from lands they do not own. The first appropriations in the West were made by persons entering on the public lands without express authority. Federal legislation validated the appropriative rights and use of lands for ditch rights-of-way by "trespassers" on the public lands. Lands conveyed to private parties were patented subject to rights of those who already had perfected water rights to use the land for ditch rights-of-way.

If a trespasser enters the land of another and constructs pipelines, ditches, or other facilities without the landowner's permission and the facilities remain long enough, the use may ripen into a prescriptive right. The period of limitations varies according to state law.

Purchase of Rights-of-Way

The most common way to obtain a right-of way to convey water across private land is by purchase. Often the property owner can also be served by the water delivery facilities and an accommodation reached based on the benefits received. The right-of-way for a canal, ditch, or pipeline includes a secondary easement for necessary maintenance and repairs.[70]

Condemnation of Water Rights Use

Sometimes an owner whose land lies in the path of a canal, ditch, or pipeline is unwilling or unavailable to grant permission for use of the land. Western states have enacted statutes authorizing appropriators to condemn rights-of-way to transport water across private lands. Private condemnation statutes have been challenged on the ground that they do not further a public use.[71] The only remedy of the landowner against the appropriator who crosses private land without permission is to seek damages for inverse condemnation. The U.S. can condemn private property for Congressionally authorized projects under the Takings Clause, but it must pay the landowner just compensation and file a Declaration of Taking in Federal Court.

Appurtenance of Ditch Rights to Water Rights

The right-of-way for a ditch and a water right are usually considered appurtenant to one another so that the conveyance of one carries the other with it. This does not prevent one from being sold apart from the other, although it could if the parties express that intention.

Storage

Without storage, beneficial use of water would be limited to short runoff periods throughout most of the West. Storage is an important way to maximize the use of scarce water resources. On channel storage means that the facility is physically part of the appropriated stream. Most major dams and projects are examples of on channel storage; their function is to retain some of the natural flow,

[70] Grants of easements or rights-of-way, like other interests in land, usually must be in writing and conform to other conveyance formalities. Yet, it has been held that a landowner's oral permission to construct a ditch is valid as a license that the landowner is estopped to contest (Gustin v. Harting, Wyoming 1912).

[71] The U.S. Supreme Court upheld Utah's grant of eminent domain power against a challenge that the law offended the due process clause of the 14th Amendment. The Court recognized the great importance of water development under conditions prevailing in the West (Clark v. Nash, Supreme Court 1905). Western state courts have upheld similar statutes.

while allowing enough water to stay in the stream to satisfy rights of downstream appropriators. Off channel storage requires diversion and transportation works to get water to the storage location away from the stream channel. There is no legal distinction between off-stream and onstream storage rights. Retention of water in the streambed by artificial means constitutes a "diversion" for purposes of perfecting a water right.[72]

Acquisition of Storage Rights

Storage Rights

Some states make statutory distinctions between diversion for immediate use – "direct flow water rights" – and diversions for subsequent uses – "storage water rights." A permit or decree for a storage water right is obtained from the same agency or court that administers other water rights. The storage right is not complete until water is put to a beneficial use.[73]

Permission to Construct Storage Facilities

Besides perfecting a right to store water, one seeking to impound it in a reservoir must have permission to build the facility. Most states require plans for construction of dams and reservoirs to be approved by the same agency that administers water rights.[74]

Use of Storage Rights

The holder of a storage water right can use stored water for any beneficial purpose.[75] Appropriative rights for a stream, whether for storage or direct flow, are governed by the same rules of priority that apply to other appropriations.[76] Storage and direct flow water rights are integrated; neither is given preference. An exception is Nebraska, where water may not be impounded, even by holders of senior rights, when needed for direct irrigation.

Limits on Storage

A widely applied limitation on holders of storage water rights is the "one-fill rule." The rule allows an appropriator to fill a reservoir only once annually and not to use it over the course of a year to store a cumulative quantity greater than its full capacity.[77] A small regulating dam can release many times its capacity during a year. This is prohibited whenever the one-fill rule is strictly applied. If applied to restrict control of water by hydroelectric dams, the result could greatly reduce their utility.

Water diverted to a reservoir but not used may be retained for future use by the appropriator. Known as "carryover storage," this practice helps balance out wet and dry years. Some states do not

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[72] See data card Appendix – Water Rights Allocation – Storage for table and field descriptions.

[73] Separate permits are required by some states (e.g., Arizona, Nevada, Wyoming, and Nebraska) for storage and for application to a beneficial use. This approach recognizes that often the entity diverting and holding the water (e.g., reservoir company) is different from the entity or persons using the water (e.g., irrigators). Some states consider the two joint appropriators (Board of County Commissioners v. Rocky Mountain Water Company, Colorado 1938).

[74] The agency or official (e.g., state engineer or director water resources) may consider factors related to the public interest such as safety, impacts on fish and wildlife, and aesthetics. Most states exempt small storage facilities like stock watering ponds from permit requirements.

[75] See Cf. Basey v. Gallagher, Supreme Court 1874.

[76] See Donich v. Johnson, Montana 1941.

[77] See Windsor Reservoir & Canal Co. V. Lake DeSmet Reservoir Co., Wyoming 1970.The purpose of the one-fill limitation was ease of regulating, but its application can be terribly inefficient. A series of several fillings and drawdowns may be necessary to even out flows throughout the year.

allow the appropriator to use the amount of carryover storage the following year; the limit of one filling still applies, with the amount carried over debited against the single filling.

Hybrid System and Other Variations

Ten states employ a mixture of riparian and appropriation doctrine in their water laws. They include Alaska, California, Oregon, Washington, and the six states that straddle the 100th meridian: Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas.[78] There is no pervasive "doctrine' that fits all the hybrid states. California adopted a dual system from the beginning, but the others originally were riparian and later converted to a system of prior appropriation. Each hybrid state has its own mixture of the systems. Riparian rights are important in each, mostly for historical reasons, because substantial riparian water rights had been established by the time appropriation laws were passed. Appropriation law is more important today in the hybrid states since it is the basis of new rights. In California, Nebraska, and Oklahoma, however, riparian rights can still originate new uses superior to prior appropriators under certain circumstances (Getches, 190).

6. Previous Research

Previous Reclamation efforts to develop a water rights database were not successful. Efforts to consolidate Reclamation water rights were initiated in August of 2008 by Western Area Power Administration (WAPA) staff. Water rights information was provided to the then Office of Policy and Administration (now Policy and Programs) and uploaded to a mainframe database system in Access. A recurring cycle on regional reporting for water rights was established; however, this process was inconsistent and yielded inaccurate data.

The last compiled water rights report was done on December 24, 2009, by Don Anderson from the Water and Environmental Resources Group, Denver, Colorado. The report was based on feedback received from the regional offices to the following prompt:

- Question (1) A paragraph or two for each state summarizing the region's involvement in the state's water right process, including tracking project water rights from our end.

A more detailed questionnaire was deployed with the current proposal efforts in July 2021 and are discussed below. Results were compared and resulted in additional analysis.

Table 2. Adapted from 2009 Reclamation Water Rights 17 State Summary of Question (1).

Office	Project/Activity
Great Plains Region	

[78] In 1890, Powell wrote, "Passing from east to west across this belt a wonderful transformation is observed. On the east a luxuriant growth of grass is seen, and the gaudy flowers of the order Compositae make the prairie landscape beautiful. Passing westward, species after species of luxuriant grass and brilliant flowering plants disappear; the ground gradually becomes naked, with bunch grasses here and there; now and then a thorny cactus is seen, and the yucca plant thrusts out its sharp bayonets."

Great Plains RO	Maintain list of regional Reclamation water rights. Assist AOs on more complex issues and settlement of Republican River Interstate Compact.
Eastern Colorado AO	Review water rights resumes to evaluate potential impact on Reclamation's rights and respond as appropriate.
Dakotas AO	Monitoring and protection of storage rights at Reclamation facilities.
Montana AO	Review of water right applications and decrees, filing objections; oversight of Reclamation involvement in Montana general adjudication.
Nebraska-Kansas AO	General water rights and water right transfer work; settlement of Republican River Interstate Compact; testimony on Integrated Water Management Plans in Nebraska.
Oklahoma-Texas AO	Monitoring for updates to Reclamation's "Summary of Water Rights" table; occasional opposition to new water uses.
Wyoming AO	General monitoring of proposed changes to state-issues water rights associated with project lands.
Lower Colorado Region	
Lower Colorado RO (including YAO and PXAO Colorado River administration activities)	Administration of approximately 200 Colorado River water entitlements in AZ, CA, and NV, and assisting PXAO and SCAO with non-Colorado River entitlement water rights activities.
Phoenix AO	Resolving/negotiating agreements and processes required by AWSA and associated with the Gila River adjudication and protecting Indian water rights.
Southern California AO	Water rights work for Santa Margarita River (Conjunctive Use Project).
Mid-Pacific Region	
Mid-Pacific RO	Various Mid-Pacific Water Rights Group activities in CA, NV and OR.
Klamath Basin AO	Monitor and evaluate water use by Projects users and others that may affect Klamath Project water rights; involvement in adjudication of the Klamath River.
Pacific Northwest Region	
Pacific Northwest RO	Water rights work, primarily in Idaho, and particularly in support of Snake River Basin Adjudication.
Columbia-Cascades AO	Variety of general water rights work including project water rights transfers and protecting Reclamation rights from injury.
Snake River AO	Water rights work, about half Snake River Basin Adjudication work.
Upper Colorado Region	
Albuquerque AO	Maintenance/protection of Reclamation water rights; leasing of water rights on Pecos and Middle Rio Grande Rivers.

Western Colorado AO	General monitoring and protection Reclamation rights; involvement in ongoing general stream adjudication for the San Juan River basin.
Provo AO	Monitor water right notices and file protests; file documents to keep project rights up to date; maintain water rights files, coordinate with project partners, State Engineer, and Regional Solicitor.

Historical Water Rights Databases

The various methods of capturing water rights data are not as accurate as would be possible with an integrated database that meets Reclamation's mission. Here is a list of attempts over the last 40 years to set up an agency-wide database:

1. Provo Water Rights Database
2. 1993 Denver Colorado Water Right GT Database
3. Great Plains WATSUMT 2009 Database
4. 1982 Cyber Database
5. ECAO Water Case Database
6. 2019 UC Water Rights & Activity Management System

While these attempts were a starting block, they always failed to implement lasting enterprise status in terms of their data. These can often be attributed to the data design of the systems oversimplifying legal standards. Water rights are bound by law and follow very prescribed and regulated meanings and definitions that cannot be redefined by Reclamation and its internal processes. Because of how valuable and fundamental this data is to the agency; it should be held at the highest level of information technology's (IT) enterprise resource planning.

For example, in the UCB Region, water rights are currently housed on a UCB Microsoft Structured Query Language (SQL) Server with multiple connected databases such as UCB Contracts Database or other databases like UCB/LCB Hydrologic Database and UCB GIS layers. The UCB Region found in its Systems and Architecture Evaluation for water rights that using Microsoft SQL Server, a relational database management system, as a database server (a software product with the primary function of storing and retrieving data as requested by other software applications, which may run either on the same computer or on another computer across a network) was the most cost effective and gave immediate local control of data management.

The UCB Water Rights & Activity Management System was built with a mixed design of Microsoft SQL Database Architecture and Access's software development tools. Having the User Interface (UI) in Access, the application keeps all the functionality in terms of forms and reports. Additionally, the path allows for future redevelopment of the UI in other programs such as .NET for an online application, while maintaining the original data structure and data.

The various systems being used are not feasible in many respects and using a centralized database will provide improved business practices and prevent gaps in water rights information. By incorporating the methodology performed in the Upper Colorado Basin Water Resources and

Compliance, WRIMS will be able to be deployed using modern application design. In addition, the WRIMS database will also prevent duplication errors, staff errors, and document processing delays related to data reporting. Accurate reporting is a must and is needed to further our mission. The data contained in the WRIMS database relates to various databases currently being used in other regional offices. All information received from regional offices was already established or taken into consideration within WRIMS.

One of the most important assets of any organization is its information. This asset is almost always used for two purposes: operational record-keeping and analytical decision-making. Simply speaking, the operational systems are where you put the data in, and the system is where you get the data out.

Enterprise System Baseline Requirements

Based on research, concerns found throughout the agency are universal and drive the bedrock requirements for all Reclamation systems. These business and management concerns were distilled into the following section requirements.

Accessible

The system must make information easily accessible. The contents of the system must be understandable. The data must be intuitive and obvious to the business user, not merely the developer. The data's structures and labels should mimic the business user's thought processes and vocabulary.

Consistent

The system must present information consistently. The data in the system must be credible. Data must be carefully assembled from a variety of sources, cleansed, quality assured, and released only when it is fit for user consumption. Consistency also implies that common labels and definitions for the system's contents are used across data sources. If two performance measures have the same name, they must mean the same thing. Conversely, if two measures don't mean the same thing, they should be labeled differently.

Adaptable

The system must adapt to change. User needs, business conditions, data, and technology are all subject to change. The system must be designed to handle this inevitable change gracefully so that it doesn't invalidate existing data or applications. Existing data and applications should not be changed or disrupted when the business community asks new questions or new data is added to the warehouse. Finally, if descriptive data in the system must be modified, you must appropriately account for the changes and make these changes transparent to the users.

Efficient

The system must present information in a timely way. As the system is used more intensively for operational decisions, raw data may need to be converted into actionable information within hours, minutes, or even seconds. The team and business users need to have realistic expectations for what it means to deliver data when there is little time to clean or validate it.

Secure

The system must be a secure bastion that protects the information assets. An organization's informational crown jewels are stored in the data warehouse. At a minimum, the warehouse likely contains information about what is being sold to whom at what price—potentially harmful details in the hands of the wrong people. The system must effectively control access to the organization's confidential information.

Authoritative and Trustworthy

The system must serve as the authoritative and trustworthy foundation for improved decision-making. The data warehouse must have the right data to support decision-making. The most important outputs from a system are the decisions made based on the analytic evidence presented; these decisions deliver the business impact and value attributable to the system. The original label that predates is still the best description of what you are designing: a decision support system.

Used by Everyone

The business community must accept the system to deem it successful. It doesn't matter that the developer built an elegant solution using best-of-breed products and platforms. If the business community does not embrace the environment and actively use it, the developer has failed the acceptance test. Unlike an operational system implementation where business users have no choice but to use the new system, usage is sometimes optional. Business users will embrace the system if it is the "simple and fast" source for actionable information.

7. Outreach

Initial Field Research and Interview

Water rights interview sessions were initially scheduled and led by the WRIMS Team, Tyler Larsen, UCB Region, and Ginger Dill, Science and Technology (S&T) Lead WRIMS Researcher. The questionnaire sessions took place with all Reclamation regions listed below and were completed prior to the testing phase of WRIMS.

- CPN Region
- CGB Region
- LCB Region
- UCB Region
- MB Region

High-level collaborative discussions were scheduled and took place with area offices and irrigation districts to ensure we received all pertinent information. The survey questionnaires were completed

in full. The questionnaire results further solidified that a centralized water rights database is needed Reclamation-wide. The survey questionnaire consisted of the following questions.[79]

- How many water rights do you track in your Area Office?
- How much time do you spend tracking water rights?
- What difficulties have you encountered tracking water rights?
- Do you have water rights that have been through litigation? How many?
- Do you report water rights and use to anyone? What tools do you use?
- How do you store your water rights documents?
- What field names do you used in your tracking system?
- What would be helpful to track in a water rights database?
- How could you benefit from a Region-wide water rights tracking database?

Table 3 is a summary of the various responses received during the general interviews based on the questions above, how each region tracks its water rights data and what fields were used.

Table 3. Interview General Criteria Discussed on Data Quality and field names tracked.

Category	**Field Name/Picklist Options**
Reclamation Organization	Region Project State Facility name Area Office Field Office
Ownership	Water rights Owner(s)
Administrative	Water rights application number Filing date Priority date
Legal Status	Water rights application status
Amount	Cubic Feet per Second, Acre-Foot
Point Types	Points of diversion, public land surveys, Geospatial information
Type of Water Rights	Storage Groundwater Surface Water Tribal Other
Type of Uses	Recreation, Municipal and Industrial, Commercial, Power, Fish & Wildlife, Storage, Supplemental Storage, Irrigation,

[79] The questionnaire survey results are notated in Appendix B

	Temporary Irrigation, Supplemental Irrigation, Other

Western States Water Council

During the outreach and collaboration phase, the Research and Development (R&D) Office received an inquiry from the Western States Water Council asking if the WRIMS team wanted to meet and discuss possibly joining forces on the water rights database. This water rights data already existed in their WaDE system, as they were farther along with their project – Phase II (2019 – 2021). R&D set up the initial meeting to discuss how we could help each other with the water rights data. We were also interested, as we wanted to see what their data standard looked like within their system. After reviewing and sharing information, we decided it would be feasible to use some of their water rights data pertaining to Reclamation water rights and for the WRIMS database Pilot Test.

