



GRAND VALLEY WATER WORKFORCE NEEDS & RELATED OPPORTUNITIES AT COLORADO MESA UNIVERSITY

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Introduction

In a changing water landscape, Western Colorado communities are facing the need to find solutions to new challenges. This report seeks to illuminate the work of people involved in water management, the information and skills they need to succeed, and how students can access water-related professions.

A wide variety of professions across the Grand Valley and western Colorado require some degree of knowledge and skill related to water. These include personnel directly involved in the distribution of irrigation and drinking water, engineers who design water management infrastructure, consultants who develop environmental compliance plans, staff at government agencies with regulatory and stewardship responsibilities, and nonprofits involved in environmental policy, restoration and education.

For this project, Hutchins Water Center staff interviewed over 30 people in a broad cross-section of these organizations in order to better understand their water-related workforce skill and knowledge needs. The purpose was to gain insights into how CMU could better prepare students to enter these professions, and how the Hutchins Water Center could better serve these agencies' continuing education needs. This document can also help students understand water career opportunities and pathways.

The following skills and knowledge areas were listed frequently as important across multiple water-related professions:

- Basic hydraulics
- Math, from basic to advanced calculus
- Strong writing and oral communication
- The ability to do fieldwork
- Project management
- Geographic Information Systems (GIS)
- Supervisory Control and Data Acquisition (SCADA)
- Colorado water law
- Environmental laws
- Hydrologic modeling
- Surveying

As a community, our ability to manage and protect water resources effectively is also influenced by public attitudes and decisions. With that in mind, interviewees were also asked what they wished the general public and community leaders better understood about water. Answers included:

- The magnitude of anticipated water supply challenges
- The importance of water infrastructure
- Policies governing water

CMU faculty then reviewed the needs assessment and provided information on how existing curriculum and capacities do and could respond to our local water community's workforce and community education needs. CMU's Biology, Engineering, Environmental Science, Geosciences and Political Science programs, as well as Western Colorado Community College programs in Agriculture Science, Land Surveying and Water Quality, already do respond to many of the identified needs, although opportunities for enhancements were noted.

Organizations and individuals involved in water management

This section provides an overview of the roles of various individuals and organizations involved in different aspects of water management in the Grand Valley and western Colorado. The subsequent section outlines workforce skill and knowledge needs for people with different roles in these organizations.

Irrigation Water Management

Irrigation water management involves building and maintaining diversions, canals and ditches; ensuring that available water is distributed according to legal rights and priorities; and applying irrigation water to the land. In addition to carrying out these basic functions, various entities assist with projects to enhance irrigation efficiency and reduce the environmental impacts of irrigation.

People and organizations involved in this work include:

- Farmers and ranchers – directly applying water to the land.
- Irrigation water providers – delivering water to farmers and ranchers, as well as to ditches and laterals serving multiple water users.
- Colorado Division of Water Resources – ensuring that water is delivered according to Colorado’s water rights system and ensuring public safety by maintaining safe dams via the Dam Safety Branch. Water is distributed among a multitude of rights, including municipal and industrial rights as well as irrigation rights.
- US Bureau of Reclamation, Water Management Group - managing Reclamation projects, including dams, irrigation structures and other associated facilities, as well as project lands, associated water rights, and other programs within the project footprints. Reclamation also manages programs to improve habitat, water quality and water use efficiency.
- US Natural Resource Conservation Service – assisting farmers and ranchers with the conservation and efficient management of resources on their properties.
- Mesa Conservation District – setting conservation priorities and assisting local landowners with conservation issues, including water management.
- Realtors – educating new residents about how water is managed in our region, including irrigation water.

Water treatment

Water and wastewater treatment starts with the protection and collection of source water, proceeds to treatment and distribution of drinking water, and then ends with collection and cleaning of wastewater before discharging it back into the environment. Organizations involved include:

- Municipal water utilities – collection, treatment and distribution of potable water, as well as collection, treatment and discharge of wastewater.
- CO Water Quality Control Division – inspection of water and wastewater facilities, as well as developing and updating water quality regulations.
- CO Source Water Protection Planning/ CO Rural Water – Colorado Rural Water works with the CO Source Water Protection and Planning Division to assist small utilities with source water protection and the operation of their utilities in compliance with regulations.

- Park facilities – Parks that provide potable water and toilet facilities have staff that carry out the same functions as water utilities for small communities.

Natural resource stewardship, science and regulation

Federal and state land management and regulatory agencies play key roles in managing and protecting water resources. These include:

- US Fish and Wildlife Service – regulation and collaboration with others to conserve, protect and enhance fish, wildlife and plants and their habitats. In the Grand Valley, much of this work involves an extensive, collaborative recovery program to protect and benefit endangered fishes native to the Colorado and Gunnison Rivers.
- US Forest Service – stewardship of natural resources, including water resources, and regulation/ permitting of activities carried out on the Forest by others, including entities involved in drinking and irrigation water management.
- US Army Corps of Engineers – regulation and permitting of activities with the potential to affect wetlands and waterways.
- US Bureau of Land Management – stewardship of natural resources on BLM lands and rivers and regulation/ permitting of activities carried out on these lands by others.
- US Bureau of Reclamation, Environment and Planning section – ensuring that activities on Reclamation land or that use Reclamation funds comply with environmental laws.
- CO Parks and Wildlife – stewardship of natural resources in parks, as well as management of water rights and infrastructure for fish hatcheries, parks, and park facilities.
- Colorado Natural Monument – stewardship of natural resources in the Monument, maintenance of facilities, and education of visitors.
- CO Water Quality Control Division – developing and enforcing regulations to protect water quality.
- US Geological Survey – collecting data and conducting studies on streamflow and water quality.

Consultants

A variety of consulting firms provide technical services for other entities involved in the management and stewardship of natural resources. These types of services include the following:

- Civil Engineering – planning, design and assessment of water infrastructure.
- Hydrogeological consulting – assessing interactions between surface and groundwater and potential movements of pollutants as well as developing monitoring plans.
- Environmental Consulting – assessing potential risks to water resources from built infrastructure, environmental contamination, and planning and design of restoration and treatment strategies.
- Water Law and related technical investigations – assisting with the acquisition and defense of water rights.

Nonprofit organizations: Education, Advocacy and Stewardship

A variety of nonprofit organizations work to protect and restore land and water resources in Mesa County and beyond, as well as provide outdoor and environmental education opportunities. Nonprofit organizations serve a critical role of connecting our community to local streams and rivers, which serves

to elevate the importance of these natural resources. These include Conservation Colorado, Colorado West Land Trust, Colorado Canyons Association, and RiversEdge West.

Workforce Skill & Knowledge Needs

This section outlines the skill and knowledge needs for employees with different roles in the water sector.

Irrigation Management Organizations

Farmers and Ranchers

Western Colorado farmers and ranchers grow a wide range of crops, with the majority of the region's acreage and water dedicated to hay production. Irrigation is necessary to produce crops in this arid climate, and each producer has their own unique combination of circumstances related to water availability, soils and crop needs.

Skill and Knowledge Needs

Irrigators need to understand the basics of Colorado water law, their own water rights, and how that relates to when and how much water they will get. If they have reservoirs or other infrastructure on public lands, they need to know how to comply with the relevant Forest Service or Bureau of Land Management regulations as they conduct maintenance and repairs. They also need to understand and be able to work with the other entities involved in managing irrigation water, including their local Water Commissioner and their ditch company or local water users' association.

Successfully applying water to the land to raise a crop requires substantial technical skill and knowledge of soil conditions and crop needs. In addition, keeping an agricultural operation financially afloat requires the ability to assess the operation financially and do cost-benefit analysis on crop and irrigation choices. There's a lot of risk involved in trying new crops and expensive irrigation systems, but these strategies may become necessary as the region faces drier conditions.

Irrigation Water Providers

Occupations with responsibilities for water management in the organizations that provide irrigation water (Districts, Associations and Companies) include Field Technicians/ Ditch Riders, Field Supervisors, Operations and Maintenance staff, Office Managers, Administrative Assistants and Managers/ Superintendents.

Skill and Knowledge Needs

Entry-level Field Technicians and Ditch Riders spend most of their time dealing with water distribution issues and broken infrastructure. They need to have some knowledge of plumbing, construction techniques, pipe installation, heavy equipment operating, and safety precautions, as well as how water works physically: basic hydraulics. They also need to have the "people skills" to be able to resolve issues between water users. It's also helpful if they have some knowledge of the kinds of legal issues that come into play in relation to managing irrigation water: water law, easements and property rights.

Field Supervisors and Operations Managers make sure that the necessary field activities and maintenance work are being done, as well as use newer technologies, like the supervisory control and data acquisition (SCADA) systems to manage large water distribution systems. They also need to understand the hydraulics of water in rivers, canals, and pipelines.

Office and administrative staff take care of business management, accounting and answering phones. They need to have basic knowledge of easements, water law, and how the district runs in order to handle shareholder inquiries.

Managers and Superintendents who oversee entire systems need to not only understand their own systems, but also how their systems fit in with water law, basin dynamics, other water organizations, and the latest developments on managing water in the Colorado River. An emerging need relates to the conversion of large amounts of agricultural land to residential housing. According to one interviewee, irrigation providers have to figure out how to blend 19th century law, early 20th century infrastructure and 21st century expectations to keep their constituents happy.

Basic skills broadly needed across occupations for irrigation providers include basic writing skills and basic math: geometry, measurement, and calculating volumes.

Continuing Education

Continuing education that is useful for the irrigation provider workforce involves strengthening and obtaining practical skills in areas like irrigation plumbing, valve maintenance and installation, welding, heavy equipment, construction skills & safety, business management, accounting, rigging, safety, CPR and traffic flagging.

An orientation to water in the Grand Valley and on the Western Slope would also be useful for irrigation provider employees: the general “plumbing” of the Grand Valley, mixing classroom instruction and tours. This would help them do their jobs better and look more credible to the public they serve.

A water certificate program that could be useful for potential managers would cover water management skills, soil-water-plant relationships, practical applications of irrigation concepts, hydrology, river dynamics and easements.

For board members and supervisors, information on water management, policies and regulations is valuable.

Colorado Division of Water Resources

The Colorado Division of Water Resources has the responsibility for ensuring that water rights are administered in accordance with the state’s priority system. Entry-level Deputy Water Commissioners have permanent, part-time, 6-9 month seasonal positions. They provide the boots on the ground for the agency, turning headgates and inspecting water court applications. Full-time Water Commissioners are responsible for an entire district, and Lead Water Commissioners supervise Water Commissioners and Deputy Water Commissioners. The Division of Water Resources also employs engineers, office staff and augmentation groups that review augmentation plans, collect diversion information, and manage reservoir releases to replace out-of-priority diversions and depletions.

Skill and knowledge needs

For Deputy Water Commissioner positions, people need, at a minimum, a high school education and typically a year or more of work experience in water use or water management. The Division needs people who understand the dynamic and variable nature of water, measurement of open flowing water and detained water, and basic information about water uses. A fundamental understanding of the Doctrine of Prior Appropriation is absolutely necessary, and self-motivation and the ability to learn on the job are necessary for career development.

The way water moves through each drainage is different, and Water Commissioners need to understand the hydrological particularities of their territory. Understanding basic hydrology helps with learning those local particularities quickly. Any kind of extended work experience related to water is helpful, and knowing the terminology of water is a huge benefit.

Education can replace work experience to some extent. The Division does hire new university graduates. A mix of a degree and experience is most competitive, as applicant pools get narrowed from around 50 to about half a dozen finalists for positions. Desirable degrees include Outdoor Resource Management, Forestry, Environmental Science, Engineering, and Geology.

Basic knowledge of Colorado water law is important to start with; more in-depth understanding can be taught on the job. The Division does a lot of in-house and on-the-job training. Great communication skills are important for communicating with water users, managers, consultants, engineers and attorneys. One of the workforce challenges is finding qualified people who are willing to relocate to the basin they will serve, which can be remote, like the Plateau Valley.

Water Commissioners can advance within the state system to positions with more responsibilities without additional education or an engineering license. These positions include Augmentation Coordinator and Hydrographer. The state is continually seeking to achieve efficient, effective and elegant operations, and positions may become available as needs change and arise. Key skills to advance include hydrologic modeling, being able to read and interpret a water right decree, GIS skills, and Excel operation and manipulations in order to track different “colors,” or legal classifications, of water as they move through a system.

There are other career opportunities within the Division of Water Resources apart from Water Commissioner that do not require any formal higher education degree or certification. Non-management positions like the Hydrographic and Dam Safety branches do require more technical backgrounds, and, in some cases, an engineering license.

Most upper level management positions in the Division require some kind of engineering degree. It’s also important to have enough legal knowledge to interact with lawyers and help with water court applications, and to understand trespass and easement laws and a few key statutes.

Career Pathways

To break into employment with the Division is difficult, as there are a limited number of sought-after positions. It helps to be willing to start as a Deputy Water Commissioner and work your way up from there, but this is not a requirement. Many employees have been hired from the private sector with pertinent skills, knowledge and practical application. Work experience within other state agencies, such as Parks and Wildlife and the Division of Water Quality can also develop the necessary skills. Advancement from within is easier, however, since the work experience is directly applicable.

Internships are another potential opportunity, but they are tied to the state budget. There's also potential interest in having CMU students work as seasonal employees to develop their skills and address the difficulty the Division has with finding people willing to relocate for seasonal, entry-level positions.

Continuing Education

Existing Hutchins Water Center programming on topics like water shortages and demand management is helpful for Division employees. The "Water Law in a Nutshell" classes are useful for new employees both for the information and the networking opportunity. Getting to know water users and developing a professional relationship with them with respect and mutual understanding is helpful.

US Bureau of Reclamation – Water Management

Positions in the Bureau of Reclamation's Water Management Group include Hydraulic Engineer or Hydrologist, Civil/ Hydraulic Technicians, Repayment/ Contracting people, and running Reclamation's Water Conservation Field Services funding program.

Skill and Knowledge Needs

Civil and Hydrologic Technicians are entry level positions and require basic civil engineering skills, hydrology, and geology knowledge. People in these positions need to be prepared for problem solving and know how to do field work and take hydrologic measurements. A surveying background is also helpful for Technicians. Construction management and project management skills are useful. They need to be comfortable with technology and instrumentation out in the field, as well as basic information technology. GIS and GPS skills are useful for working in the Bureau, which is expanding its geospatial databases.

For the Hydrologist position, Reclamation needs someone who can run the RiverWare modeling tool to put together daily operation models. They need to be comfortable writing code for that, setting up operation models and planning models that look at current year operations with a suite of different inflow scenarios and assess probabilities.

Communication skills are important, as is the ability to work with different stakeholders with different goals to come together to solve problems.

Continuing Education

For continuing education, Reclamation sends people to classes on RiverWare at the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado. Water law classes, like "Water Law in a Nutshell," are a good introduction. Something similar but more advanced and geared towards engineers and scientists would be useful. The Hutchins Water Center's seminars and forums are good for getting a bigger picture, bigger river perspective. Content tends to be similar from year to year, so the Bureau sends new people to these courses.

Leadership classes are helpful for learning how to work with other people with different objectives. Reclamation staff have done the Water Leaders course through Water Education Colorado and the Bureau's internal leadership courses.

Partnership Opportunities

It would be beneficial to have someone who could get on the ground and work with the water resources organizations to identify opportunities for grants and how Reclamation could help fund water conservation projects. This could be an opportunity to partner with Water Center. Reclamation needs to know what water users need for delivery systems, not on-farm systems. Reclamation has done workshops and would like to have more in order to publicize grant opportunities and walk people through the application process.

Reclamation also has a lot of old maps related to projects that they are working on putting into GIS. That's an area for potential senior projects.

Career Pathways

Internships are available for students, and that's a good way to get started with Reclamation and get exposed to different work areas. Most people come into Reclamation with a bachelor's degree, and then advancement depends on what they learn along the way. A person who comes in with a technical background, basic problem-solving skills and a willingness to learn can do well. It's nice if someone comes in with a Professional Engineer (PE) credential, but Reclamation helps people get that certification. A PE isn't required for a lot of positions.

US Natural Resources Conservation Service

Personnel with the Natural Resources Conservation Service (NRCS) assist farmers and ranchers with the conservation and efficient management of resources on their properties, including irrigation water, by providing technical and financial assistance for voluntary conservation measures. Positions include Conservation Planners, Technicians and Engineers.

Skill and knowledge needs

Conservation Planners with the NRCS need to be able to identify resource concerns in the field, such as water distribution, quantity and quality challenges. They need to understand water law, basics of irrigation and irrigation water management. More detailed information on relative efficiencies of different irrigation systems can be learned after they are hired. It is helpful if they have an agricultural background. Range management positions are harder to fill than others. Requirements include a natural sciences degree with a certain number of soils credits. It is really helpful for candidates to have had direct experience with some kind of natural resource management through an internship or summer job, particularly if that experience involved working with private landowners in voluntary conservation, with a role involving facilitation and not regulation, with projects driven by landowner interests.

Technicians and Engineers assess water rights and crop water needs and then design a system. They have to understand water law, water rights, crop needs and water volume and flow calculations. Some of that can be taught on the job. Technical skills include the ability to use auto-CAD computer-aided design software and survey equipment, including GPS.

Technicians don't necessarily need a college degree. To be an Engineer, you need to have an engineering degree of some kind, but a Professional Engineer credential is not necessary. However, because Engineers design systems to convey water, they need to understand hydraulics. Some in-house training is available for planners and technicians. Also, with increasing desire for irrigation systems to become

more efficient, there's a need for skills with designing sprinklers, which also requires an understanding of soil health, because that plays a role in what kind of system will work in a given location.

For technicians and planners, coming in with GIS, AutoCAD and survey experience enables them to hit the ground running a lot faster, although training is available if they don't. Spreadsheet and database skills are also helpful. It's getting harder for the NRCS to find applicants with agricultural backgrounds and experience assessing resources and natural systems, particularly hands-on experience.

Career Pathways

The NRCS has Earth Team volunteer opportunities, and it is possible to get internship credit. Having this experience with the NRCS would make an applicant much more competitive. Student internships are another good avenue for getting relevant experience. Internships through the Pathways program are typically advertised in the middle of winter. In addition to working on irrigation systems, there is also a lot of potential for work on rangeland health and forest health.