Collaborative discussions between AMD and the Western States Water Council were held from February to June 2021. A webinar hosted by Western States Water Council on March 25, 2021, provided an overview of their water rights information stored in WaDE. We also got to review their water rights data schema and standardization, which provided us a snapshot of similarities between both systems. The Western States data call presentation can be accessed at this link. This webinar provided a synopsis of the WaDE 2.0 architecture and design system, which provides streamlined access to water rights, water supply, and water use data for the Western U.S.. Discussions were led by WaDE's Program Manager, Adel M. Abdallah, Ph.D. The Western States Water Council team members were extremely forthcoming with their material and were able to provide Reclamation water rights information with some core elements pertaining to their system.

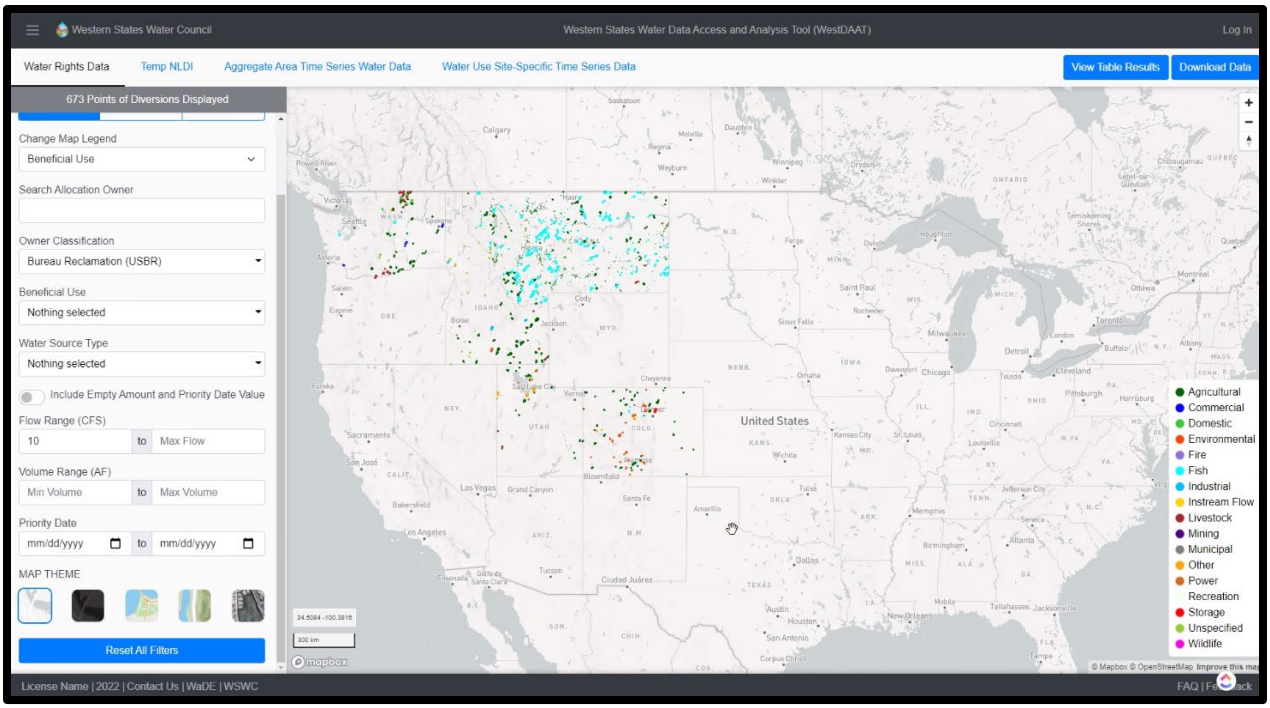


Figure 1. Western States Water Data Access and Analysis Tool (WestDAAT) Western States Water Council.

Some of the information included data schema from WaDE 1.0 to WaDE 2.0 Data System as they had made updates to fit both groundwater and surface water rights. Further findings revealed that the WaDE system had state-recognized Federal water rights across the West and confirmed about 1,000 records were directly named Reclamation and covered seven Western states. The collaboration with Western States Water Council was and continues to be valuable. Some of their water rights information was used and uploaded for the WRIMS Application in preparation for the Test Pilot. Collaboration talks continue as they develop updates to their system.

B3 Insight

During the outreach process, we looked to a private company, B3 Insight. The company's purpose statement is: "B3 Insight is building the definitive source for water data. We empower smart water management with data-driven intelligence for responsible and profitable decisions about water resources. Customers evaluate assets, enhance operational efficiencies, mitigate risk, allocate capital, and benchmark performance while saving significant time, investment, and resources – all with one intuitive platform." With their proprietary system they have amassed a great deal of records primarily for Colorado water rights. The team stopped pursuing business relationships due to the limited scope of their system.

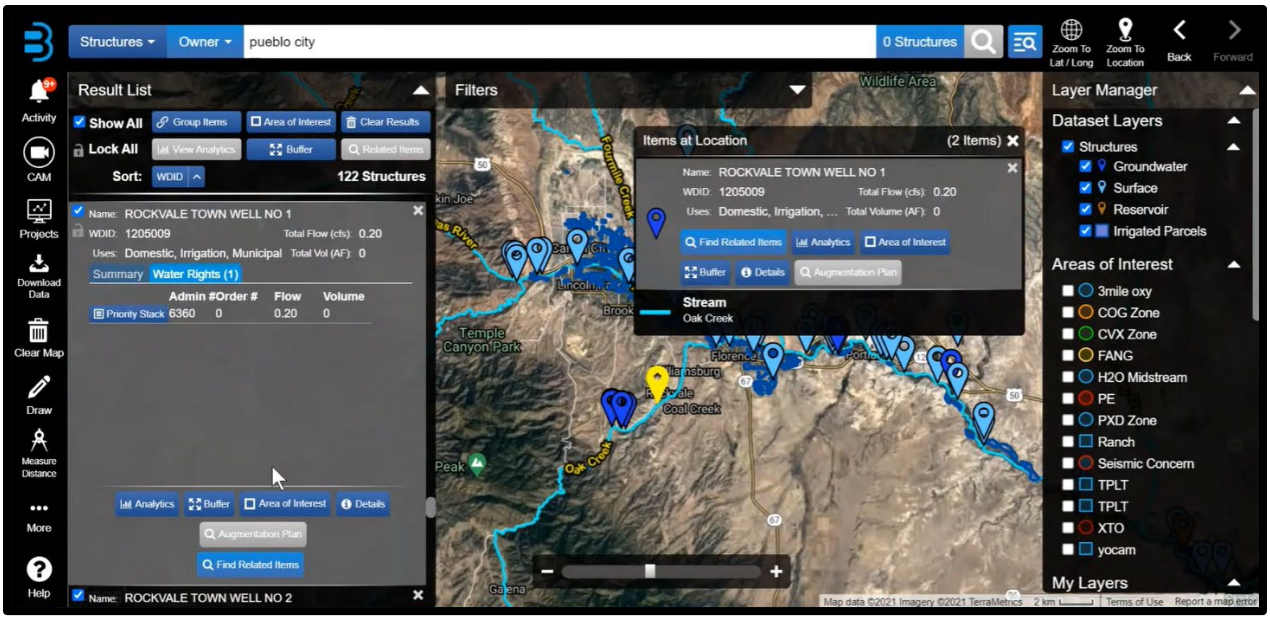


Figure 2. B3 Insight Proprietary Platform for Water Rights focused on Colorado.

8. Objectives

Every state has certain procedures in place for recognizing and administering a water right. The first task was to meet with the regional offices to gather information (data) on how they were currently tracking their individual water rights. The objectives for this project were to:

- Perform water rights research
- Gather and monitor water rights activity
- Track and record water rights data in an enterprise data repository
    - File and store related documents
    - Establish a common library management system for water rights activity
    - Use consistent file naming conventions
- Custom user interface
    - Create and produce standardized reporting tools
    - Visualize geospatial and temporal data
- Data Warehousing and Business Intelligence

Before we delve into the details of dimensional modeling, it is helpful to focus on the fundamental goals of data warehousing and business intelligence. The goals can be readily developed by walking through the halls of any organization and listening to business management. These recurring themes have existed for more than three decades:

- "We collect tons of data, but we can't access it."
- "We need to slice and dice the data every which way."
- "Businesspeople need to get at the data easily."

- "Just show me what is important."
- "We spend entire meetings arguing about who has the right numbers rather than making decisions."
- "We want people to use information to support more fact-based decision-making."

9. Data System Design

As data volume continues to grow, so does the challenge of wrangling that data into well-formed, actionable information. Reclamation users want data that's ready for analytics and to populate visuals, reports, and dashboards, so they can quickly turn volumes of data into actionable insights.

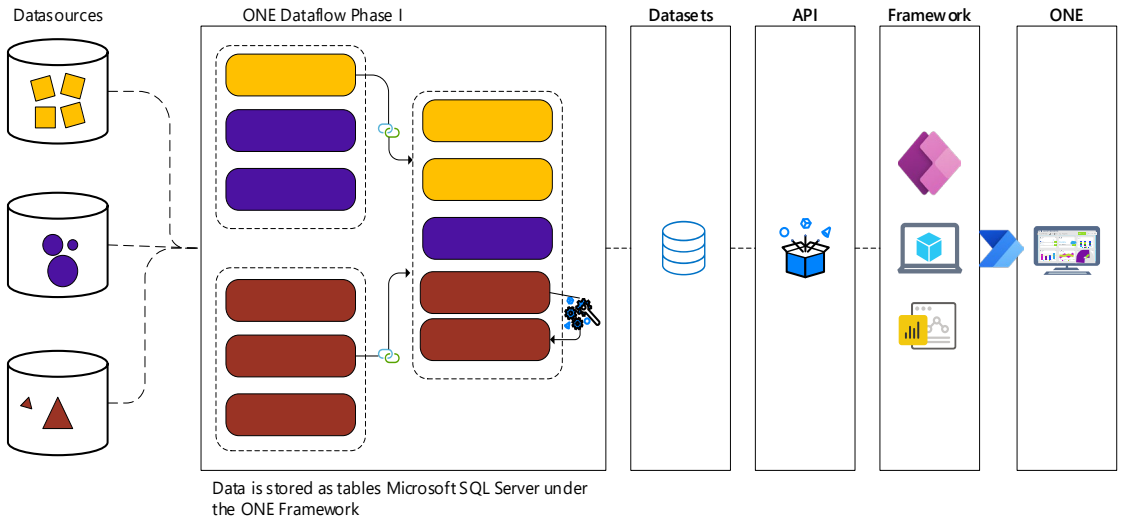


Figure 3. Omni Networking Environment Dataflow and generic processing (Microsoft Contributors, 2022).

Dimensional data modeling is an iterative design process requiring the cooperative efforts of people with a diverse set of skills, including subject matter experts, engineers, solicitors, and project managers. The design effort began as an initial graphical model pulled from the ONE Framework and presented at the entity level. The detailed modeling process develops the definitions, sources, relationships, data quality problems, and required transformations for each table. The primary goals are to create a model that meets the business requirements, verify the data is available to populate the model, and provide users with a clear direction.

The task of determining column and table names was interwoven into the design process. The Reclamation Data Council approves the names, definitions, and derivations of every column and table in the dimensional model. This is more of a political process than a technical one. The resulting column names exposed through the portal tools must make sense to the Reclamation community. The detailed modeling effort is followed by several reviews. The result is a dimensional model that has been successfully tested against both the business needs and data realities (Kimball, 2013).

Data Schema

The database schema is its structure described in a formal language supported by the database management system (DBMS). The term "schema" refers to the organization of data as a blueprint of how the database is constructed (divided into database tables in the case of relational databases). The formal definition of a database schema is a set of formulas (sentences) called integrity constraints imposed on a database. These integrity constraints ensure compatibility between parts of the schema. All constraints are expressible in the same language. A database can be considered a structure in realization of the database language. The states of a created conceptual schema are transformed into an explicit mapping: the database schema. This describes how real-world entities are modeled in the database.

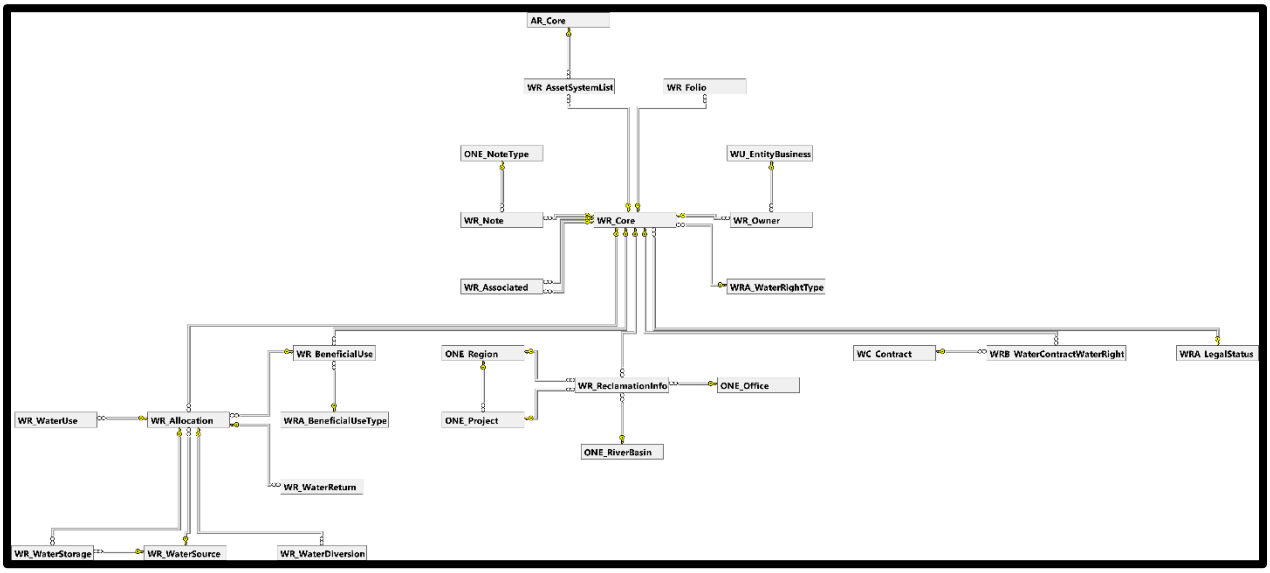


Figure 4. Simplified Data Schema for Water Rights Information Management System.

Star Schema Overview

Star schema is a mature modeling approach widely adopted by relational data warehouses. It requires modelers to classify their model tables as either dimension or fact. Not to obfuscate the star schema, the Omni Networking Environment Framework for Water Rights Information employs Core and Attribute Tables.

Dimension tables (ONE attribute tables) describe business objects. Attribute objects can include products, people, places, and concepts including time itself. The most consistent table found in a star schema is an attribute type table. An attribute table contains a key column (or columns) that acts as a unique identifier and descriptive columns (Microsoft Contributors, 2022).

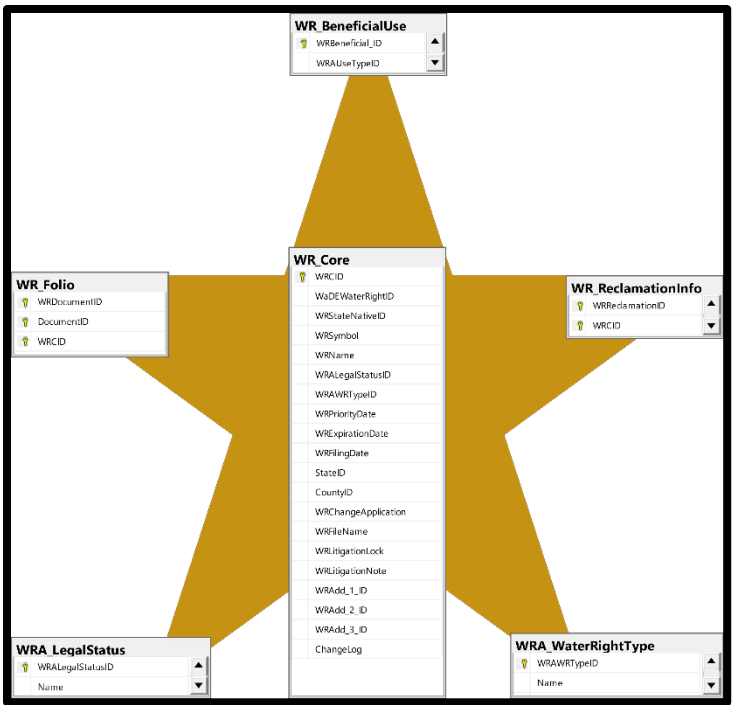


Figure 5. Adapted Water Rights Star Data Schema Structure Example Using Core Tables with Attribute and Core table relationships.