Mesa Conservation District

Conservation Districts are special districts with elected boards. They have the latitude to work with federal, state, special district moneys, with corporations, schools, individuals, etc. with anyone who wants to help achieve conservation activities that the landowner wants to achieve. Typically, their main objectives relate to soil health and water, and they focus a large part of their energy on helping farmers and backyard gardeners understand efficient water use.

The Mesa Conservation District currently does not have any employees, but is planning to hire a manager soon. Important skills for working with the District include the ability to connect with landowners, build partnerships and bring disparate groups together who may not share the exact same vision – but they share enough parts of their visions to get jobs done on the ground. Grant writing and administration capabilities are also important.

Continuing Education

It is helpful for Conservation District board members and staff to understand who the players are in the local watershed and larger region.

Partnership Opportunities

The District can get grants to give educational seminars and pay speakers, and they need to be able to promote these. The District could also potentially set up a mentoring program for people interested in getting into farming.

Realtors

Realtors play an important role in educating new landowners about how water management works in the Grand Valley – even though they aren't necessarily always very knowledgeable about the topic themselves. At the most practical level, irrigation needs and how to access irrigation water are most important: which water provider to contact for which locations, how to get access to irrigation shares, and negotiating dynamics between homeowners' associations and irrigation water providers.

Partnership opportunities

The Grand Junction Area Realtors Association (GJARA) has an education committee that puts together courses, which the Hutchins Water Center could help with and get accredited for continuing education credit. There's an effort to develop a "local expert" designation, and taking a course on water would be a requirement for getting that designation, an idea borrowed from Vail. Strengthening communication between the Center and GJARA would be helpful.

Water Treatment

Municipal Water Utilities

The collection, treatment and distribution of domestic water, as well as the collection, treatment and discharge of wastewater, are highly regulated activities with significant technical requirements. Utilities range from specialized entities serving larger populations to "jack of all trades" utilities that carry out all functions for smaller towns. Public lands agencies with visitor facilities also have to run small water treatment systems, so they need people with similar skills.

Skill and Knowledge Needs

In municipal utilities, there are some positions for which much of the training can be done in-house, such as plant operators, field technicians, and people taking care of the watershed. For others, such as lab personnel, personnel running SCADA systems, electricians and engineers, employees have to come in with a good base of experience.

For a larger utility like the City of Grand Junction, entry level jobs include Operator positions in the water plant and pipeline maintenance. Both of these jobs have four levels of certification, and employees can move up as they pass tests. Many applicants come in with little experience and get training on the job. To get hired, it is helpful to have some kind of water-related experience, such as working in a water lab or reading water meters. Some kind of water or utility experience helps employees understand how a utility operates. On the mechanical side, skills with SCADA and low voltage electrical systems are important. A person who has aptitude, a base of scientific understanding, which could come from a degree in math or science, good communication skills and a good work ethic can be trained to run the plant.

Pipeline maintenance is the entry level work for water distribution systems. This involves fixing water leaks, doing valve maintenance, flushing hydrants and installing pipelines. For this work, people need mechanical aptitude, and to be good at handling conflict and other interpersonal issues in a professional way.

Water quality labs employ analysts and specialists, and these are generally middle-tier positions, for which employees need to come in with lab skills, although entry-level technicians may be able to be trained on the job. People with chemistry majors and medical technology backgrounds are often hired, or people with experience working in other labs.

In smaller utility systems, every employee needs to be able to do everything to manage the system. People are cross-trained, getting trained on the job or via training from equipment salespeople on their products.

In-demand Skills

It's hard to find applicants with skills in SCADA and electronics, as well as computer programming skills and the ability to display information in visually appealing and understandable ways. A growing need for operators is to be able to do the paperwork to explain what they are doing and prove that it is working. This is a different skill than being able to operate the plant effectively.

Consultants

Consultants are occasionally hired to do SCADA and electronics work, meter calibrations, engineering design, project management, and hydrologic and hydraulic modeling to evaluate water supply reliability and storage and distribution infrastructure.

Continuing Education

Hutchins Water Center programming and other seminars are useful to help staff understand the context they are working in, although it's hard to get people to attend evening programs. It would be useful to learn more about the historic user pool (HUP) and coordination of flows on the Colorado River.

The City of Grand Junction Utilities sets up a training for distribution operators, and there are seminars for backflow protection and other issues for operators. These could be open to students, too, which would be helpful in exposing them to current practices. The Western Colorado Water Users Conference is another good venue for learning. Vendors bring out hardware that attendees can see and touch, and it provides an opportunity to learn about current, real world issues operators are dealing with.

Southwestern Colorado Community College is developing a type of operator training that would be useful to have locally, which provides hands-on learning with a working plant.

CO Water Quality Control Division

Water Quality Control Division regulatory staff inspect drinking water systems and regulated dischargers for compliance with the Safe Drinking Water Act and the Clean Water Act. Other groups focus on stormwater management and the protection of domestic water supply watersheds (source water protection).

Inspectors work with the regulated community to try to achieve compliance, as well as monitor for violations. They try to educate treatment plant managers and local governments about new regulations that are under development that could require plant upgrades so that sufficient funding is budgeted for upgrades and new regulations don't come as a surprise. The Division also employs some engineers to review design plans and check calculations.

Skill and Knowledge Needs

Inspectors should be well-versed in regulations, such as Regulation 11 under the Safe Drinking Water Act; Regulations 84 and 85 on biosolids and nutrients, as well as Regulation 100, which deals with professional guidelines for system operators and reporting issues. New issues on the horizon include temperature regulations on discharges from treatment plants, nutrients and algae.

New hires in the Division need to be curious and like to learn. Wastewater treatment plants use mostly mechanical processes and microbes to process waste, while drinking water treatment plants rely more

on chemicals and filtration to treat raw water. Entry level workers don't have to have a science background, but they need to be observant and have some mechanical knowledge. For the chemistry and biology, there are "cheat sheets" to look up what is needed for key processes.

Continuing Education

New hires initially shadow experienced inspectors, and then get more involved as they gain more experience. Then the experienced person shadows the new hire. They start with inspecting simpler systems.

The ability to interpret regulations is important, and is addressed with regular meetings and continuing education on the job. The Rural Water Association and other organizations give seminars for which participants can obtain continuing education units, which are required for license renewals.

CO Source Water Protection Planning/ CO Rural Water

Colorado Rural Water serves water utilities in a couple of ways: providing free source water protection planning for rural communities (paid for a grant from the Colorado Department of Public Health and Environment), and technical assistance and continuing education for system operators.

Skill and Knowledge Needs

To create source water protection plans, CO Rural Water Source Water Specialists gather stakeholders who, as a group, identify potential threats to raw water supplies for drinking water (source water) and what to do to protect the source water from those threats.

The job requirements for a Source Water Specialist are to have a degree in a water-related field, and then experience with how to apply the academic knowledge. A Source Water Specialist needs to have enough technical and scientific knowledge related to water and wastewater treatment to be able to have conversations with stakeholders about these topics. They also need facilitation skills and the ability to handle heated conversations. Finally, it's important to have very strong writing skills, with the ability to produce writing that can be understood by people with no more than a high school level of education.

Providing technical assistance to rural water systems involves supporting individuals who are juggling a lot of different tasks. These individuals may have to run emergency response, dispatch, firefighting and drinking and wastewater treatment for their communities. Recognizing the stress these folks are under and finding ways to help communities fill in for each other can help a lot, as can helping them find and apply for grants.

Natural Resource Stewardship and Regulation

State and federal agencies with natural resource stewardship and regulation responsibilities often have to carry out two kinds of activities: promoting the health of the natural resources they are responsible for and making determinations about whether to issue permits for activities, as well as monitoring for compliance. Personnel for the agencies can be more focused in one area or another, or have a blend of both kinds of responsibilities.

US Fish and Wildlife Service

US Fish & Wildlife Service divisions with a presence in the Grand Valley and Colorado include the Ecological Services Division, which focuses on endangered species; the Fisheries Division, which gets out on the river and manages non-native fish in order to benefit native fish; the Water Rights Division, which works on managing and being efficient with the Service's water rights; and the Colorado River Program, which works with other water users and management entities to manage water in the Colorado System, within state laws. There's a whole suite of opportunities within the Service that touch water, from the legal side to being out in the field every day managing water on the land.

Skill and Knowledge Needs

Skills and knowledge needed for someone coming into entry-level positions in the agency include basic biological knowledge and general species biology. One thing that is often lacking is an understanding of botany, plant type, and range, and bigger picture range management. What do the plants that support the animals need?

Fieldwork is very important for accessing careers with the Service. Colorado Parks and Wildlife or other internship experience out in the field in different conditions shows that students really want to do that work and can deal with adverse conditions.

Another thing that is important is an understanding of the diversity of thought, opinion and knowledge among the people Service personnel interact with. The Service's work involves so much collaboration with other individuals and organizations that learning how to handle conflict and different perspectives is very important. Role playing can be very helpful.

Career Pathways

Entry level opportunities here in the Grand Valley include summer technician positions with the Fisheries Division, which is one of the best opportunities for students. Through the Pathways program (learn more here: <https://www.usajobs.gov/help/working-in-government/unique-hiring-paths/students/>), the Service can hire people still in school part time, which may lead to a permanent position. A Pathways Student is GS, General Schedule, the white-collar job classification system used in the agency. All jobs are rated by classification system based on schooling and education, and people move up the classification scale as they gain skills and experience.

The Ecological Services Division occasionally uses the Pathways program to get help with surveys and consultations with other agencies. Entry-level work with the Ecological Services Division often involves informal consultations that occur when another agency has an activity that will happen in endangered species habitat, which may affect species, but not significantly. The agency will come up with their plan, give it to the new person (with a mentor), and that's a good way for them to start thinking about how to analyze proposed action plan and proposed modifications to reduce impacts. They go out and help with surveys on the species and learn about the land and the community so they can understand what they are asking of people and build relationships. This helps with developing collaborative approaches that minimize impacts and still achieve long-term goals.

Continuing Education

The Service provides a broad range of in-house continuing education opportunities, although employees can also take advantage of local opportunities provided by other organizations. Each employee has a performance plan that they are evaluated on and an individual development plan for continuing education in both technical and non-technical areas. Courses could include anything from biology of species, to legal language and conflict resolution or writing improvement.

US Forest Service: Grand Mesa and Uncompahgre National Forest

The Forest Service is responsible for promoting resource health and regulating activities on National Forests. The first step in a Forest Service career is to be a Resource Specialist. Later steps involve becoming more of a generalist or manager, looking at the landscape as a whole. For the Grand Mesa and Uncompahgre National Forest, the Realty Specialist is responsible for working with the water companies that own the 300 reservoirs on the Grand Mesa on maintenance and reconstruction permitting. The Realty Specialist also has to track flows and understand the needs of the water users as well as the needs of the Forest Service. If there is any accelerated erosion due to flow rates, for example, they may ask the reservoir owners to adjust those. They also work closely with dam safety inspectors to be aware of any problems and work with the dam owner to address them.

There are several Realty Specialists across the GMUG, but only one in this district. There are 5 district level ones now in the GMUG. Other Forest Service positions which also require water knowledge include:

- Fisheries Specialists, who need to understand stream flows and water quality.
- Range Specialists, who need to understand erosion, different range types, and surface and subsurface flows of water.
- Foresters need to understand, when looking at a timber sale, how much buffer a wetland needs, and how to lay out a road to avoid accelerated erosion.

Skill and Knowledge Needs

The Realty Specialist is in the federal government's "general natural resource specialist" 401 series of positions, which requires a bachelor's degree in a science-based field. Formal requirements can be found on the federal Office of Personnel Management (OPM) website at: <https://www.opm.gov/policy-data-oversight/classification-qualifications/general-schedule-qualification-standards/0400/general-natural-resources-management-and-biological-sciences-series-0401/>.

All Resource Specialists need to have an understanding of basic concepts from the beginning; they will learn how to apply these concepts on the job.

The ability to write clearly is also very important. Following inspections, it is important to clearly define what was found in the inspection. Clear verbal communication with supervisors and water users is also important, as is interacting in a personable way that avoids unnecessary friction.

Other helpful knowledge to have includes the basics of Colorado water law and the general land management laws passed over the years, and why they were created.

In the scientific and technical arena, the most important abilities are critical thinking and how to collect information and draw reasonable conclusions from it. A good foundation in natural resource

management and how one resource affects another to keep a landscape functioning is also important. Personnel need to know how a nearby timber sale could affect hydrology, or how roads could affect flows, how subsurface and surface flows interact, and how geology influences those interactions.

Specific technical skills and knowledge needs include:

- Geographic Information Systems (GIS)
- Understanding how to do different types of modeling.
- Vegetative sampling.
- Water quality parameters.
- Seasonality of natural and human-influenced streamflows.

Emerging knowledge needs include an understanding of the impact of climate change on the National Forests. Impacts are already being observed on the landscape. It is important to pay attention to the results of landscape vegetation modeling at both local and global scales. For example, models indicate that in many of our mountains in Western Colorado, aspens will be gone by 2060. On the Uncompahgre Plateau, modeling shows that spruce will be gone, and Ponderosa Pine and Douglas Fir will remain, so it makes more sense to invest funding and effort in the health of those species.

Continuing Education

Continuing education is provided through informal and agency trainings on water law, agency operations, budget and leadership.

Career Pathways

Seasonal jobs and practical field experience are almost imperative stepping stones for getting into Resource Specialist positions. Rarely is a new graduate going to be competitive without some field skills and previous experience. Summer internships can be helpful, as can volunteering or temporary work. Particularly valuable experience includes building trail, firefighting, or doing recreation type work. Most jobs get tasked with things beyond the description: fire crews can build trail, recreation crews end up doing bird surveys. It is helpful to build familiarity, broaden horizons, see what work aligns with the person's interests. These experiences also provide the opportunity to obtain professional references, and agency professional references count for a lot.

Before moving into a management role, employees need a solid foundation in their specialty. After 3-5 years in that specialty, they can grow professionally and spread out. They get the necessary knowledge through exposure, working with peers, moving around to different parts of agency and resource types, and trainings. It is critical to learn the landscape you are responsible for, see impacts, and make positive change. It is important to develop relationships, learn political realities and discover who the partners are that have similar goals.

Partnership Opportunities

Many of the companies that own reservoirs on the Grand Mesa are small and lack the financial resources to do dam maintenance and repairs and don't understand how the transport of water can affect other aspects of the landscape. They also often don't understand permit requirements for doing

construction on reservoirs. The Hutchins Water Center could help educate them, so they aren't surprised by regulations once a project is already underway and are better prepared for long-term planning.

US Army Corps of Engineers

The US Army Corps of Engineers (USACE) is the lead agency for permitting activities involving discharges to surface waters and impacts to wetlands.

Skill and Knowledge Needs

USACE hires Biologists, Ecologists, Hydrologists and Engineers and looks for those kinds of degrees right out of school. USACE staff need a good understanding of the natural environment, so a background that provides an understanding of plant ecology, soil science, or aquatic habitats is helpful. Strong written and oral communication skills are important, because people have to write a lot of environmental assessments and talk to a wide variety of people. Employees also need to be able to juggle multiple projects and make decisions efficiently. Employees need to understand the relevant regulations and be able to review permit proposals with applicants and try to help find a way the applicant can achieve their goal, but also protect the aquatic environment.

At a technical level, employees need to be able to work outdoors, read a map and use GIS and related tools. They also use survey equipment. Using remote tools, like LIDAR and Google Earth are also becoming increasingly important.

Continuing Education

The USACE provides many on-the-job training opportunities, including in-house training on issues like wetland delineation, regulations, the National Environmental Policy Act, Endangered Species Act and cultural resource protection requirements. New hires work with other project managers at first, and later there's peer review, so people are always working with a team. Each project manager has their own area of responsibility (geographic territory). There is a lot of teamwork and sharing of knowledge between people with different backgrounds.

Career Pathways

The local USACE office occasionally has Student Assistant positions, for which the office can hire and train a local student, bringing them into the agency without competition. This is a good opportunity, because Colorado positions are competitive.

Partnership Opportunities

While the USACE has many of their own courses for employees, there is a gap that the Hutchins Water Center can help fill, and that is to provide Colorado-specific trainings on issues like Colorado Water Law, as well as opportunities to learn the landscape of players in Colorado water law. Remote learning opportunities could be particularly useful, although opportunities for networking are helpful, too.

Consultants

The USACE also occasionally hires outside consultants. Field skills are very important for consultants, as the USACE is starting to do less direct fieldwork. On the West Slope, there is a lack of water quality

consultants, and expertise on Environmental Impact Statements for big water projects, particularly to address secondary and indirect downstream effects of projects.

US Bureau of Land Management

The Bureau of Land Management (BLM) has soil, water and air programs. A Hydrologist for the Grand Junction Field Office oversees those three programs. The BLM's Grand Junction Field Office, like others, has Resource Management Plans with goals and objectives for each of these programs. Staff take those plans, and then based on current administration priorities (which are set every year), they try to achieve national goals through local plans. Soil, water and air goals don't normally change significantly year to year.

BLM staff also have responsibilities under the Colorado River Salinity Control Act with Congressionally designated funds for BLM to help with reducing salt levels in the river. BLM helps to develop and complete programs for erosion control and sediment on lands adjacent to saline areas. This work involves travel management, stream alterations and bank stability issues. Many historical detention basins are unraveling. Work in this area is also related to soil.

Skill and Knowledge Needs and Career Paths

The Hydrologist develops a plan of work, and often gets enough funding to hire seasonable employee or intern. The BLM has an agreement with CMU with funding for summer interns. These positions provide a good opportunity to get a foot in the door to get a career in the agency.

Hydrologic Technician positions (1316 in the federal government's classification system), which are typically seasonal, are the entry-level positions. People in these positions work under the direction of a professional Hydrologist (1315 in the classification system). These positions provide an excellent opportunity to integrate theory with real world settings. Formal requirements can be found at OPM.gov.

Moving up to qualify for the 1315 series requires at least 6 semester hours of physics and 6 of calculus, and 3 of those must be integral calculus. A lot of young interns don't have that higher level of math and physics. Students can use OPM.gov to learn about the requirements for positions that may not currently be advertised, and use that knowledge to plan their courses. If they do that and also get experience through seasonal positions or internships, that will put them in a good position for a career with the agency.