Core tables store observations or events and can be water rights, hydrologic flow, release rates, temperatures, etc. A core table contains attribute key columns that relate to attribute tables and numeric measure columns. The attribute key columns determine the dimensionality of a core table, while the attribute key values determine the granularity of a core table. For example, consider a core table designed to store water rights that has two attribute key columns: Legal Status and Water Right Type. It's easy to understand that the table has two attributes. The granularity, however, can't be determined without considering the attribute key values. In this example, consider that the value stored in the WRALegalStatusID column is the name or term of the legal status type. In this case, the granularity is at legal status level.

Generally, attribute tables contain a relatively small number of rows. Core tables, on the other hand, can contain a very large number of rows and continue to grow over time.

Data Normalization vs. Denormalizations

In order to understand the ONE Framework, it's important to know two terms: normalization and denormalization.

Normalization is the term used to describe data that's stored in a way that reduces repetitious data. Consider the water rights core table that has a unique key value column, like the WRCID (water right core identifier), and additional columns describing the water rights characteristics, including legal status name, right type, priority date, and state native identification. A table is considered normalized when it stores only keys, like the WRALegalStatusID key. In the following image, notice that only the WRALegalStatusID column records the legal status type.

	WRCID	WaDEWaterRightID	WRStateNativeID	WRSymbol	WRName	WRALegalStatusID	WRAWRTypeID	WRPriorityDate
1	1	6508541	A000023	CA:A000023	Bureau Reclamation Water Right - CA:A000023	1	1	1915-03-27
2	2	6527413	A000234	CA:A000234	Bureau Reclamation Water Right - CA:A000234	1	1	1916-01-19
3	3	6520484	A001465	CA:A001465	Bureau Reclamation Water Right - CA:A001465	1	1	1919-09-26
4	4	6517353	A002212	CA:A002212	Bureau Reclamation Water Right - CA:A002212	1	1	1921-02-17
5	5	6517093	A003660	CA:A003660	Bureau Reclamation Water Right - CA:A003660	1	1	1923-10-04
6	6	6511826	A005618	CA:A005618	Bureau Reclamation Water Right - CA:A005618	1	1	1927-07-23
7	7	6512899	A005625	CA:A005625	Bureau Reclamation Water Right - CA:A005625	1	1	1927-07-30
8	8	6524629	A005626	CA:A005626	Bureau Reclamation Water Right - CA:A005626	1	1	1927-07-30
9	9	6507675	A005627	CA:A005627	Bureau Reclamation Water Right - CA:A005627	1	1	1927-07-30
10	10	6508092	A005628	CA:A005628	Bureau Reclamation Water Right - CA:A005628	1	1	1927-07-30

Figure 6. Normalized Data View of Water Rights Core Table highlighting Attribute key WRLegalStatusID (Microsoft Contributors, 2022).

If, however, the water rights core table stores details beyond the key, it's considered denormalized. In the following image, notice that the WRALegalStatusID and other water rights-related columns record the name and terms.

	WRCID	WRName	WRALegalStatusID	Name	Term
▶	1	Bureau Reclamation Water Right - CA:A000023	1	Unspecified Legal Status	Default Unspecified Legal Status
	2	Bureau Reclamation Water Right - CA:A000234	1	Unspecified Legal Status	Default Unspecified Legal Status
	3	Bureau Reclamation Water Right - CA:A001465	1	Unspecified Legal Status	Default Unspecified Legal Status
	4	Bureau Reclamation Water Right - CA:A002212	1	Unspecified Legal Status	Default Unspecified Legal Status
	5	Bureau Reclamation Water Right - CA:A003660	1	Unspecified Legal Status	Default Unspecified Legal Status

Figure 7. Denormalized data view of water rights core table highlight attribute key WRALegalStatusID – Name – Term (Microsoft Contributors, 2022).

When you source data from an export file or data extract, it's likely that it represents a denormalized set of data. In this case, use Power Query to transform and shape the source data into multiple normalized tables.

Factless Fact Tables

A factless fact table (bridging table) doesn't include any measure columns. It contains only keys. A factless fact table could store observations defined by dimension keys, for example, at a particular date and time, the user who last modified the record. These analytics allow us to define a measure to count the rows of the factless fact table to analyze when and how many users have edited.

For example, consider that water users can be assigned to one or more water rights owners groups. The bridging table water user owners group is designed as a factless fact table consisting of two columns: WRCID key and WUBusinessEntityID key. Duplicate values can be stored in both columns.

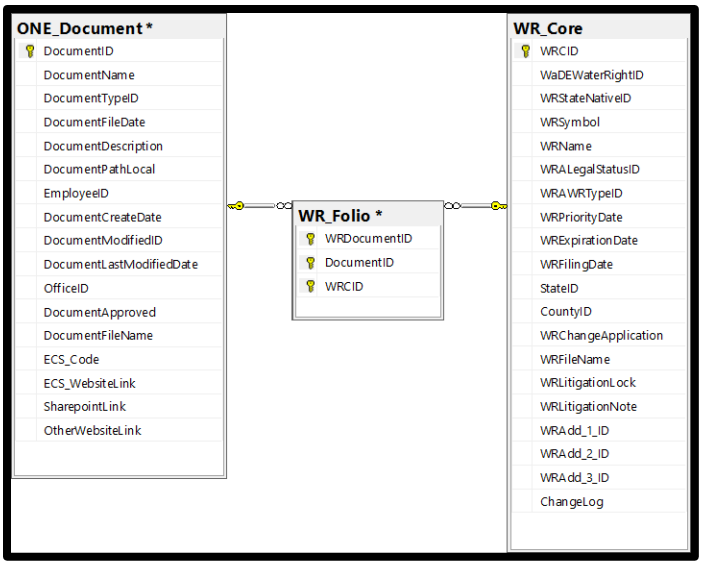


Figure 8. Factless table or bridging core tables (Microsoft Contributors, 2022).

The above image shows a factless fact table bridging water rights document folio and document dimensions. The factless fact table comprises two columns, which are the dimension keys. This many-to-many design approach is well documented, and it can be achieved without a bridging table. However, the bridging table approach is considered the best practice when relating two dimensions.

Data Extraction, Transformation, and Load

The extract, transformation, and load (ETL) system of an environment consists of a work area, instantiated data structures, and a set of processes. The ETL system is everything between the operational source systems.

- Extracting – gathering raw data from the source systems and usually writing it to disk in the ETL environment before any significant restructuring of the data takes place.
- Cleaning and conforming – sending source data through a series of processing steps in the ETL system to improve the quality of the data received from the source and merge data from two or more sources to create and enforce conformed dimensions and metrics.
- Delivering – physically structuring and loading the data into the presentation server's target dimensional models.
- Managing – supervising the related systems and processes of the ETL environment in a coherent manner.

Extraction is the first step in the process of getting data into the data warehouse environment. Extracting means reading and understanding the source data and copying the data needed into the ETL system for further manipulation. At this point, the data belongs to the data warehouse. After the data is extracted to the ETL system, there are numerous potential transformations, such as cleansing the data (correcting misspellings, resolving domain conflicts, dealing with missing elements, or parsing into standard formats), combining data from multiple sources, and de-duplicating data. The ETL system adds value to the data with these cleansing and conforming tasks by changing the data and enhancing it. In addition, these activities can be architected to create

diagnostic metadata, eventually leading to business process reengineering to improve data quality in the source systems over time.

The final step of the ETL process is the physical structuring and loading of data into the presentation area's target dimensional models. Because the primary mission of the ETL system is to hand off the dimension and fact tables in the delivery step, these subsystems are critical. Many of these defined subsystems focus on dimension table processing, such as surrogate key assignments, code lookups to provide appropriate descriptions, splitting or combining columns to present the appropriate data values, or joining underlying third normal form table structures into flattened denormalized dimensions. In contrast, while fact tables are typically large and time consuming to load, preparing them for the presentation area is typically straightforward. When the dimension and fact tables in a dimensional model have been updated, indexed, supplied with appropriate aggregates, and further quality assured, the business community is notified that the new data has been published (Kimball, 2013).

Data Verification and Validation

Develop One-Time Historic Load Processing

After the ETL specification has been created, the focus shifts to developing the ETL process for the one-time load of historic data. Occasionally, the same ETL code can perform both the initial historic load and ongoing incremental loads, but more often we build separate ETL processes for the historic and ongoing loads. The historic and incremental load processes have a lot in common, and, depending on the ETL tool, significant functionality can be reused from one to the other.

Populate Dimension Tables with Historic Data

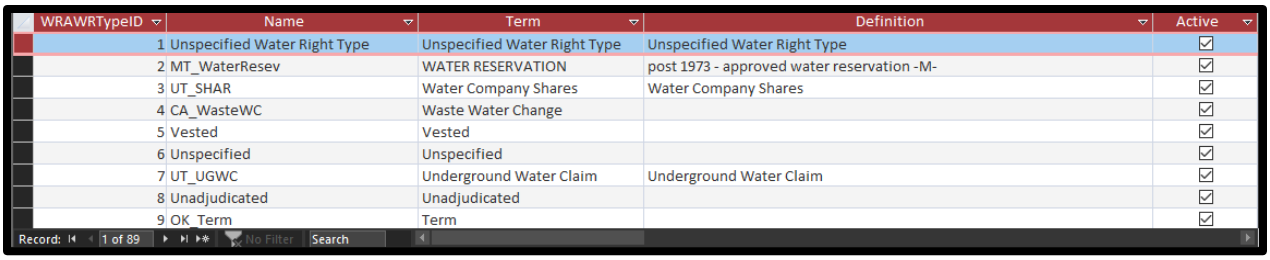
In general, we start building the ETL system with the simplest dimension tables. After these dimension tables have been successfully built, the historic data is loaded for dimensions with one or more managed columns.

WRSiteID	SiteNativeID	SiteUUID	SiteName	WRASiteTyp	Longitude	Latitude	HUC8	HUC12	StateID	CountyID	SiteCounty
1		NV_1	Unknown	1	-118.527229	41.988335			29	1764	Humboldt
2		NV_10179	097 N26 E19 25	1	-119.794219	40.08617			29	1762	Washoe
3		NV_10180	097 N26 E19 23	1	-119.812376	40.1103			29	1762	Washoe
4		NV_10811	101 N18 E29 23	1	-118.697186	39.405323			29	1766	Churchill
5		NV_1114	024 N34 E22 11	1	-119.457951	40.851489			29	1762	Washoe
6		NV_1117	024 N36 E22 26	1	-119.482801	40.977384			29	1762	Washoe
7		NV_1118	024 N36 E22 11	1	-119.482723	41.010903			29	1762	Washoe
8		NV_1119	024 N33 E23 12	1	-119.320158	40.752886			29	1762	Washoe
9		NV_1120	024 N33 E23 03	1	-119.366936	40.767826			29	1762	Washoe

Figure 9. Water rights site location simple dimension table post load of historic data normalized in the database.

Populate Type 1 Dimension Tables

The easiest type of table to populate is a dimension table for which all attributes are managed as type 1 overwrites. With a type 1–only dimension, the extract is the current value for each dimension attribute from the source system.



WRAWRTypeID	Name	Term	Definition	Active
1	Unspecified Water Right Type	Unspecified Water Right Type	Unspecified Water Right Type	☑
2	MT_WaterResev	WATER RESERVATION	post 1973 - approved water reservation -M-	☑
3	UT_SHAR	Water Company Shares	Water Company Shares	☑
4	CA_WasteWC	Waste Water Change		☑
5	Vested	Vested		☑
6	Unspecified	Unspecified		☑
7	UT_UGWC	Underground Water Claim	Underground Water Claim	☑
8	Unadjudicated	Unadjudicated		☑
9	OK_Term	Term		☑

Record: 1 of 89 No Filter Search

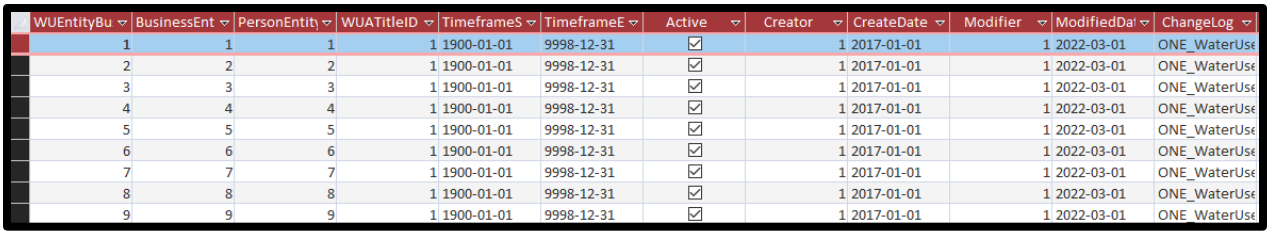
Figure 10. Normalized water rights attribute right type of type 1 dimension tables data post load view.

Dimension Transformations

Even the simplest dimension table may require substantial data cleanup and will certainly require surrogate key assignment.

Simple Data Transformations

The most common, and easiest, form of data transformation is data type conversion. All ETL tools have rich functions for data type conversion. All NULL values were replaced with default values within dimension tables. NULLs can cause problems when they are directly queried.

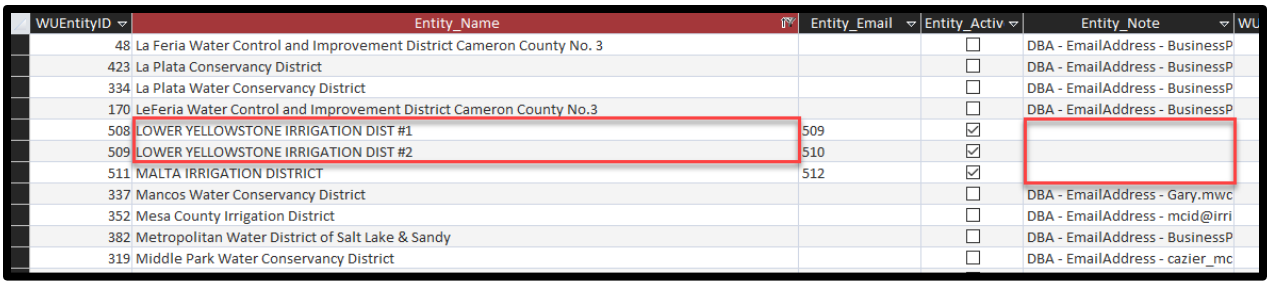


WUEntityBu	BusinessEnt	PersonEntity	WUATitleID	TimeframeS	TimeframeE	Active	Creator	CreateDate	Modifier	ModifiedDat	ChangeLog
1	1	1	1	1900-01-01	9998-12-31	☑	1	2017-01-01	1	2022-03-01	ONE_WaterUse
2	2	2	1	1900-01-01	9998-12-31	☑	1	2017-01-01	1	2022-03-01	ONE_WaterUse
3	3	3	1	1900-01-01	9998-12-31	☑	1	2017-01-01	1	2022-03-01	ONE_WaterUse
4	4	4	1	1900-01-01	9998-12-31	☑	1	2017-01-01	1	2022-03-01	ONE_WaterUse
5	5	5	1	1900-01-01	9998-12-31	☑	1	2017-01-01	1	2022-03-01	ONE_WaterUse
6	6	6	1	1900-01-01	9998-12-31	☑	1	2017-01-01	1	2022-03-01	ONE_WaterUse
7	7	7	1	1900-01-01	9998-12-31	☑	1	2017-01-01	1	2022-03-01	ONE_WaterUse
8	8	8	1	1900-01-01	9998-12-31	☑	1	2017-01-01	1	2022-03-01	ONE_WaterUse
9	9	9	1	1900-01-01	9998-12-31	☑	1	2017-01-01	1	2022-03-01	ONE_WaterUse

Figure 11. Water Users entity business table post load with simple data transformation removing null date values to min max values.

Combine from Separate Sources

Often dimensions are derived from several sources. Water user information may need to be merged from several lines of business and from outside sources. Seldom is there a universal key pre-embedded in the various sources to make this merge operation easy. Most consolidation and deduplicating tools and processes work best if names and addresses are first parsed into their component pieces. Then initiate a set of passes with fuzzy logic that account for misspellings, typos, and alternative spellings, such as Irr. District, Irr.D, and Irrigation District. Unlike most organizations, Reclamation has yet to perform a large one-time project to consolidate existing master data like water users. This is a tremendously valuable role for master data management systems.