Even seasonal field positions are becoming increasingly competitive, and field seasons are short, so it is desirable not to have to spend a lot of time training seasonal staff. Because of this, having specific training, skills and abilities really improves a candidate's chances of getting hired. Having experience in science and hydrologic-related measurements in the field is desirable and not common among students.

With the intern program, sometimes a goal is to hire people with minimal experience. The agency usually does this when it can pair less-experienced interns with people who have more experience.

Emerging Skill Needs

The BLM needs more personnel with a fundamental understanding of modeling and statistical information. There are models now that are highly informed and rely on artificial intelligence methods.

If people aren't trained in the modeling theory, they could use one of these advanced models without understanding its limitations. With statistics, there are many different statistical methods and tests used in water resources data analysis, but they can be manipulated and misinterpreted. Misuse of models and statistics could lead to misinforming important decisions. In addition, understanding modeling and statistics to make actionable predictions and quantify their uncertainty is important in a hotter and dryer future.

Continuing Education

Both interns and seasonal employees gain exposure to other programs, like archeology and range management. BLM supports individual professional development through both internal and outside trainings (more internal; they host a lot of trainings). If it's local and free, BLM will allow seasonal employees to take additional training.

Useful trainings include BLM protocol trainings to make sure formally trained on BLM standard protocols; supervisory training, Rosgen stream classification and restoration design courses. Employees do trainings that match their work needs and interests.

Modeling and statistics training is also useful. It is important to bring scientific rigor to validate the assumptions of the impacts that dealt with in NEPA processes.

Hutchins Water Center programming is useful to BLM employees. Getting together with other people in the local water community is valuable.

Partnership Opportunities

The Colorado River Valley Field Office in Silt has a great partnership with Middle Colorado Watershed organization – the Grand Valley doesn't really have an equivalent. BLM seeks out those kinds of partnerships. The Grand Junction Office works with RiversEdge West to complete projects and is working with them on a Dolores River comprehensive restoration planning document. The relationships BLM has built in the community have helped BLM do what it needs to do cooperatively.

Nongovernmental organizations with goals that align with BLM's can bring technical expertise, workforce and engage larger groups of people to complete projects.

BLM is mandated to do things in a certain way, while for private organizations and consulting firms it's different – that can make it hard for groups to mesh together. Understanding roles of different folks in this space is helpful. For instance, CO Parks and Wildlife (CPW) is state, while BLM is federal; BLM manages the land, and CPW manages the animals. BLM tries to manage the land to benefit animals, but CPW is actually managing the animals, so with restoration, each has different role to make a whole project complete. With water rights, BLM manages the land, but the state manages water rights. Someone may need to go through a BLM process to access a point of diversion, but work with the state on the water right.

Bureau of Reclamation – Environmental and Planning Group

In addition to managing dams and facilities, the US Bureau of Reclamation also has an Environmental and Planning group that makes sure that whenever anything is done on Reclamation land, by its contractors or that involves federal action or funding, complies with the National Environmental Policy

Act (NEPA). NEPA requires analyzing and disclosing environmental impact of actions, and NEPA documents help inform decision maker on whether a project would have a significant impact or not and what mitigation options are. The Environmental and Planning group also does permitting.

Skill and Knowledge Needs

People that work in Reclamation's Environmental and Planning Group include a Biologist, a NEPA specialist, an Engineer and an Administrator. The Biologist does field surveys, helps with habitat replacement plans, writes consultation memos and biological assessments with endangered species consultations and carries out a wide range of other tasks related to wildlife and vegetation impacts and management.

The NEPA Specialist (at the time of this interview, a CMU Environmental Science graduate) pulls all the necessary information together for the required documents, working with engineers, other staff and partners that manage areas around BOR reservoirs. Some documents are written by environmental consultants and BOR staff review them.

An Engineer with a Professional Engineer credential helps come up with engineering ideas/ solutions to minimize project impacts. It's helpful for all staff in the group to learn to read and understand engineering drawings, which comes with experience.

Having analytical and scientific foundation, whether biology or environmental science, is critical for all personnel in the group. Field skills are also very useful, and good writing skills are important.

An awareness of the regulatory framework is helpful in order to be able to assess a project's compliance with federal regulations. A skill that tends to be missing with new hires is the practical application of environmental laws and regulations to real projects.

Continuing Education

Federal employment offers numerous opportunities for training. The Group puts together individual development plans with employees, and sometimes will pay for people to attend conferences and other relevant outside training opportunities.

Career Pathways

BOR has an internship program through which students can try out different aspects of the work and get on-the-job training. Getting experience through part-time employment while in college is more helpful to prepare for obtaining water-related employment with the Environmental and Planning group than any particular credential or certification.

Emerging Skill Needs

GIS skills are increasingly important.

Colorado Parks and Wildlife – Park Focus

State parks have responsibilities for managing park facilities, natural resource stewardship, law enforcement, and hosting visitors. There are several levels of positions that require some knowledge of water.

Skill and Knowledge Needs

Entry level Park Resource Technicians are essentially “handyman” positions, with few opportunities to move up. Each park has its own water distribution and wastewater systems, and the people that run those need skills similar to those for municipal utilities, as well as licenses: Class D water distribution licenses and small systems licenses for sanitation.

Mid-level positions in the parks need an understanding that those certifications are necessary, as well as a little about regulations and laws pertaining to water. Higher level positions include water lawyers, engineers, dam safety and water quality personnel and people who hold water assets for the agency need more advanced and specialized knowledge.

The agency does habitat restoration as well, sometimes carrying out that work in-house and sometimes hiring outside firms. For the reclamation of wetlands, consultants have been hired for design, implementation and looking at the water table relief for groundwater. Even when consultants are hired, staff needs to work with them, drawing on their experience, background and knowledge of the history of the site, as well as knowing which entities to work with for permits or other issues.

For Rangers, Senior Rangers, and Park Managers, the mix of natural resource management vs. law enforcement work depends on the character of the specific park. In the Grand Valley, most parks are former gravel pits, so there’s a significant amount of work to do on habitat quality.

Understanding water quality and the fact that water quality matters is important, and the more employees advance, the more important it gets. Water quality ties into whether or not fish can be stocked or whether to do a fishing closure. For entry-level Parks and Wildlife staff, having a good work ethic, customer service skills and knowing that the water issues matter and need to be considered is enough. They will learn the additional information they need to know gradually. Some water-related skills and knowledge they will have to learn include monitoring for algal blooms, converting units, understanding volumes and pressures, water tables and how to test for water quality.

Career Pathways

For entry-level positions, the parks hire people with 4-year degrees and exclude criminal justice degrees, because they want personnel to focus on the natural resource issues and do law enforcement in support of that.

Colorado Parks and Wildlife – Water Management Focus

In addition to managing parks, Colorado Parks and Wildlife (CPW) also employs temporary Fisheries staff, Fisheries Biologists and Water Resource Specialists.

Skill and Knowledge Needs

Entry-level, temporary Fisheries staff have basic skills and will work several years before they get an opportunity for full-time, permanent employment with CPW. Most higher-level Fisheries staff people have Master’s Degrees in fisheries management.

The Water Resource Specialists work to protect and optimize the agency's water rights. They also compile and organize data from other agency personnel and make sure it complies with plans, as well as work with technicians to gather the information on diversion structures and meters necessary to optimize the agency's decrees and portfolio of water rights for its needs. It's important for the Technicians and the Water Rights Specialist to have GPS, GIS and basic field skills.

Water Resource Specialists also work with Fisheries Biologists employed by the agency, gathering information from them and drawing on that to represent the agency in community meetings and planning processes.

Most people in the Water Resource Specialist position have law or engineering degrees or Master's degrees in water-related fields. They need to be able to understand the science involved in agency projects and research, as well as the cultural and social side of managing water in Colorado.

Career Pathways

A common route into a career with CPW is to get a degree in Biology or Fish and Wildlife. Many people come in through the training programs and then branch out: new park ranger training, and new district wildlife managers trainings every year. CPW does those training programs one time/ year when they recruit. Seasonal jobs are stepping stone to get into training classes. Seasonal jobs include labor jobs, aquatic nuisance species inspections, and seasonal ranger positions.

District Wildlife Managers (DWM) can be hired with a Bachelor's degree, but Master's degrees are important to advance to higher level positions. Taking a DWM position lets you get in with a Bachelors degree, and then decide where you want to go. People take DWM positions to learn and then go back to school for a Master's degree. There's a pretty clear progression from DWM to Area Wildlife Manager, and generally responsibility and pay go up with area size.

CPW Professional Biologists and Researchers need Master's or Ph.D. degrees.

National Park Service: Colorado National Monument

At Colorado National Monument, positions include Interpreters and Natural and Cultural Resource Managers, an Archeologist and Biological Technicians. Biology Technician is a type of job across the federal government. Recently, there has been a lot of emphasis on non-native species and restoration work. That work intersects with geosciences and hydrology. Trail maintenance is another team. Those doing maintenance are in facilities division. Everyone has to come together to plan a project.

Most of the science that happens in the park is coordinated by Northern Colorado Plateau Inventory and Monitoring Program, which is made up of National Park Service employees that do research monitoring, traveling between the different parks.