WUEntityID	Entity_Name	Entity_Email	Entity_Activ	Entity_Note	WU
48	La Feria Water Control and Improvement District Cameron County No. 3		☐	DBA - EmailAddress - BusinessP	
423	La Plata Conservancy District		☐	DBA - EmailAddress - BusinessP	
334	La Plata Water Conservancy District		☐	DBA - EmailAddress - BusinessP	
170	LeFeria Water Control and Improvement District Cameron County No.3		☐	DBA - EmailAddress - BusinessP	
508	LOWER YELLOWSTONE IRRIGATION DIST #1	509	☑		
509	LOWER YELLOWSTONE IRRIGATION DIST #2	510	☑		
511	MALTA IRRIGATION DISTRICT	512	☑		
337	Mancos Water Conservancy District		☐	DBA - EmailAddress - Gary.mwc	
352	Mesa County Irrigation District		☐	DBA - EmailAddress - mcid@irri	
382	Metropolitan Water District of Salt Lake & Sandy		☐	DBA - EmailAddress - BusinessP	
319	Middle Park Water Conservancy District		☐	DBA - EmailAddress - cazier_mc	

Figure 12. Water user table showing data combination from multiple sources and data cleansing.

Decode Production Codes

A common merging task in data preparation is looking up text equivalents for production codes. In some cases, the text equivalents are sourced informally from a nonproduction source such as a spreadsheet. The code lookups are usually stored in a table in the staging database.

Validate Many-to-One and One-to-One Relationships

The most important dimensions probably have one or more rollup paths, such as water diversions, uses, and storage rolling up to water allocation, beneficial use, and water right core. These hierarchical rollups need to be perfectly clean.

WRCID	RightType	LegalStatus	WRName	AllocationFlow	AllocationVolume	BeneficialUse	DiversionActualFlag	DiversionFlow
1	Unspecified Water Right Type	Default Unspecified Legal Status	Bureau Reclamation Water Right - CA:A000023	0.00	0.00	Domestic	False	0.00
2	Unspecified Water Right Type	Default Unspecified Legal Status	Bureau Reclamation Water Right - CA:A000234	0.00	0.00	Domestic	False	0.00
3	Unspecified Water Right Type	Default Unspecified Legal Status	Bureau Reclamation Water Right - CA:A001465	0.00	0.00	Domestic	False	0.00
4	Unspecified Water Right Type	Default Unspecified Legal Status	Bureau Reclamation Water Right - CA:A002212	0.00	0.00	Agricultural	False	0.00
5	Unspecified Water Right Type	Default Unspecified Legal Status	Bureau Reclamation Water Right - CA:A003660	905.00	0.00	Domestic	False	905.00

Figure 13. Denormalized view of water rights core information showing proper attribute dimension values validating many-to-one and one-to-one relationships.

Perform the Fact Table Historic Load

The one-time historic fact table load differs fairly significantly from the ongoing incremental processing. The biggest factor during the historic load is the sheer volume of data, sometimes thousands of times bigger than the incremental load.

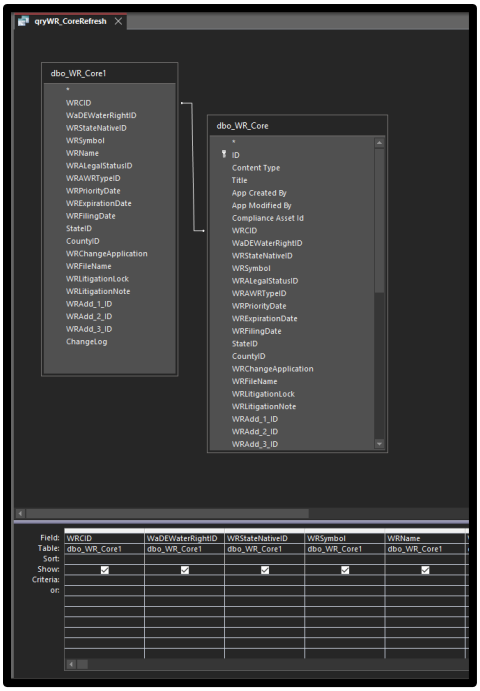


Figure 14. View of SQL query connecting a temporary table to load denormalized data into a core table.

Audit Statistics

During the planning phase for the ETL system, the team identified various measures of data quality. These are usually calculations, such as counts and sums, compared between the data warehouse and source systems to cross-check the integrity of the data. These numbers tie backward to operational

reports and forward to the results of the load process in the warehouse. The tie back to the operational system is important because it is what establishes the credibility of the warehouse.

Audit Scenario

There are scenarios in which it's difficult or impossible for the warehouse to tie back to the source system perfectly. In many cases, the data warehouse extract includes business rules that have not been applied to the source systems.

Fact Table Transformations

The ETL system developer spent a lot of time improving the dimension table content, but the facts usually required modest transformation. The most common transformation to fact data included transformation of null values, pivoting or unpivoting the data, and precomputing derived calculations. All fact rows then enter the surrogate key pipeline to exchange the natural keys for the dimension surrogate keys managed in the ETL system.

Null Fact Values

All major database engines explicitly support a null value. In many source systems, however, the null value is represented by a special value of what should be a legitimate fact. Perhaps the special value of -1 is understood to represent null. For most fact table metrics, the "-1" in this scenario should be replaced with a true NULL. A null value for a numeric measure is reasonable and common in the fact table. Nulls do the "right thing" in calculations of sums and averages across fact table rows. It's only in the dimension tables that you should strive to replace null values with specially crafted default values.

Data Testing and Methods

To test the WRIMS Application, next steps involved planning the WRIMS Test Pilot Workshop. The purpose of the WRIMS Test Pilot is to provide an introduction and overview of the WRIMS system and test the system. The Test Pilot was followed by a post-workshop discussion, which was beneficial for some regions. The material covered during the Test Pilot included:

- Management of a water right
- Reporting and exporting water right data
- Roadmap to water rights via the GIS component

The WRIMS Pilot Test took place within a two-week timeframe and a kick-off was scheduled in September 2021. Developer office hours were established after the Pilot Test for individuals (end-users) who had further questions, needed guidance within the WRIMS system, or could provide constructive feedback as it related to the WRIMS application.[80] Additional user guides for the WRIMS database were established to assist end-users using the system.

[80] See Appendix Water Right Information Management System Pilot – User Testing Package.

Data Summary After ETL

The Water Right structure is fundamentally complex because of the varied legal parameters between the 17 Western States requiring water right subject matter experts to update and maintain the meta data. The water right data schema process involved recording the technical data schema, water right attribute data values and definitions, data diagrams, data workflows and processes, and data research sources. The current Water Rights Information Management System was loaded on data coming from the Western States Water Council water rights system, which at the time contained 81,210 Water Rights, 17,462 Water Sources, and 96,937 Water Sites.

WRIMS – Water Right Core

During the first historic data load of core rights information, there was a total of 1,014 records. This contained records for 10 out of the 17 Western States that Reclamation helps manage.

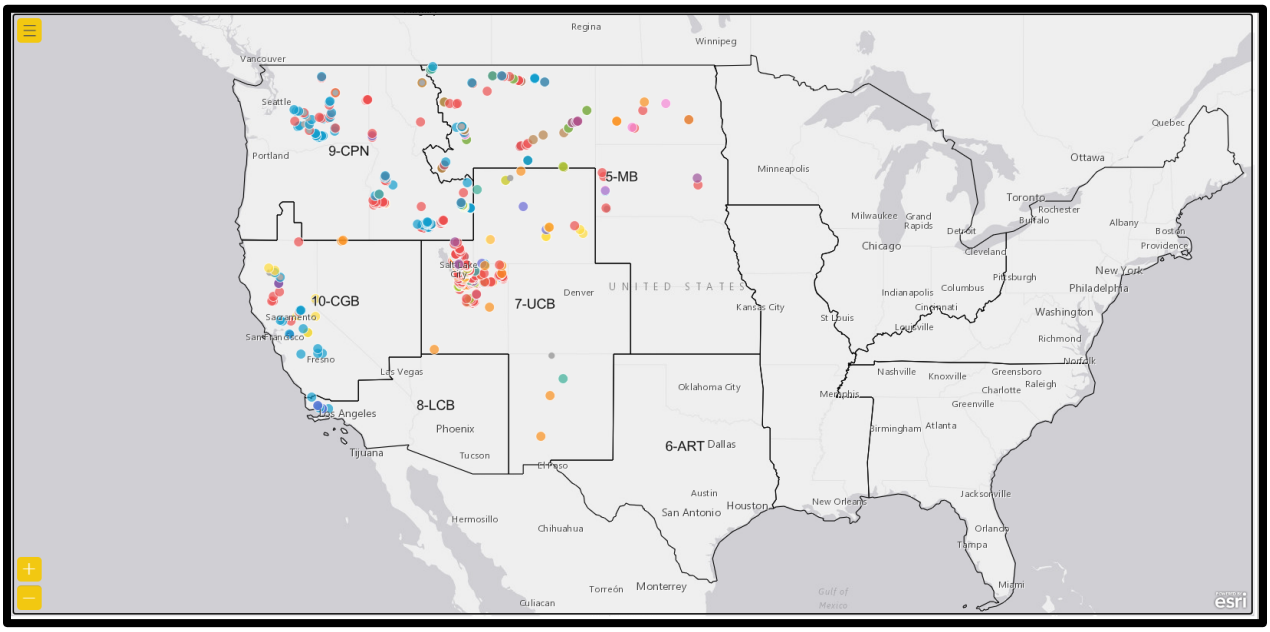


Figure 15. Integrated Power BI report that shows ArcGIS BORGIS Interior region layer and Water Rights colored based on the type of the right.

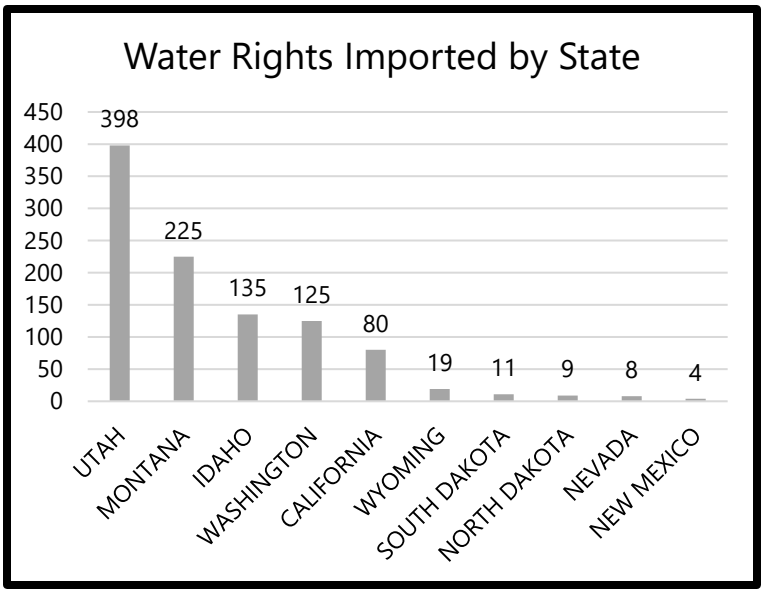


Figure 16. Water Rights imported during historic ETL by state.

WRIMS – Folio

Each water right core record can associate document records that have been created in reference to the Reclamation network or Electronic Enterprise Records and Document Management System (eERDMS) Enterprise Content System (ECS). For the testing of integrating ECS into the system there was a batch download of Upper Colorado's Water Resources folder that captured the ECS nickname, file name, description, record date, and a few other metadata points. After an initial data cleanse, there were 54,202 water rights-related records that were imported into the system and autogenerate the permalinks directly to ECS. These records have not entirely been matched in the folio table to the appropriate water rights. However, the method of capturing enterprise record data into the system has been finalized and complete.

WRIMS – Entity

A water entity is an individual or entity with interest in water. Based on the 1,014 water rights records, after data cleaning there are 578 entities and 578 unique business entity records with 72 unique districts identified and hundreds of private users.

WRIMS – Owner Group

Each individual state has the authority to determine how water will be allocated within its borders. State law governs the allocation and administration of water rights and beneficial water use. For the 1,014 water rights records, there are 1,223 relationships between the users and rights. This means that there are potentially 209 water rights that have more than one owner or vested interest.

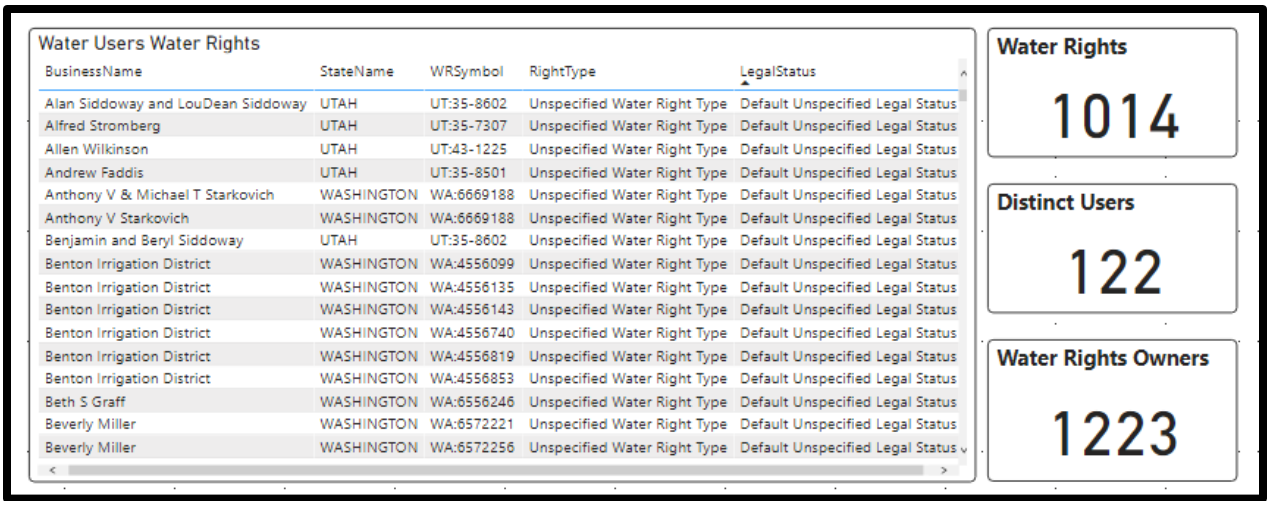


Figure 17. Power BI report that shows waters users rights and totals in the system.

WRIMS – Reclamation Information

In 1902, Congress passed the Reclamation Act to help the Western States finance reservoirs. Under the 1902 Act, all Reclamation projects must obtain rights based on state law. The Upper Colorado Basin has the most accounted for Water Rights at 570 completed records. Other regions still will need to go through and verify the information.

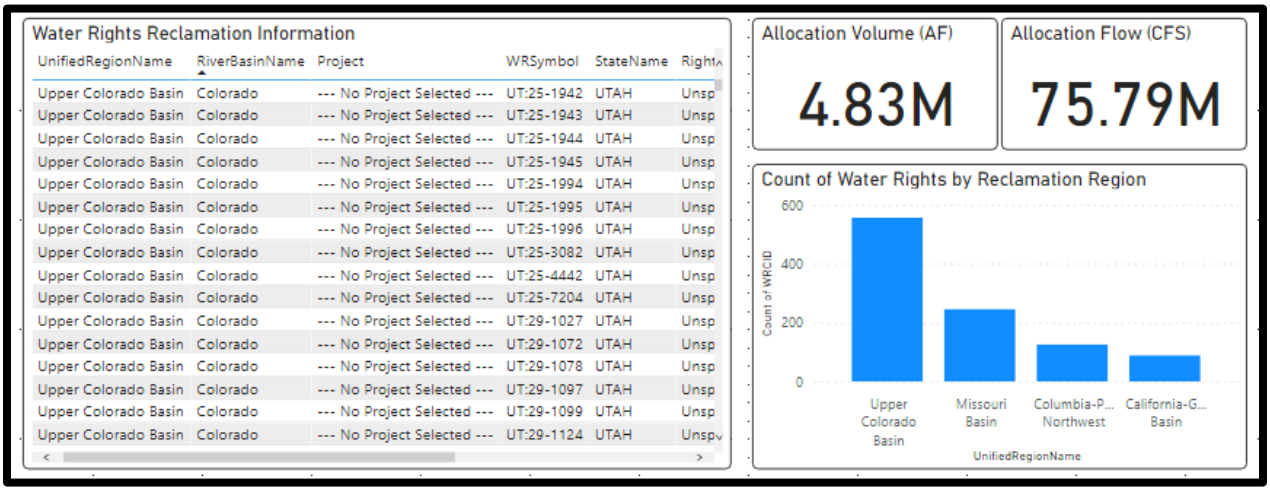


Figure 18. Normalized Power BI Report that shows generic reclamation information pertaining to each water right and total allocation by flow and volume.