Skill and Knowledge Needs

For interpretation, water isn't seen, but it is relevant to the natural history of the park. Interpreters talk with students about weathering and erosion. They teach a lesson in which they go out on the trail and find evidence for weathering and erosion, and they create simulations. They also bring in the human

element: how do you build Rimrock Drive with all the natural hazards involved with bringing the built and natural world together? There's also an engineering element: 200 historic culverts – if they weren't there, the road wouldn't be there.

For working in the Monument, having some knowledge about water rights and water politics is beneficial. The Monument experiences the downriver effects from different kinds of uses, including being just below an agricultural community. As temperature and drought impacts go up, having surface water less available leads to resource management concerns. There's a connection between hydrology and how cottonwood seedlings germinate, so changes make a big difference. Understanding the human dynamics of resource management, and different stakeholders is important.

Facilities staff have to manage water and wastewater treatment, just like other system operators.

Resource management and science are pretty standard at most parks. There are a couple of priority areas, like managing non-native species. Interns to help with specific projects and guide research projects.

Monument staff partner with researchers on specific topics of concern. On the day of our interview, they were working with hazardous spill experts, using microbes to help with the cleanup from a vehicle crash.

The agency has a growing focus on resilience and adaptation, as well as on human dynamics, knowing how to work in interdisciplinary teams. Communication is important.

Continuing Education

A lot of training happens with webinars within a network of experts. The National Park Service works closely with other federal agencies. There's been a push nationally on learning how to be resilient and adapt to a changing future. There are a lot of different methods for risk assessment and create different projects of what might happen, under different scenarios. A whole branch of the National Park Service helps parks put together risk assessments.

United States Geological Service (USGS)

The USGS office in Grand Junction focuses on the water resources discipline, primarily, and is made up of two main sections, the Hydrologic Data Section which has two sections, one focused on Streamflow (Surface Water) information and the second is focused on Water-Quality information. There are currently 18 hydrologic technicians and 3 supervisory hydrologic technicians. Together, the Hydrologic Data Section is responsible for the installation, maintenance and data collection/review of 150 real-time streamflow gages and 30 real-time water-quality sensors, varying from one parameter sites (typically, water temperature) and up to five parameter sondes that measure water temperature, specific conductance, pH, dissolved oxygen, and turbidity.

The Water Quality sections is also responsible for the collection and review of discrete samples at ~75 sites, collecting ~350 samples annually. In general, the Hydrologic Data section is tasked to collect long-term data, and technicians spend a lot of time in the field completing the data collection portion of their job and the rest of the time in an office setting, compiling, reviewing and approving the data.

The second section is the Hydrologic Studies section which employs ~10 hydrologists, currently. This section's main focus is to work with local and national customers and scientists to answer specific questions of interest. Hydrologists spend some time collecting data as well, but their main task is to compile and publish results from specific studies to answer targeted questions.

Skill and Knowledge Needs

The Grand Junction USGS office employs people in two main job series: the [GS-1316](#) (Hydrologic technician) and GS-1315 ([Hydrologist](#)). There are different scholastic requirements for each job series, which can be accessed from the links above. Job opportunities are posted through [USAJobs](#) as well as other avenues.

To qualify for a Hydrologic Technician position, applicants need to have studied subjects such as engineering, industrial technology, construction drafting, surveying, physical science, biology, or mathematics. Relevant job experiences include: Technician or aid in engineering, earth, physical, or natural science, forestry, soil conservation, or surveying; Trades or crafts work in maintenance or construction of facilities or equipment related to hydrology; Drafting; Construction estimating. Full details about the requirements for this job series can be found at <https://www.opm.gov/policy-data-oversight/classification-qualifications/general-schedule-qualification-standards/1300/hydrologic-technician-series-1316/>

To qualify for a Hydrologist position, applicants need to have a degree in a physical or natural science or engineering that includes at least 30 semester hours in any combination of courses in hydrology, the physical sciences, geophysics, chemistry, engineering science, soils, mathematics, aquatic biology, atmospheric science, meteorology, geology, oceanography, or the management or conservation of water resources. The course work must have included at least 6 semester hours in calculus (including both differential and integral calculus), and at least 6 semester hours in physics. Relevant professional experience includes field or laboratory work applying hydrologic theory and related sciences to solving hydrologic problems. Full details on the requirements for this job series can be found at <https://www.opm.gov/policy-data-oversight/classification-qualifications/general-schedule-qualification-standards/1300/hydrology-series-1315/>.

Consultants

Consultants play important roles in water development, management and stewardship.

Water Engineering Consultants

Some of the activities water engineering consulting firms carry out include characterization of water supplies and water quality. They can support land use authorities on expanding water supplies, reviewing developments that require water, and conducting groundwater and well studies. They can also do engineering design work to build drinking water and wastewater treatment facilities that comply with the Safe Drinking Water Act and Clean Water Act, as well as other water infrastructure.

Skill and Knowledge Needs

For engineering drinking water systems, personnel need strong chemistry knowledge and an understanding of how to get water to the plant and then out into the distribution system. Wastewater

systems require more biological knowledge. Entry level engineers need to understand foundational concepts in those areas.

Entry level duties at a water engineering consulting firm include drafting and hydraulic modeling. Employees need to understand the fundamentals of engineering and have a degree in engineering. A Professional Engineer (PE certification) is usually required at some point after hire. GIS and auto-CAD certifications are helpful, as well as an understanding of stormwater management requirements.

Higher level employees need to have experience and relationships in the industry. A good foundation in technical writing is also important, as are other “soft skills” like project management, interacting with teams, having appropriate conversations, scoping issues correctly, and managing projects profitably.

Emerging skill and knowledge needs include an understanding of how climate change influences water use and discharge requirements, as designs need to consider diminishing water supplies as well as potential reductions in the water available to dilute discharges. Water re-use technologies will probably become more prominent on the western slope.

Continuing Education

For continuing education, the short courses that CMU puts on are helpful. Information on industry-specific data and experiences and anything that broadens the employee’s understanding of the market and the community is helpful: grant funding available, types of organizations that are involved, state and federal planning efforts. This knowledge helps employees understand what types of projects will be appropriate and fundable. Water law and policy knowledge are also helpful for understanding the landscape.

Related Areas of Expertise

Water engineering firms also often employ or partner with geotechnical engineers on projects, as well as partnering with land surveyors. It is helpful to have a local surveyor, because they can find benchmarks. There are a couple of firms, but there is demand for more trained surveyors.

Hydrogeology Consulting

When a person or company wants to obtain a new water right or drill a well, there are often complex technical issues involving groundwater movement and chemistry that can affect the viability of the project, and whether it will affect other water users or resources. Consulting firms can be hired to do the studies to identify and resolve these issues. Surface and ground water quality monitoring can also be required for permits, so consultants develop monitoring plans. Government agencies are also often clients for hydrogeological consulting work, including the Uranium Mill Tailings Remedial Action (UMTRA) program, which is based out of Grand Junction.

Skill and Knowledge Needs

Entry level employees in firms doing this kind of work need a well-rounded understanding of scientific applications, the scientific approach and mathematical calculations, which is knowledge people usually get with a science degree. A good understanding of geology is also important, because geology is so connected to hydrology, and it’s harder to find people with that understanding. GIS work is also done frequently. Entry level employees learn a lot of skills on the job by getting pulled in for short lessons. To

be ready to learn the specific technical skills they can learn on the job, they should have gone through all the calculus courses and differential equations.

It would be useful for CMU to offer a course with a section on water rights applications – most entry level hires don't have much knowledge of water rights. A basic understanding of numerical groundwater modeling would also be useful.

Continuing Education

Employees are encouraged to go out and find on-line webinars, seminars, and courses, and the company will pay. Water Center programming offers a bigger picture opportunity to learn what's going on in the basin and get oriented to the various players in the water community.

Career Pathways

For projects with a lot of basic fieldwork, the firm has hired a lot of CMU students with BS degrees in Environmental Science. They fit in well and had enough knowledge of water issues and water projects to be able to hit the ground running with groundwater well sampling and related activities. CMU's Environmental Science has come closest to providing the skills people need for entry level positions; on occasion the firm has looked at individuals with Geology degrees, especially those who have had some hydrology, but often they aren't interested because positions don't involve enough geology.

Environmental Consulting

Environmental consulting firms perform work related to compliance with environmental laws, carrying out tasks such as wetland delineation and surveys related to compliance with the Endangered Species Act and National Environmental Policy Act. Environmental consulting firms employ seasonal field technicians, environmental scientists, hydrogeologists and civil engineers.

Skill and knowledge needs/ Career Paths

Many field technicians come out of CMU with Environmental Science or Biology degrees. Environmental Science majors tend to have wider variety of skills that they can use right away. Understanding water quality measurements and GPS and GIS mapping systems are important for conducting field work. Students that take CMU GIS courses are well-prepared for field work. Understanding a variety of ecosystems is also important.

Firms look for an understanding of how to implement policy learned in school and take it to the ground. The important laws to be familiar with are the National Environmental Policy Act (NEPA) and the Clean Water Act (CWA). Education on the policy side could be strengthened at CMU. NEPA drives the demand for a lot of what environmental consultants do.