WRIMS – Beneficial Use

Beneficial Use – contains the use amount of water that is reasonable and appropriate under reasonably efficient practices to accomplish without waste the purpose for which the appropriation is lawfully made. With a wide range of potential uses and ETL of data for beneficial uses, there are currently 407 unique beneficial use types in the attribute table. There are 1,407 beneficial uses associated with the imported 1,014 water rights, meaning there are potentially 307 water rights that have more than one use type associated to its record. Additionally, of the 407 different beneficial

uses defined in the 17 Western States only 20 have been used, while the top 10 make up nearly 95% of all beneficial uses.

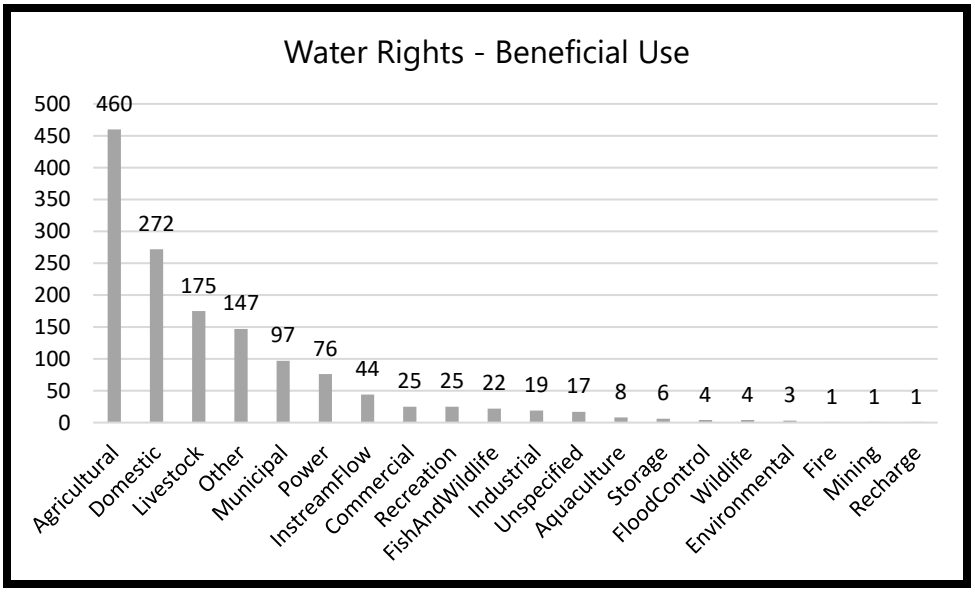


Figure 19. Water Rights Count by Beneficial Use.

WRIMS – Allocation Diversion

Point of Diversion – a specified point of diversion and source of water that incorporates location; the site of diversion showing volume and flow and providing real timeframe for diversion(s). A diversion is removal of water from its natural source by an owner who puts the diverted water to beneficial use. Water right diversions are described by point of diversion sites and amount of water allocated to the site.

Diversion Flow Details

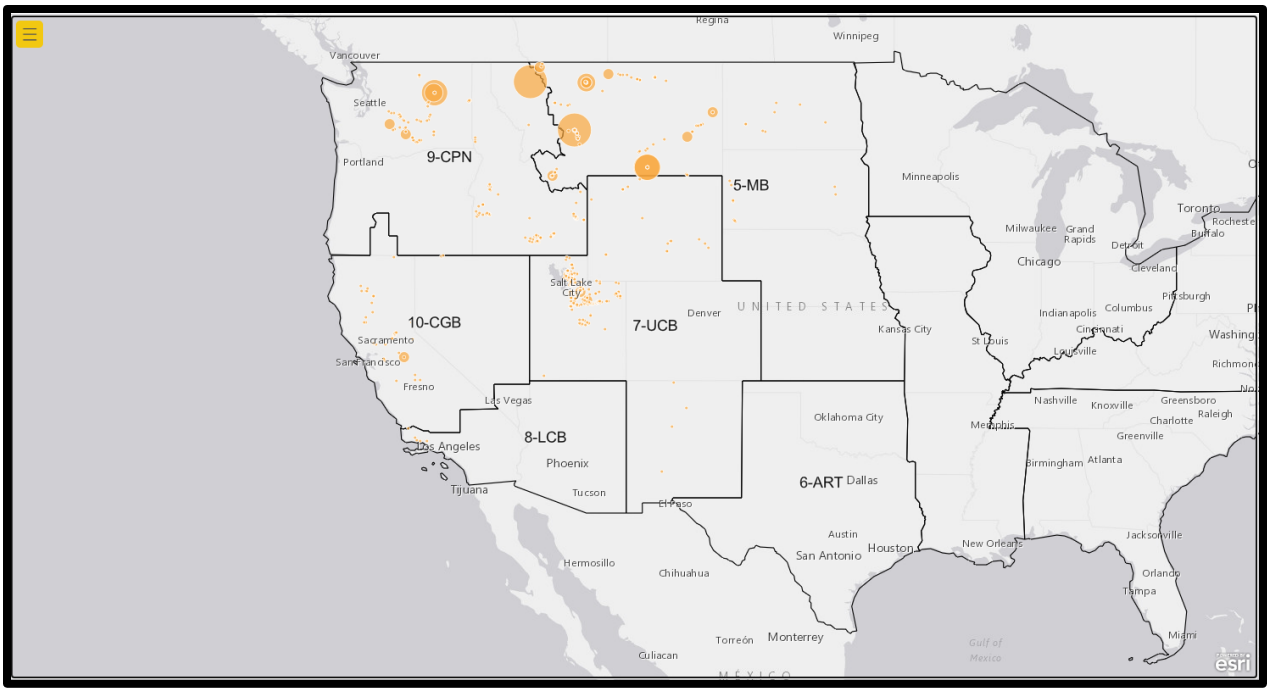


Figure 20. Water Rights Map Data Points Sized by Flow Overlaid with BORGIS Interior Region Layer.

Table 4. Water Rights Allocation – Diversion Accounting for Flow in cfs by State and Beneficial Use.

Beneficial Uses	California	Idaho	Montana	Nevada	New Mexico	North Dakota	South Dakota	Utah	Washington	Wyoming
Agricultural	0	0	5,078,928		-	0	0	2,312,451	10,616,714	0
Aquaculture	0	-	-	-	-	-	-	-	-	-
Commercial	-	-	1,780,127	-	0	-	0	-	-	-
Domestic	1,018,635	0	16,423	-	-	-	0	6	432	-
Environmental	36	-		-	-	-	-	-	37,500	-
Fish & Wildlife	-	-	9,145,566	-	-	0	0	-	-	0
Flood Control	-	-	1,388,095	-	-	-	-	-	-	-
Industrial	0	0	20,379	-	-	-	-	-	-	0
Instream Flow	-	-		-	-	-	-	-	322,576	-
Livestock	-	0	2,531	-	-	-	-	320	-	-
Mining	0	-		-	-	-	-	-	-	-
Municipal	1	-	6,954	-	-	0	0	969,704	-	-
Other	-	-	1,119,141	0	0	0	-	86,991	-	0
Power	0	0	24,999,073	-	-	-	-	0	0	0
Recharge	-	-		-	-	-	-	-	-	0
Recreation	-	-	9,839,501	-	-	-	-	-	-	-

Storage	-	-	6,815,659	-	-	-	-	-	-	-
Unspecified	-	-	207,407	-	0	-	-	3,438	-	0
Wildlife	-	-	350	-	-	-	-	-	-	-
Grand Total	**1,018,672**	**0**	**60,420,133**	**0**	**0**	**0**	**0**	**3,372,910**	**10,977,222**	**0**

Of the 10 States with which the 1,014 water rights were associated, only 4 states have flow values greater than 1.0 cfs. The total amount of diversion allocated by a flow rate is 4,83,937 cfs per year. In Table 4, the top 3 beneficial uses for the water are Dom (24 million cfs), Recreation (9.8 million cfs), Fish & Wildlife (9.1 million cfs), and Storage (6.8 million cfs).

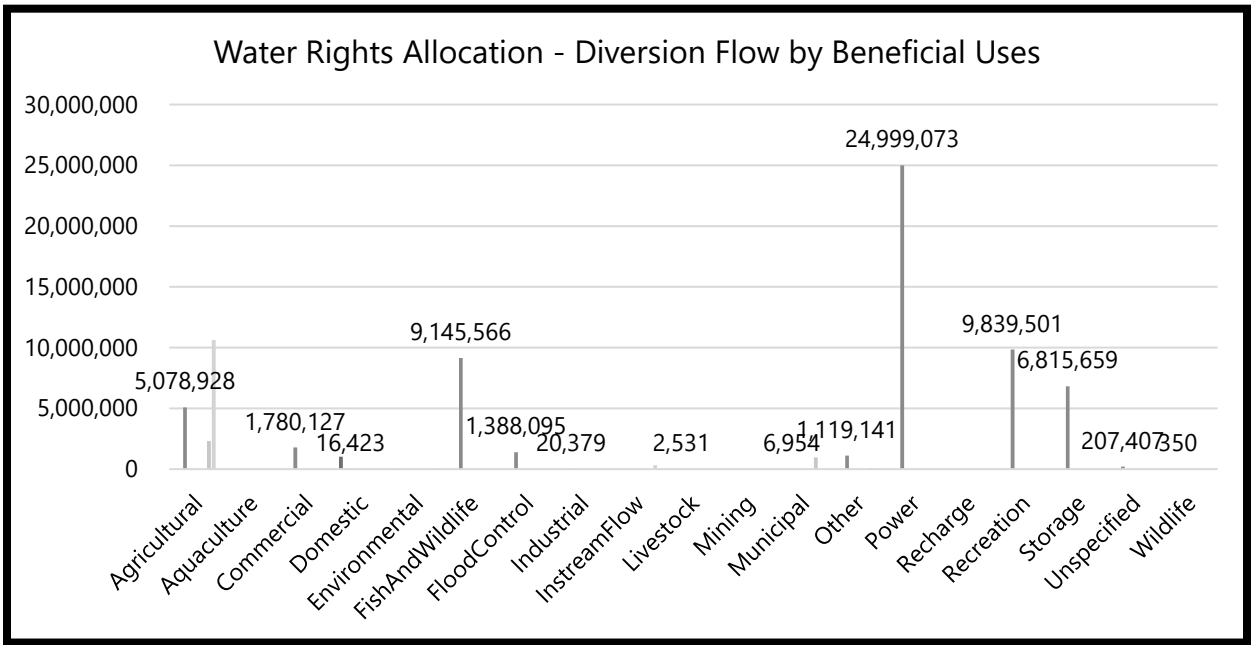


Figure 21. Grand total of Water Rights Allocation – Diversion Flow by Beneficial Use.

Diversion Volume Details

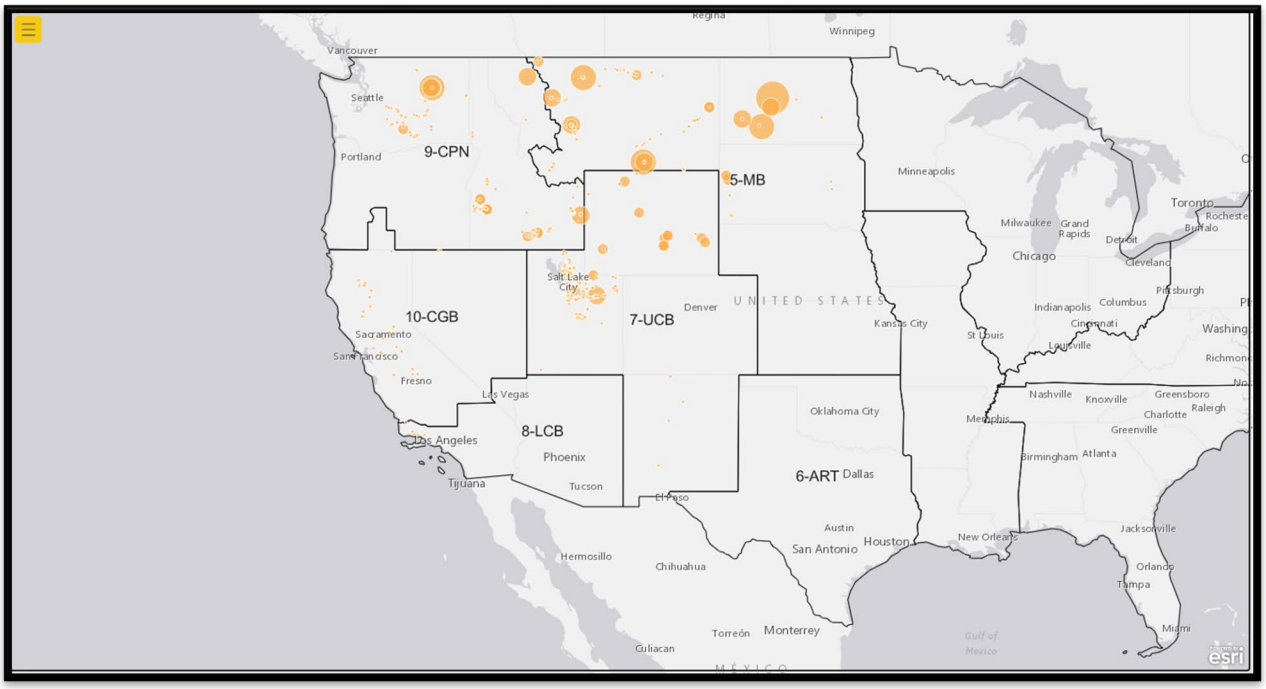


Figure 22. Water Rights Map Data Points Sized by Volume Overlaid with BORGIS Interior Region Layer.

Table 5. Water Rights Allocation Diversion Volume by State and Beneficial Uses.

Beneficial Uses	**California**	**Idaho**	**Montana**	**Nevada**	**New Mexico**	**North Dakota**	**South Dakota**	**Utah**	**Washington**	**Wyoming**
Agricultural	0	9,907	10,777	-	-	212,866	2,880	13,710	16,165	4
Aquaculture	0	-	-	-	-	-	-	-	-	-
Commercial	-	-	1,450	-	0	-	0	-	-	-
Domestic	0	2	2,554	-	-	-	0	0	71	-
Environmental	0	-	-	-	-	-	-	-	305	-
Fish & Wildlife	-	-	33,237	-	-	0	0	-	-	0
Flood Control	-	-	182,775	-	-	-	-	-	-	-
Industrial	0	81	59	-	-	-	-	-	-	5,920
Instream Flow	-	-	-	-	-	-	-	-	507	-
Livestock	-	0	2,010	-	-	-	-	36	-	-
Mining	0	-	-	-	-	-	-	-	-	-
Municipal	0	-	2	-	-	0	0	1,463	-	-
Other	-	-	0	0	0	3,983,690	-	756	-	1,403
Power	0	16,915	73,615	-	-	-	-	2,247	206,000	16,044
Recharge	-	-	-	-	-	-	-	-	-	1,000
Recreation	-	-	2,492	-	-	-	-	-	-	-

Storage	-	-	29,775	-	-	-	-	-	-	-
Unspecified	-	-	850	-	0	-	-	31	-	1,010
Wildlife	-	-	4	-	-	-	-	-	-	-
Grand Total	**0**	**26,905**	**339,600**	**0**	**0**	**4,196,556**	**2,880**	**18,244**	**223,048**	**25,381**

Of the 10 States with which the 1,014 water rights were associated, seven states have volume values greater than 1.0 cfs. The total amount of diversion allocated by volume is 4.83 million af per year. In Table 5, the top beneficial use for the water is Other.