Seasonal field technicians can move into higher level positions if there's enough work to sustain new positions.

Growing Skill Needs

Water modeling is a growing field. Improved management and expansion of water storage is becoming a priority. The permitting associated with this work requires skills associated with delineating wetlands,

identify waters of the US, fens, and types of wetlands is an important skill. Engineering knowledge of dams and hydrology will also be important.

Continuing Education and Partnership Opportunities

The networking at Water Center conferences is useful, and getting stakeholders together is helpful. Smaller breakout sessions might be helpful for a little more time to talk with folks. Having various topics, including more locally-focused topics would be good.

Water storage is a concern for a lot of folks. Implementing water storage projects will be a challenge, requiring the users, agencies, and others to work together. New storage projects on federal land is perceived to be a challenge with many unknowns.

Water Lawyers

Water lawyers are essential members of the water community in Colorado, participating in the acquisition and defense of water rights, as well as policy discussions. A science background and good writing skills provide a good background for going into law, and new lawyers often begin with general practice work and then become more specialized. Water lawyers commonly partner with professional engineers and hydrologists.

Nonprofit Organizations

A variety of nonprofit organizations are engaged in working to educate the public about water resource issues, as well as advocacy and restoration activities to enhance the health of water resources and riparian habitats.

Conservation Colorado

Conservation Colorado advocates for environmental protection. The organization has a government affairs team, an organizing team, a communications team, and a digital team. Those are the four teams that would work on water. The lead water advocate is based in Denver and works with statewide coalition partners, diving deep into policy needs, different policies being crafted, and creating strategies for how to support those policies. Then organizers, communications and digital teams help with enacting the strategies. There are organizers all across the state.

It is useful for organizers and the community to understand how water law works in Colorado. The prior appropriation doctrine is so fundamental to how it is possible to protect water, especially water quantity. It's also important for them to understand what the state has already done. Who are the basin roundtables, what is the Colorado Water Plan, and how can it be a solution for communities and state overall? It's also important for them to understand the role that agriculture plays and the history of the agricultural sector and their rights to water in order to learn how they can work with ag communities on conservation efforts.

Colorado West Land Trust

The Colorado West Land Trust works with water in a couple of different ways. For conservation easement transactions, water is an important component. The easements restrict how water can be used off the property and ensure that the water rights are not severed from the land. Part of the initial transaction is doing due diligence on the water rights. For each easement that the land trust holds, as part of monitoring the property, the land trust has to look at water use as well, to make sure it is not severed from the property. Understanding resources for tracking if there have been changes of use would be helpful.

The way land trusts treat water has changed significantly over the years. In the past, conservation easements simply stated that water shall remain with the land. Recently, conservation easements have become more nuanced. Some landowners have requested the flexibility to use their water to augment in-stream flows, and land trusts are seeking out opportunities for that. Some easements allow for leasing water for use on other properties.

Colorado West Land Trust is also contemplating an alternative transfer method (ATM, a temporary transfer alternative to “buy and dry”) with a landowner in Whitewater who holds a senior water right downstream from the city’s intake. Under an ATM, in dry years the landowner could lease water to the city. In northern Colorado, there’s an example of an easement that allows leasing to municipalities in drought years to avoid buy and dry. There is a potential role for the land trust when looking at Demand Management (temporary, voluntary and compensated transfers); land that stays in agriculture ensures that there are water rights that could be temporarily dedicated to other purposes, which is not necessarily the case when land is converted to a residential subdivision. This is all in brainstorming, strategizing with the stresses on the water we’re facing with least harm to west slope and economies.

These kinds of water issues are being looked at by mid and senior level staff, and require learning the legal and practical nuts and bolts of water management. Other staff can benefit from basic water information, like how ditches work and basic water law.

In general, it’s helpful for the land trust to have opportunities to understand the Colorado Water Plan process and other water policies in order to ascertain how the land trust may be able to get involved, and what opportunities there may be for the land trust to add value to conserving landscapes, habitats and water resources and further local resiliency in western Colorado.

Opportunities vary from place to place. Palisade farmers don’t think about availability as much as those in Cedaredge. In Cedaredge, it may be useful to have a water bank or water sharing arrangement to keep water going to fruitgrowers who would be devastated if went a year without water.

Partnership Opportunities

It could be useful to convene small groups of thought leaders to discuss these issues surrounding demand management, other water policies, nongovernmental organization activities and community resilience. Some trainings also useful, in addition to convening a meeting like this, include water law, water management (how water moves through the system – nuts and bolts), and the legal and policy framework for managing water.

Colorado Canyons Association

Colorado Canyons Association (CCA) is a “friends” group to the local National Conservation Areas, which promotes stewardship and education about the areas and their resources. CCA has a land education program and a river education program.

The river education program lead does curriculum development, planning, coordination with partner organizations and supervision of seasonal river educators/ guides. The guides need to have rafting and safety skills as well as the knowledge to educate kids in river-related science. CCA also does some restoration work, so it is also helpful to have employees who have knowledge in that area as well.

RiversEdge West

RiversEdge West (REW) advances the restoration of riparian lands through education, collaboration and technical assistance. Staff plan and carry out the replacement of invasive plants with native plant species, conduct research on best practices, educate partners on best practices, and coordinate with a wide range of partners.

REW staff need both technical knowledge on riparian ecology and restoration and the ability to communicate that knowledge to others. GIS, grantwriting and project management are also key skills.

Community Knowledge Gaps

When the water professionals interviewed for this project were asked what they wished the community better understood about water, several themes emerged.

Water Supply Challenges

Interviewees felt that residents are not sufficiently aware of the impacts our region is likely to experience from increased water demand and shrinking availability, and the related need for long-term planning, especially given how complex it is to go from project conception to a finished project.

Water Infrastructure

Interviewees noted that domestic water quality is a front-line public health issue, and noted that the need to continually invest in maintaining and upgrading water infrastructure is not sufficiently appreciated. For small, financially strapped systems, regionalization could be a solution. Providing more information on how water treatment plants and other infrastructure works was mentioned as potentially helpful.

Different Perspectives

Interviewees highlighted how different water stakeholders don't always appreciate each other's importance. For example, the economic impact of river-based recreation and the environmental and recreational benefits provided by irrigated agriculture may both be under recognized. An agency interviewee noted that it would be helpful if people better understood how stakeholder input and science come together in decision making.

Hydrology

Areas where interviewees felt public knowledge was lacking included an understanding of groundwater resources, the connections between forest/ watershed health and water in communities, and how one person's actions can affect others downstream or downgradient. Stormwater and flood management needs and requirements were mentioned as another area where public knowledge is lacking.

Water Law and Administration

At the local level, interviewees mentioned that even law enforcement officers don't always understand easement issues related to cleaning ditches for water delivery and draining tailwater. At a larger scale, some interviewees wished the general public and leaders had a better understanding of water law and the various policies governing how the Colorado River is managed, as well as the limits to the resources.

Relevance of selected water-related subject areas covered at CMU

Water management and regulations

General knowledge of water management and regulations is helpful for a wide range of water professionals, including employees at the Natural Resources Conservation Service, Bureau of Reclamation and managers and board members for irrigation entities and domestic water providers, as well as the consulting engineers who provide services to these entities. The Bureau of Land Management also has water rights and helps administer others' water rights, so BLM staff need to understand the Colorado water rights system. Colorado Parks and Wildlife also need to understand water laws and regulations. Even people in highly scientific and technical occupations need to be aware of the water management and policy environment, since it influences the context of their work.

More specifically, interviewees mentioned the following:

- A basic understanding of the Colorado River Compact and Colorado water law is important for people involved in managing water and working with farmers and ranchers.
- An overview of the Clean Water Act is sufficient for most people involved in managing water, with more depth helpful for people working in environmental regulation, permitting, water treatment plant operation and design. Provisions related to stormwater management are important for managers at municipal utilities. For people involved in water quality regulation, it is helpful to know why the regulations were put in place and to have an overview; they can learn the details that are most important for their work on the job.
- Knowledge of the Safe Drinking Water Act is important for water treatment system operators, designers and regulators.
- Understanding the National Environmental Policy Act (NEPA) is important for people involved in environmental consulting and federal permitting. analysis, stewardship and water treatment plant operation and design.
- Understanding the Endangered Species Act and its consultation requirements is particularly important for personnel in the US Fish and Wildlife Service, but is also helpful for personnel in other agencies and organizations engaged in activities that could affect endangered species.

Basic Concepts in Biology and Chemistry

An understanding of basic concepts of biology and chemistry related to water is important for many water-related professions, particularly those whose work relates to municipal water treatment and other aspects of water quality, including irrigation projects designed to improve water quality in rivers and streams. These basic concepts are also part of the general background needed by engineers involved in water projects and employees of land management and regulatory agencies, including the US Army Corps of Engineers, the Bureau of Reclamation and the US Fish and Wildlife Service.

Hydrology

A solid understanding of hydrology, including the precipitation, storage, and movement of surface and ground water, and interaction between surface and groundwater, is of primary importance for most water professionals. Understanding hydrologic concepts and being able to use field equipment to conduct hydrologic measurements, such as the discharge and velocity of streams and ditches as well as groundwater and aquifer properties is very important.