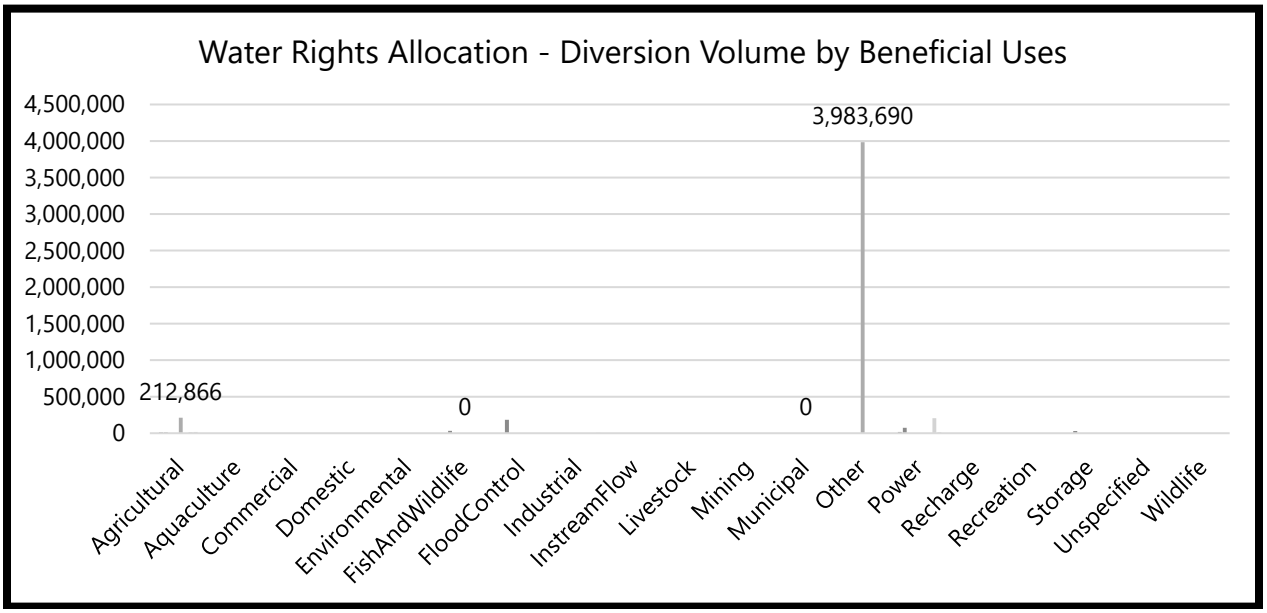


Figure 23. Water Rights Allocation – Diversion Volume by Beneficial Uses.

WRIMS – Allocation Return

Point of Return – a point of return is the point where unconsumed water that has been diverted is returned to a natural source.

WRIMS – Allocation Storage

Place of Storage – a specified place of beneficial use that will show location site of use, use benefit amount, use benefit units, and timeframe for water use.

WRIMS – Allocation Use

Place of Use – a specified place of beneficial use that will show location site of use, use benefit amount, use benefit units, and timeframe for water use. Water use refers to use of water by agriculture, industry, energy production, and households, including in-stream uses such as fishing, recreation, transportation, and waste disposal.

10. Development and Pilot Test

After gathering all regional data and incorporating regional feedback to the scope of the WRIMS database, the next phase involved setting up a WRIMS Pilot Test. These successful efforts were led by the WRIMS Architect Developer, Jesus V. Hernandez, and the WRIMS team. The Test Pilot was tailored for a specific end-user list that incorporated water right specialists from each region, as these are the main individuals/subject matter experts who work with water rights daily.

Custom User Interface – ONE UI/UX

The Omni Networking Environment (ONE) extends the Microsoft and Office 365 experience by providing contextual functionality that users can access utilizing Federated and Azure Active Directory, related resources, and clients. ONE – WRIMS empowers users to get more done by enabling them to access their data and work flows and all the functionality within Office, without context switches or endless navigation.

ONE UI design integrates seamlessly with Microsoft products and Office 365 to provide an efficient, natural interaction for Reclamation users. Take advantage of ONE to provide access to users' work data and utilize built-in best practices when users create new data records or information regarding the data.

ONE Design Principles

ONE applications and modules follow a general set of interaction guidelines. The applications and modules share content and have elements that look and behave similarly. This commonality is built on a set of design principles. The principles help the ONE team create interfaces that support users' tasks. Understanding and following them will help Reclamation support its staff and partners' goals inside of ONE.

Design Explicitly for Microsoft Architecture

The functionality, as well as the look and feel, of ONE is a harmonious complement to Reclamation's mission and visual identity. Modules inside ONE should feel native. They fit seamlessly into Word, Excel, Power Bi, Power Apps, Power Automate, Access, SharePoint, Forms, Project on a desktop, iPad, or on the web. The well-designed modules are an appropriate blend of user experience, the platform, and Microsoft's architecture. Document and UI theming are applied where appropriate. ONE utilizes Fluent UI for the web as a part of the design language and tool set. React front-end framework is designed to build experiences that fit seamlessly into a broad range of Microsoft products. It provides robust, up-to-date, accessible React-based components that are highly customizable using CSS-in-JavaScript.

Favor Content over Chrome

ONE – WRIMS is an auxiliary interface. An important thing is that ONE provides users with a unique, recognizable experience that avoids distraction. ONE strives to keep the focus on content and task completion, not brand attention.

Users in Control

Reclamation users enjoy using products that are both functional and visually appealing. ONE has crafted its user's experience carefully. ONE gets the details right by considering every interaction and visual detail. This allows users to control their experience. The necessary steps to complete a task are clear and relevant to the user to know how to complete the flow. Important recordkeeping decisions are easy to understand. While actions that modify can be easily reversible on the administrative maintenance end, ONE is not a destination – it's an enhancement to Reclamation and Office 365 functionality and integration.

Design for All Platforms and Input Methods

ONE is designed to work on all the platforms that Microsoft Office supports, and the UX has been optimized to work across platforms and form factors, while supporting mouse/keyboard and touch input devices, as well as ensuring that the custom area's UI is responsive to adapt to different form factors.

A test user group and active directory list were established for easy access (during the Test Pilot) for the end-user testers. The total list consisted of 25 individuals. The Test Pilot Workshop consisted of an hour-long presentation and a detailed WRIMS walkthrough for all participants. For this Pilot, a disclaimer was added to the front cover of the database as the WRIMS Test Pilot was populated with sample water rights information gathered from a few Reclamation area and regional offices.

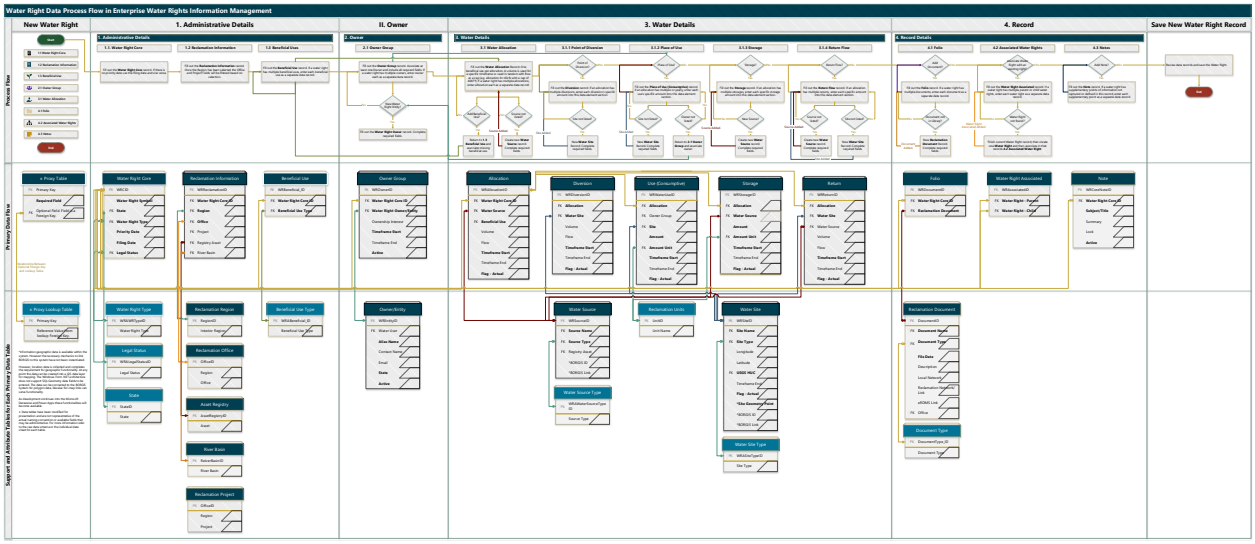


Figure 24. Water Rights Information Intake flow.

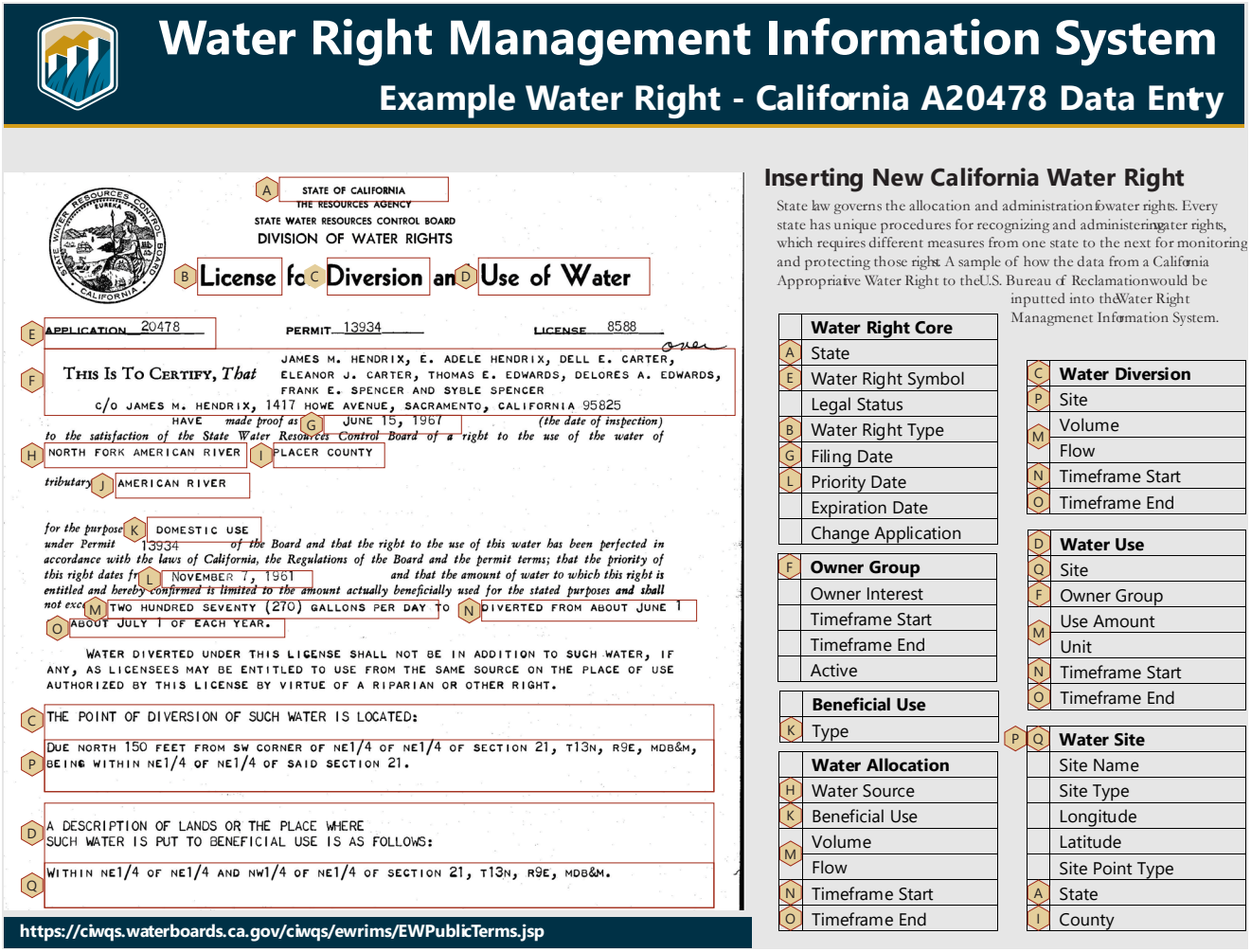


Figure 25. Example Water Right – California A20478 breakdown fields.

11. Application and Project Access

Currently, the WRIMS Pilot Database is maintained on Reclamation's computer network located at the Dam Safety and Infrastructure – Asset Management Division. The WRIMS database files, application files, attribute references, and location is a work in progress. Regional data will continue to be added to the WRIMS database.

Project Folder:

WRIMS file path is located at DFS \\bor\ReclamationONE\

Point of Contacts:

Ginger Dill, Lead S&T Researcher

Jesus V. Hernandez, WRIMS Architect Developer

Active Directory User Group for Data Access:

IBRENTGWtrResources

Azure Active Directory User Group for Office 365:

WaterRightsDatabase-STProjectID20088@doimspp.onmicrosoft.com

Quantity of Files:

~75MB

Data Source Types:

Word documents, .pdf, Excel spreadsheets, Diagrams, Data sets

Integrated Application Types:

- Microsoft Windows Forms .Net Architecture
- Microsoft SharePoint
- Microsoft Power Platform – Power Apps, Power BI, Power Automate,
- Microsoft Stream
- Microsoft SQL Server
- Microsoft Access, Excel, Project
- Adobe Cloud Suite

Non-ONE Enterprise Systems Connected:

- Financial Business Management System
- Bureau of Reclamation Geospatial Information System
- Enterprise Asset Registry
- Enterprise Content System and Enterprise Electronic Record Data Management System

Desktop Application

Upon request, access can be granted to use the WRIMS Application. The user will need to send an email to the Reclamation Enterprise Service Center (RESC@USBR.gov) requesting to be put on the IBRENTGWtrResources group with either Read or Write access. Once the user is on the active directory list, they will also need to be put into the Office 365 Azure Active Directory. The WRIMS desktop Application can be accessed via Reclamation's DFS \\bor\ReclamationONE\setup.exe.

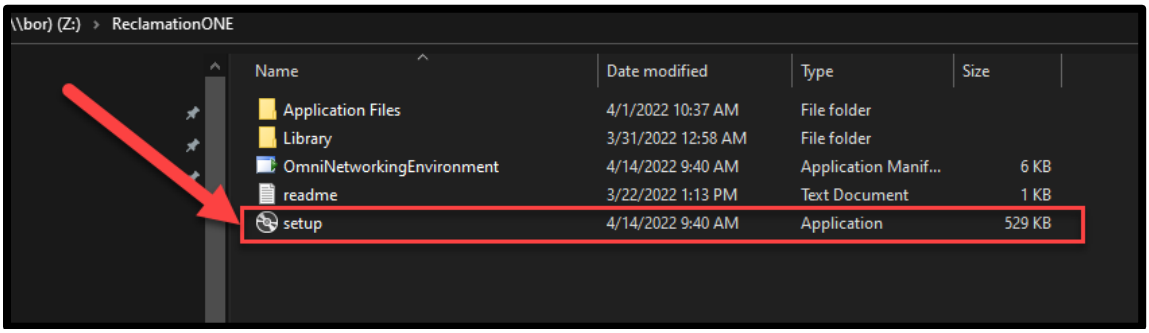


Figure 26. How to navigate to the Corp folder to install the ONE Desktop Application.

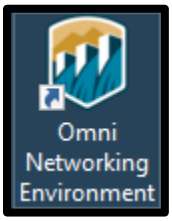


Figure 27. Auto-created shortcut link on desktop for quick application launch.

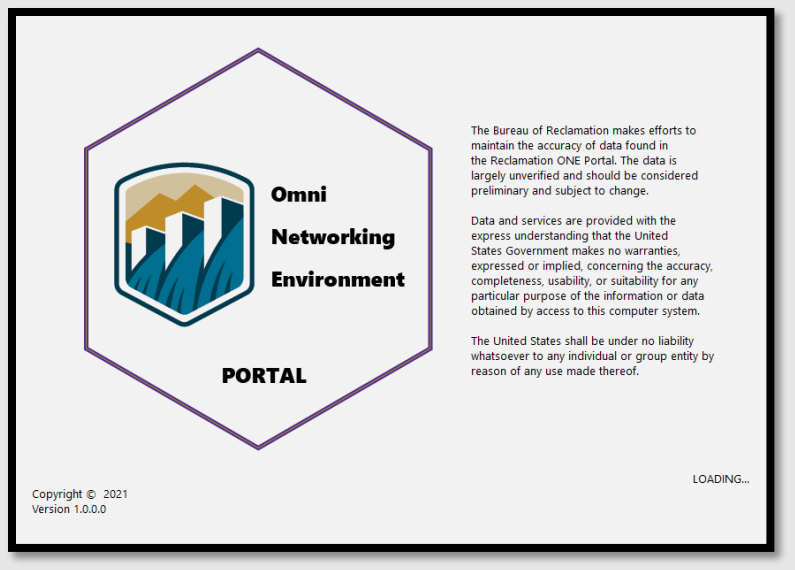


Figure 28. Data Warning Screen Entering into the Reclamation ONE – Water Rights Module.

Figure 29. Reclamation ONE – Water Module Home Screen and Centers

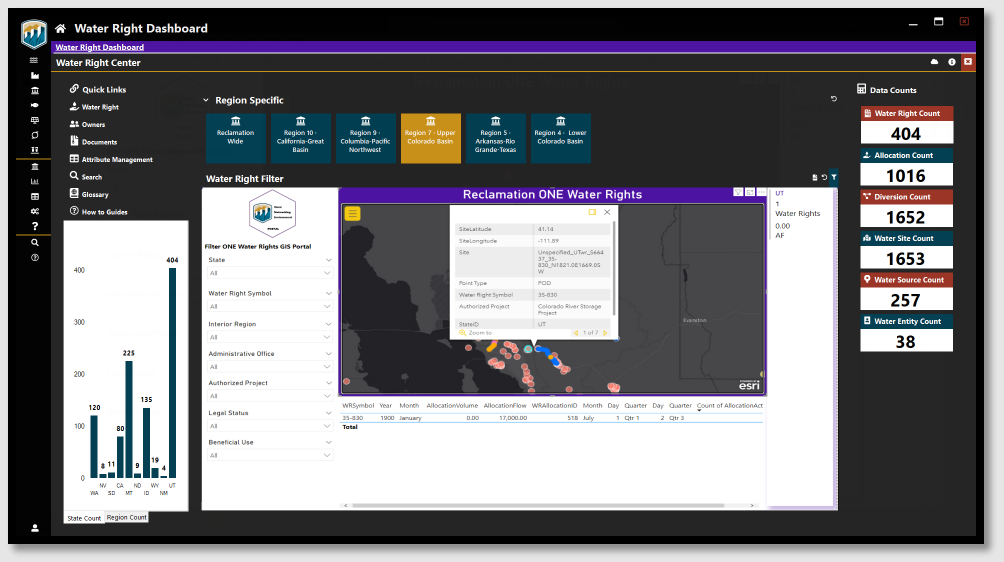


Figure 30. Reclamation ONE – Water Rights Center Dashboard with Microsoft Power BI IFrame in Windows Forms using VB .NET Architecture.

Part of the Test Pilot kick-off included testing an example water right. This was created for testing purposes only. The end-user guides/processes developed were streamlined for easy use, per feedback received from the regional offices and end users. See below a sample of how data from a California Appropriative Water Right to Reclamation would be processed in WRIMS.

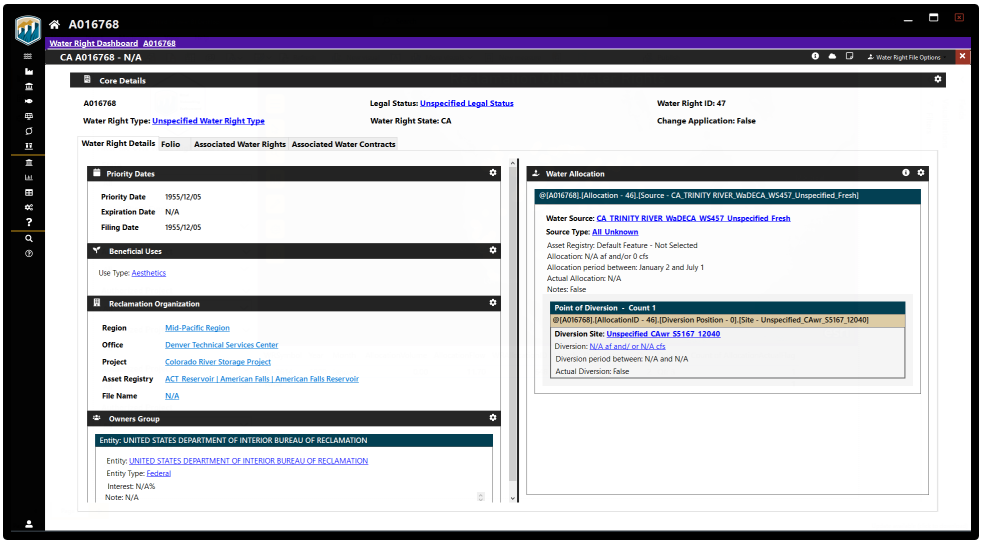


Figure 31. Form view using desktop WRIMS of a single Water Rights with its pertinent details.

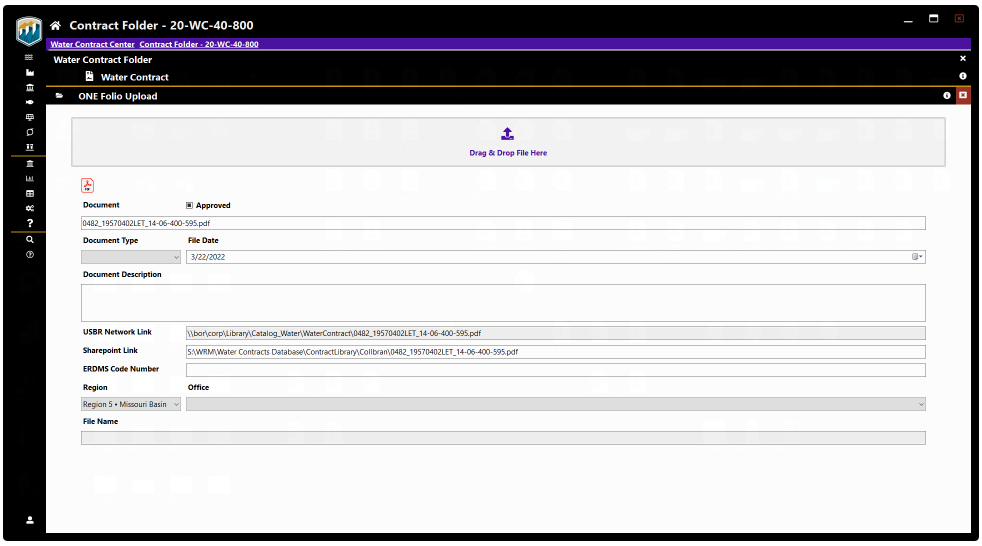


Figure 32. ONE – Water Rights Document Uploading Form.

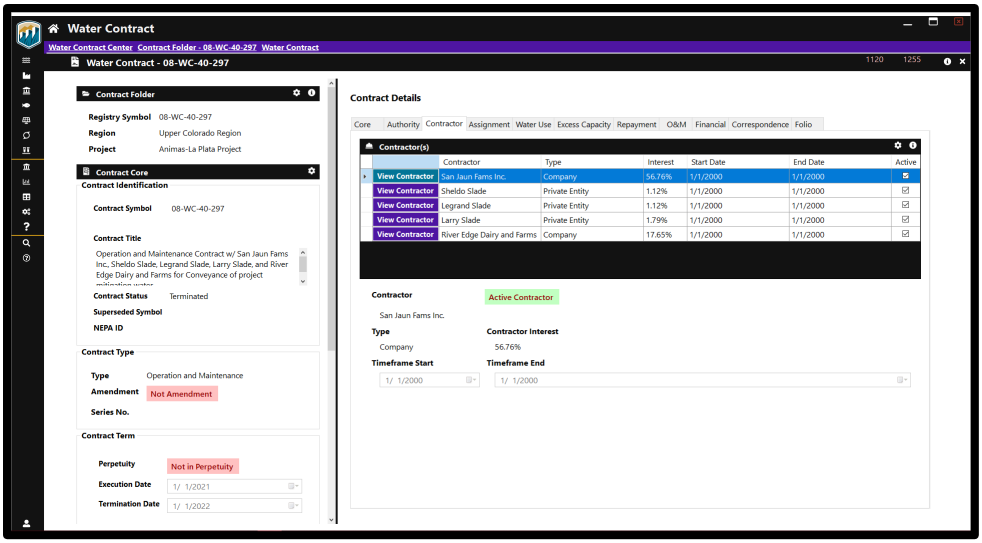


Figure 33. ONE – Water Contracts View data form for 08-WC-40-297.

SharePoint

The modern experience in SharePoint is designed to be compelling, flexible and faster. The modern experience makes it easier for anyone to explore and get fast fact sites and pages that are mobile-ready. With Microsoft SharePoint WRIMS has: an intranet site and pages, document libraries, and lists. With web parts customized to display water rights information. SharePoint for WRIMS shows important visuals, news, and updates to the agency. Additionally, users can perform their daily routine with workflows, forms, and lists. Sync and store water rights files in the cloud so anyone can securely work with the documents.

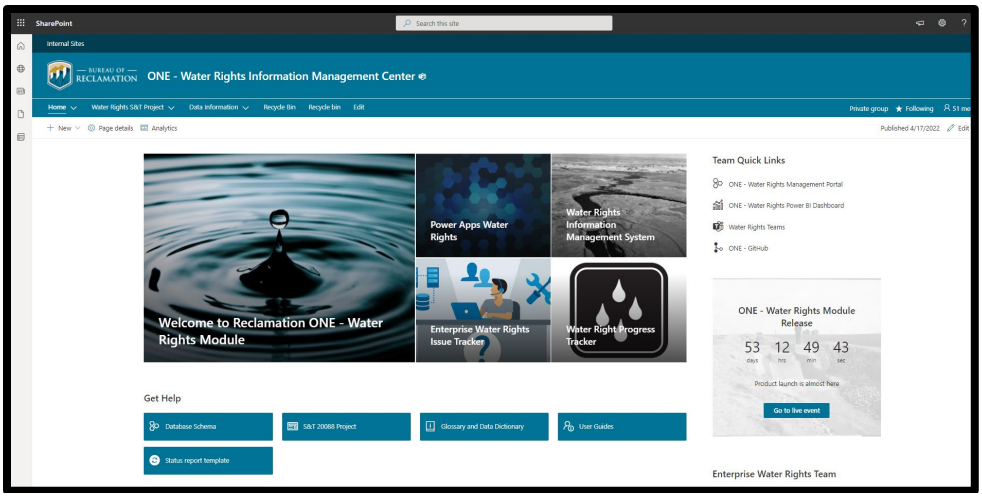


Figure 34. SharePoint Landing page for ONE Water Rights Information Management Center.

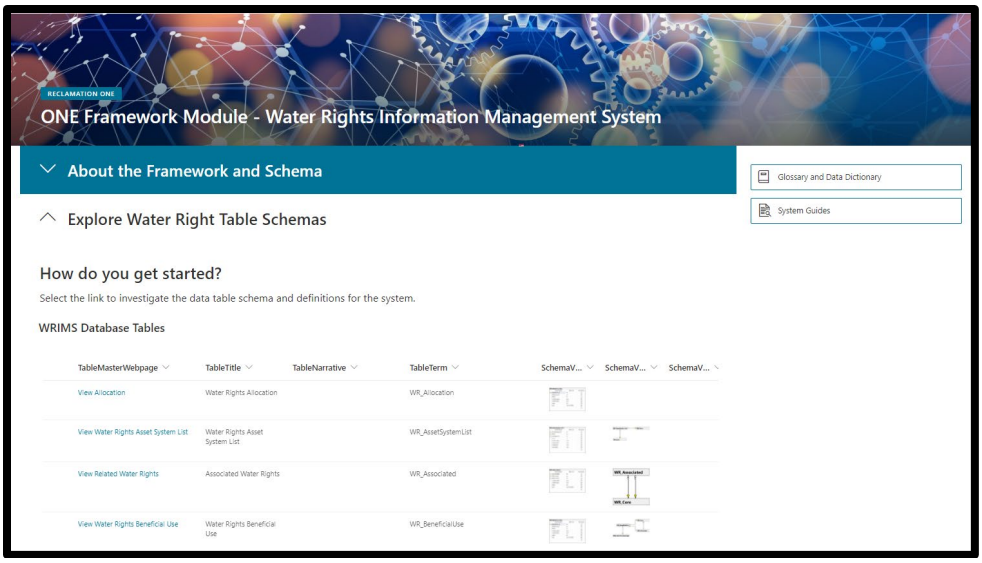


Figure 35. SharePoint site page for exploring water rights table schemas links and views.

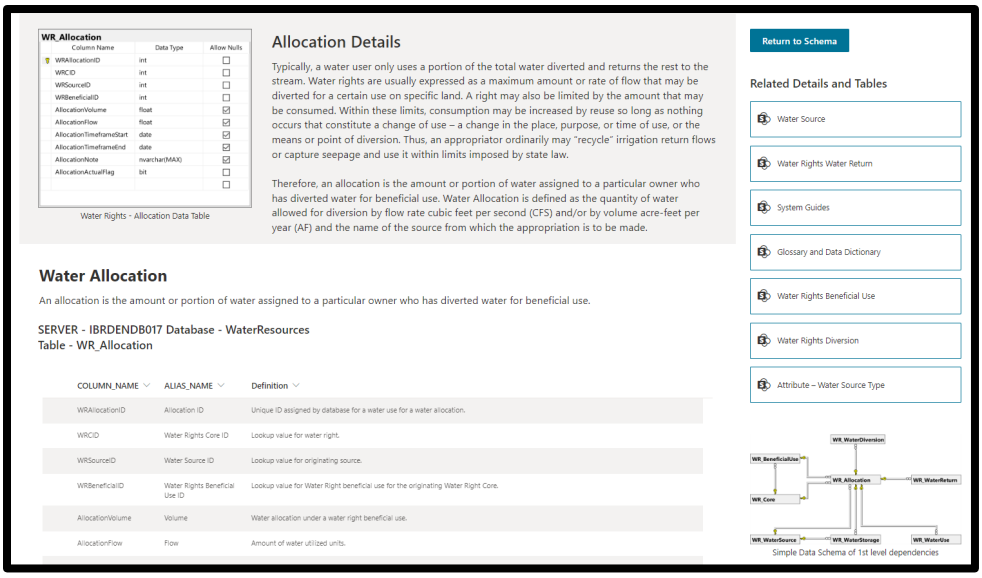


Figure 36. SharePoint site page of water allocation details and associated details.

Figure 37. SharePoint site page of water rights core denormalized details.

Metaverse – Spaces

SharePoint spaces is a web-based, immersive platform, which allows Reclamation to create and share, secure and extensible mixed reality experiences. Adding a new dimension to Reclamation's applications by using 2- and 3D web parts to create a mixed reality vision of Water Rights.

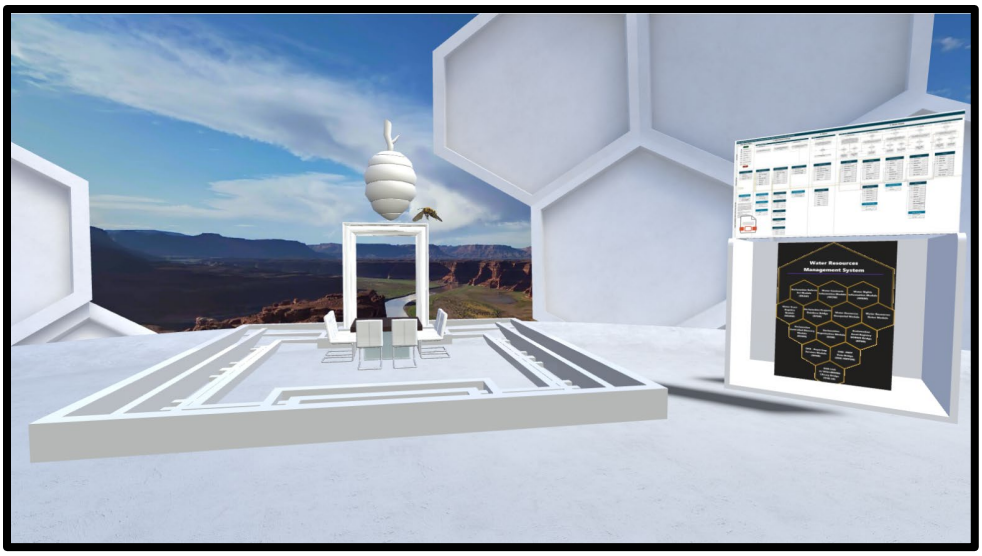


Figure 38. Omni networking environment – Water Rights Information System High level view of how data is in the system relates to the overall environment and mission of Reclamation.

Figure 39. Water Rights Information System Metaverse Data Card – Water Rights allocation.

Teams

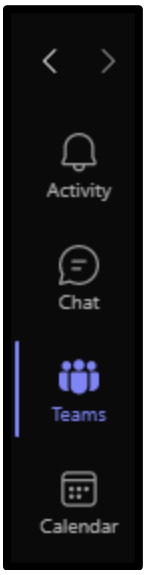


Figure 40. Navigating to Teams on Teams to access ONE Water Rights Information Management System.

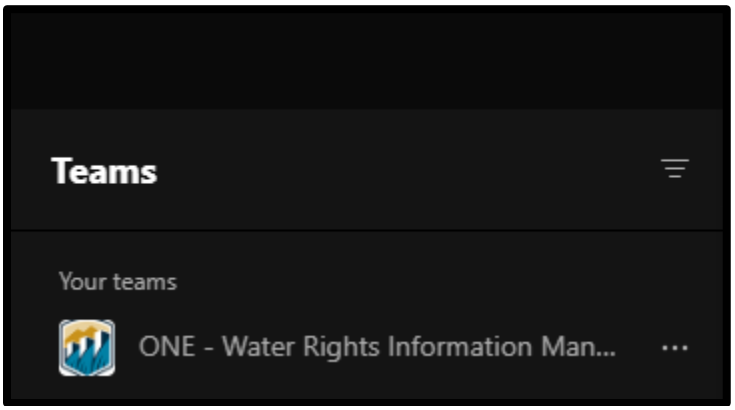


Figure 41. Navigating to Teams on Teams to access ONE Water Rights Information Management System (continued).

Power Platform in Teams

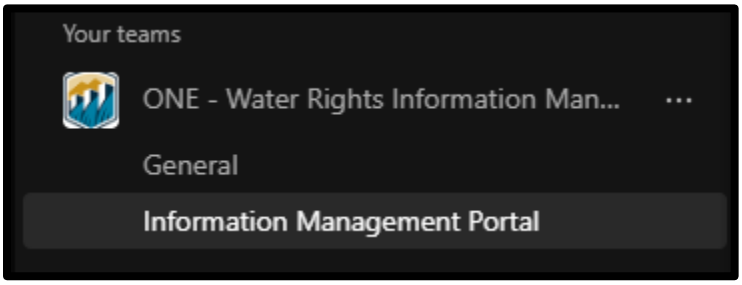


Figure 42. Expand Channel and navigate to the Information Management Portal.

Power Apps Integrated into Teams

Power Apps is a suite of apps, services, and connectors, as well as a data platform, that provides a rapid development environment to build custom apps for Reclamation's business needs. Using Power Apps, Reclamation can quickly build custom business apps that connect to agency data stored either in the underlying data platform (Microsoft Dataverse) or in various online and on-premises data sources (such as SharePoint, Microsoft 365, Dynamics 365, SQL Server, and so on).

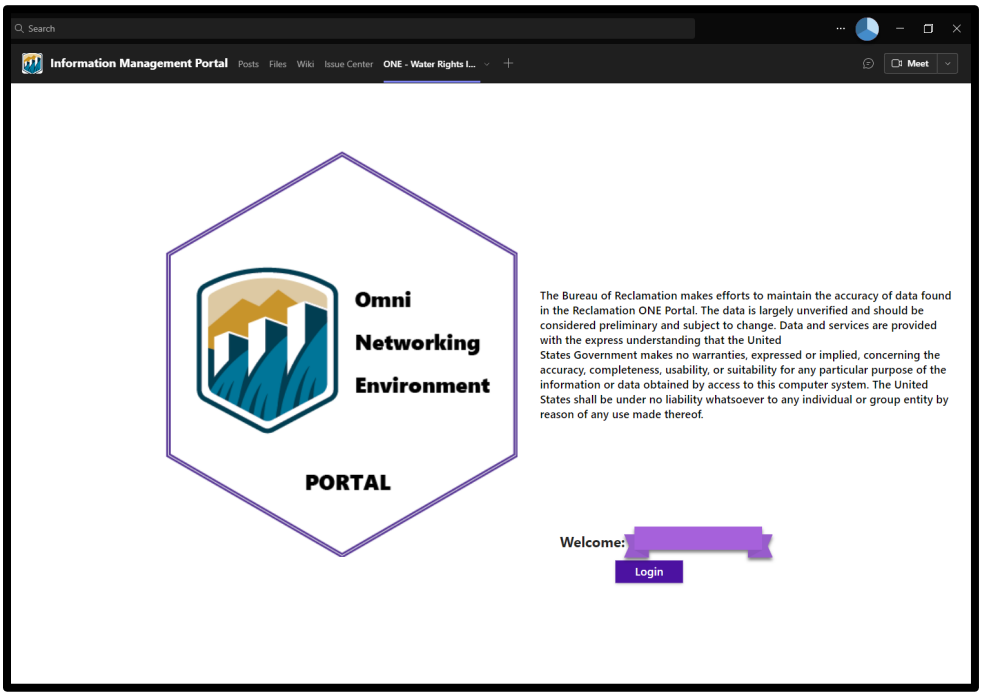


Figure 43. ONE – WRIMS Power Apps Portal Login Page.

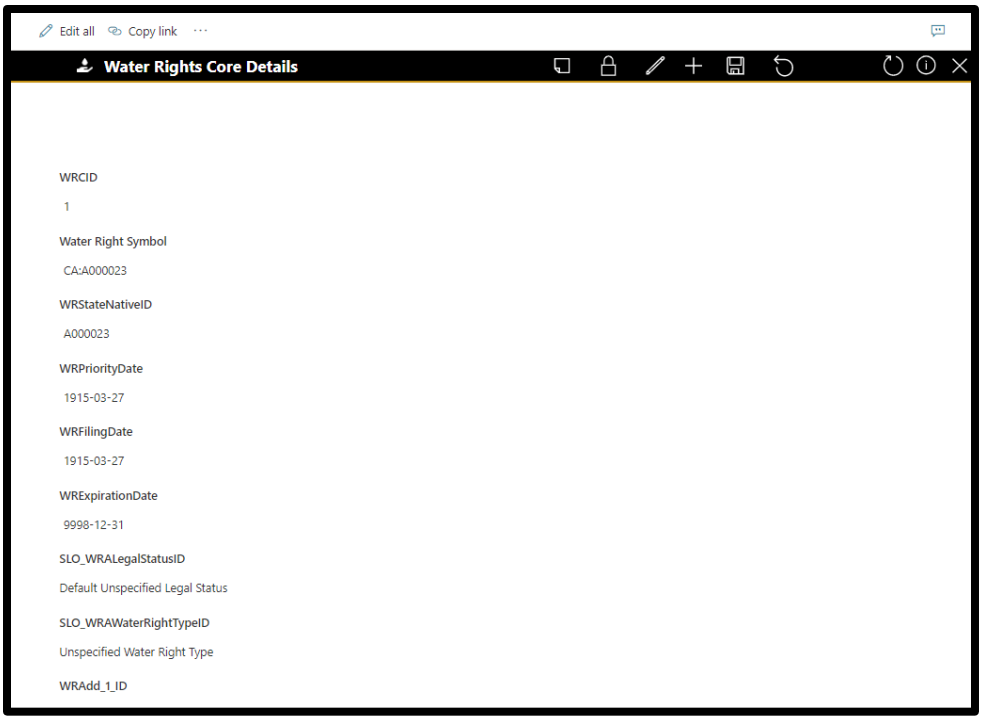


Figure 44. Water Rights – Core Information Details editable within Power Apps.

SQL Database

WRIMS utilizes Microsoft SQL Server, a relational database management system developed by Microsoft. As a database server, it is a software product with the primary function of storing and retrieving data as requested by other software applications—which may run either on the same computer or on another computer across a network. The SQL database is on premise and the software applications are connected to the database through data connectors utilizing the Federated Active Directory for the agency. The figures below show the generic setup of the WRIMS database on IBRDENDB017/WaterResources. There is a mix use of tables and data views giving access to read/write of the data based on the organizations demands.

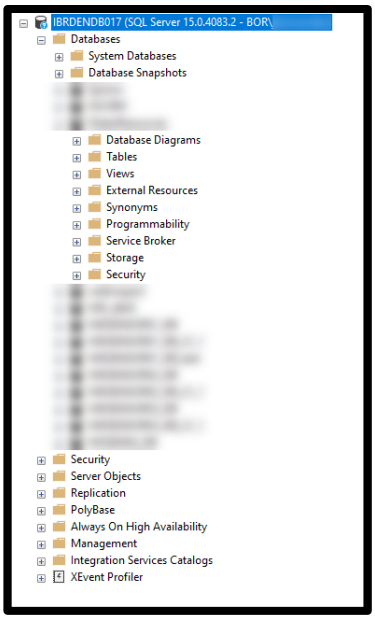


Figure 45. ONE – WRIMS Database setup.

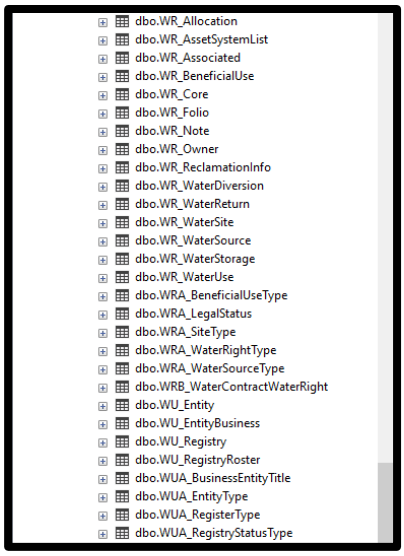


Figure 46. WRIMS – Data Tables.

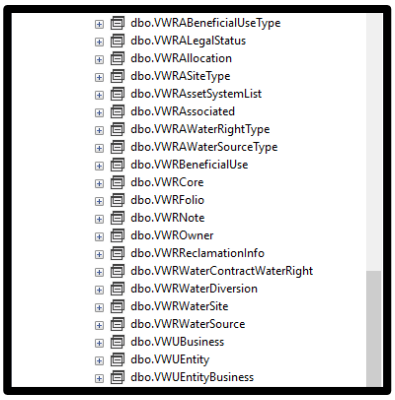


Figure 47. WRIMS View Tables.

Stream

Microsoft Stream (Classic) is an Enterprise Video service where business users in the Department of the Interior can upload, view, and share videos securely. WRIMS has a number of recordings of classes, meetings, presentations, training sessions, or other videos that aid users' experience in the system. Users can find the video content here at [ONE Water Rights Help Portal.]

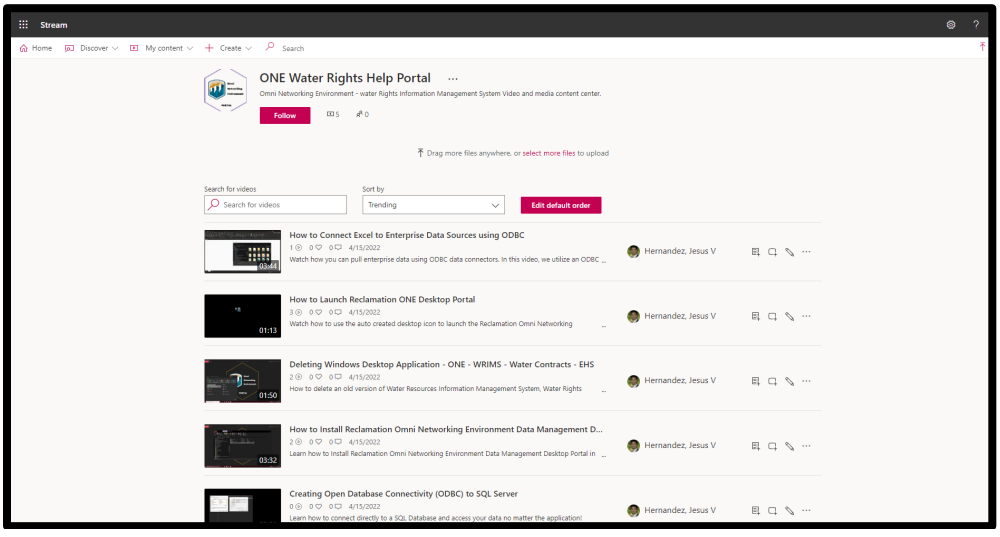


Figure 48. Stream ONE Water Rights Help Portal for dynamic media content.

12. Conclusion

Upon completion of the WRIMS database, end users were able to perform the following WRIMS activities based on major water right and database activities related to the WRIMS database:

Water Right Type Activities

- Enter a water right
- Change applications
- Non-use Requests
- Proof of Appropriation
- Extensions/Petitions
- Administrative

Database Activities

- Research
- Reports
- Visualize geographic data points
- Monitor/Record water right activity
- File/Store water right activity
- Record/Track water right activity
- Set red flags on upcoming action dates
- Create/Produce custom standardized reports

Identified water right specialists from each region will maintain the WRIMS database inventory for their region. This effort requires Reclamation-wide participation to enter and verify all existing water rights. The next steps are to validate GIS components in order to maintain current and up-to-date facility information for the future. These efforts have validation efforts have not been implemented. Dam Safety and Infrastructure is looking at linking the WRIMS database to the Asset Registry under AMD.

As a national leader in water and power infrastructure, Reclamation takes pride in maintaining a state-of-the-art platform and application available bureau-wide to display, edit, and maintain Reclamation asset information. The availability of this enterprise will streamline the water rights processes, therefore, supporting operations and improving the management of Reclamation assets across the West. This is a benefit for Reclamation and the public audience

Developer Comments

In theory, data virtualization can present a data source in any format the analyst needs. But data virtualization trades off the cost of computing at run time with the cost of ETL to build physical tables before run time. Data virtualization is a powerful way to prototype data structures and make rapid alterations or provide distinct alternatives. The best data virtualization strategy is to expect to materialize the virtual schemas when they have been tested and vetted, and the analysts want the performance improvements of actual physical tables.

Big data brings a host of changes and opportunities to IT, and it is easy to think that a whole new set of rules must be created. But with the benefit of big data experience, many best practices have emerged. Many of these practices are recognizable extensions from the data warehouse world, and admittedly quite a few are new and novel ways of thinking about data and the mission of IT. But the recognition that the mission has expanded is welcome and is in some ways overdue. The current explosion of data-collecting channels, new data types, and new analytic opportunities means the list of best practices will continue to grow in interesting ways.

Building Legacy Environments

It's not a good idea to attempt to build a legacy big data environment at this time. The big data environment is changing too rapidly to consider building a long-lasting legacy foundation. Rather, plan for disruptive changes coming from every direction: new data types, competitive challenges, programming approaches, hardware, networking technology, and services offered by literally hundreds of new big data providers.

Assume you will reprogram and rehost all your big data applications within two years. Choose approaches that can be reprogramed and rehosted. Consider using a metadata-driven codeless development environment to increase productivity and help insulate from underlying technology changes.

Although if a proper and correct data structure exists in a framework in which the agency's data is housed and queryable for big data interrogation, then moving towards an omni networking environment may be beneficial to investigate.

Build From Sandbox Results

Consider embracing sandbox silos and building a practice of productionizing sandbox results. Allow data scientists to construct their data experiments and prototypes using their preferred languages and programming environments. Then, after proof of concept, systematically reprogram these implementations with an IT turnover team. IT must be uncharacteristically tolerant of the range of technologies the data scientists use and must be prepared in many cases to re-implement the data scientists' work in a standard set of technologies that can be supported over the long haul.

Build Comprehensive Ecosystems

Reclamation can use big data integration to build comprehensive ecosystems that integrate conventional structured DBMS data, documents, e-mails, and in-house business-oriented social networking. One of the potent messages from big data is the ability to integrate disparate data sources of different modalities. Reclamation can get streams of data from new data producing channels such as social networks, mobile devices, and automated alert processes.

Strive for Performance Improvements

Search for and expect tenfold to hundredfold performance improvements over time, recognizing the paradigm shift for analysis at high speeds. The openness of the big data marketplace has encouraged hundreds of special purpose tightly coded solutions for specific kinds of analysis. This is a giant blessing and a curse. When free from being controlled by a big vendor's DBMS optimizer and inner

loop, unlike the current and redeployment of the Capital Asset and Resource Management Application, smart developers can implement spot solutions that are truly 100 times as fast as standard techniques. The challenge is these individual spot solutions may not be part of a unified single architecture. One very current big data theme is visualization of data sets. "Flying around" a petabyte of data requires spectacular performance! Visualization of big data is an exciting new area of development that enables both analysis and discovery of unexpected features and data profiling. Another exciting application that imposes huge performance demands is "semantic zooming without pre-aggregations," in which the analyst descends from a highly aggregated level to progressively more detailed levels in unstructured or semi-structured data, analogous to zooming in on a map.

Expect to Integrate Structured and Unstructured

Big data considerably broadens the integration challenge. Much big data will never end up in a relational database; rather, it will stay in Hadoop or a grid. But after you are armed with conformed dimensions and durable surrogate keys, all forms of data can be combined in a single analysis. For example, a medical study can select a group of patients with certain demographic and health status attributes and then combine their conventional data warehouses data with image data (photographs, X-rays, EKGs, etc.), free form text data (physician's notes), social media sentiments (opinions of treatment), cohort group linkages (patients with similar situations), and doctors with similar patients.

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Appendix A

Prior to testing and publishing the WRIMS database, survey sessions were scheduled with regional leads. Each region submitted a survey questionnaire that can be found at this link.

Appendix B

The survey results can be found at this link.