Personnel involved in irrigation efficiency and water quality programs need to understand the flow of pollutants through ground water in order to address problems with salt and selenium loading to local waterways.

Staff at land management agencies like the Bureau of Land Management and Colorado Parks & Wildlife need to understand hydrology in order to understand potential impacts of proposed projects and to manage for wildlife habitat and recreation. Personnel with the Bureau of Reclamation need to understand forecasted inflows and snowpack and model that to determine how to operate facilities to meet environmental requirements and avoid public safety problems.

Understanding the effects of drought and climate change on hydrology is becoming increasingly important for many water professionals. It is helpful for water treatment plant operators and inspectors to understand how drier conditions can affect not only the quantity, but the chemistry and biology of their raw water supplies in order to solve problems.

Watershed Assessment

Watershed assessment is a fundamental skill needed by personnel involved in regulation and landscape stewardship, including the US Army Corps of Engineers, the Natural Resources Conservation Service, US Forest Service, CO Parks and Wildlife, Bureau of Land Management, and engineering firms involved in environmental assessments and mitigation planning. This may include GIS analysis of land uses including vegetation types and management practices, hydrologic and water quality analysis, as well as infrastructure and planning. Field assessments may also inform this, which rely on a variety of protocols. The Rosgen stream classification system is used by many of these entities.

BLM adopted the Assessment, Inventory and Monitoring (AIM) protocol about 5 years ago. This is BLM's new protocol to understand condition of BLM lands nationally. Designed to collect quantitative data to assess condition of water and uplands. BLM and DOI is required by Congress to report every year on condition of BLM lands, did qualitatively and sporadically for years, now have a systematic and scientific way to do this. Landscapetoolbox.org is a website that explains the protocol and provides data.

Water Quality

Knowledge of methods for management and monitoring of water quality is important for a broad range of water professionals, particularly for those involved in treatment plant design, operation and regulation, but also for personnel involved in environmental stewardship. It can also be helpful for employees at the Natural Resources Conservation Service, depending on what resource concerns they address with landowners. Personnel with the Bureau of Reclamation also take water samples at their facilities. Employees at regulatory agencies also need to be well-versed in this area.

The ability to sample and test for water quality parameters is most important for personnel involved in water treatment, inspection and, to some degree, public agencies engaged in land and water stewardship, such as the US Forest Service, Bureau of Land Management, and CO Parks and Wildlife. Personnel with the US Fish and Wildlife Service need to understand water quality as it relates to the habitat needs of endangered species.

Wetlands/ Riparian Ecosystems

Understanding wetland ecology, and particularly wetland delineation, is very important for people involved in land and water stewardship and regulation, as well as consultants who work on

environmental assessments and mitigation planning. The ability to apply this understanding in the field is important in all these sectors. People involved in providing irrigation and domestic water don't need detailed knowledge, but they do need to be able to recognize when wetlands could be disturbed by a project, and who to contact for more information, so they don't get into regulatory trouble.

Treatment Techniques and Technology

Learning about water treatment techniques and technology is most important for people directly involved in water treatment and regulation as well as some consultants and some personnel with land and water stewardship responsibilities. Regulatory and stewardship agencies, like the US Army Corps of Engineers and Bureau of Land Management, need to understand enough about these techniques and technology to recognize if a permit applicant is taking a reasonable approach to any relevant water quality issues.

Engineering

Engineering knowledge in the water community is important for activities like dam maintenance and inspection and designing and reviewing plans for water treatment systems. The combination of environmental engineering and hydrology is important for personnel at agencies and consulting firms involved in stream restoration.

Environmental Politics

A good basic background in environmental politics is helpful for people involved in managing and regulating public facilities and activities on public lands in order to understand the big picture these facilities and projects fit into, as well as different perspectives on them. This is also important for people working in the nonprofit sector on advocacy and stewardship.

Environmental Economics

A good basic background in environmental economics is important for people involved in making decisions about federal projects, like Bureau of Reclamation personnel. Natural Resources Conservation Service personnel have to make decisions about what conservation projects make economic sense, and they have some in-house training on that. Understanding the economic impact of regulations is also helpful for people involved in inspecting treatment plants and attempting to help systems comply with them.

Environmental History

It is helpful for people involved in natural resources stewardship and regulation, as well as managing federal facilities like dams, to have some background in how and why their agencies were founded, the history behind the relevant regulations, and why the facilities were built and came to be managed with the guidelines that currently exist. When looking at a disturbed system, understanding how it got into its current state is important.

Geographic Information Systems (GIS)

GIS was among the most commonly cited desired skill across a wide variety of water occupations.

General Skills

Technical writing and oral communication skills were mentioned as highly important by almost every interviewee. Many water-related professions require writing inspection reports that communicate what

is happening in the field into reports. In addition, many water professionals need to interface with the public in one way or another, whether through one-on-one conversations with water users and customers, public presentations on reservoir operations or working with stakeholders and partners with different points of view. Technical reading in order to be able to understand regulatory documents and technical reports was also cited as important for water quality inspectors. Grant writing is particularly useful for consultants, who can help smaller water entities apply for grants to supported needed projects.

For agencies that have to prepare documents pursuant to the National Environmental Policy Act (NEPA), like the Bureau of Land Management, being a good writer is really important in order to efficiently convey knowledge to members of the public, so that they can understand the documents and provide comments.

Project management and adapting to variable conditions was also frequently cited as important.

Field experience was frequently mentioned by interviewees as important in a wide variety of occupations, both in terms of comfort level and the ability to apply classroom knowledge in real-world situations.

Subject areas that could be strengthened

The interviewees mentioned the following areas where they perceived that CMU could strengthen its water-related curriculum.

- An understanding of Colorado Water Law and how to navigate the state's water rights system are important for personnel involved in providing irrigation and ditch water and developing new projects that require water, as well as some water efficiency projects.
- Understanding the National Environmental Policy Act (NEPA) process is important for people involved in permitting projects, whether as an applicant or a regulator. Understanding the Endangered Species Act would also be helpful to a wide range of water professionals, given the large role that the program to recover endangered fish in the Colorado River system plays in water management in the region.
- A hydrology field camp like one that CSU has, to provide more hands-on learning, would be valuable, as would a 400-level hydrogeology course.
- Numerical groundwater modeling was mentioned as a desirable skill for water professionals to have.
- If there's room to study basic methods by which state regulators design and author regulations, there would be something to learn there. In consulting business, understanding those regulations and where there might be room for change, will be a step ahead.

Opportunities at Colorado Mesa University

Coursework in a number of CMU programs provides many of the technical and general skills identified by interviewees, and the strong preparation these programs provide was recognized by a number of interviewees. In addition, student organizations and Hutchins Water Center programming have provided additional learning opportunities.

Water-Related Instruction and Field Experience Opportunities

Technical skills are provided in CMU's Biology, Engineering, Environmental Science, and Geosciences programs. Western Colorado Community College also offers relevant certificate and degree programs in surveying, water quality and agriculture. These programs also work to develop students' written and oral communication skills.

CMU's Political Science program provides helpful context on the development of environmental and water policy, as well as the development of an appreciation for different perspectives and enhanced communication skills. Hutchins Water Center conferences and seminars have also provided students with exposure to current water policy developments and debates.

CMU's Outdoor Recreation Industry Studies program also offers several classes that focus on water, the Davis School of Business offers an environmental economics class offered as a topics class, and an interdisciplinary "milestone" class focuses on different ways of understanding the Colorado River.

The needs for professional experience and field experience are currently addressed through labs, field courses, individual research projects and "capstone" classes, in which students complete projects for clients in the community. Partnerships for paid internship programs with federal agencies also give students a head start in their careers and help agencies fill their workforce needs.

In recent years, the Hutchins Water Center has administered a Student Water Field Research Grant program, which has provided an additional opportunity for students to apply their classroom knowledge to real-world problems in the field.

More detailed information on selected academic programs can be found in Appendix A.

Student Organizations

In addition to formal educational programs, student organizations offer opportunities for learning, professional development and networking.

The Fish & Wildlife Club is an academic student organization that is also a student subunit of the Colorado-Wyoming Chapter, American Fisheries Society. The content varies among years, but the students bring in monthly speakers on topics they are interested in learning more. Speakers are commonly in a water related field and represent a diverse group including CPW, USFW, BLM, USFWS, BOR, Rivers Edge West, TU, private consultants, and other NGO's. In these meetings the students have been introduced to Colorado water law, environmental laws, project management, basic hydrology. The club helps student participate in conferences and annual meetings including: Water Forum, Colorado-Wyoming AFS, Colorado Chapter of the Wildlife Society, Society of Range Management. Also this club

facilitates networking with professionals and students establish contacts for internships and seasonal positions where they gain the most experience relevant to the skills needs identified in this report.

The Sustainability Council provides opportunities for students to learn about sustainability-related topics, carry out projects and connect with local agencies and community organizations engaged with sustainability efforts.

Ideas for Strengthening Water Career Preparation and Continuing Education at CMU

The following are ideas generated by faculty for how water-related instruction could be strengthened at the university in the areas of academic offerings, opportunities for field skills and professional experiences, continuing education for water professionals, and community awareness.

Academic Offerings

- The Civil Engineering program is light on groundwater. Students could seek credit for a groundwater course in the Geology Department as an upper division technical elective if interested.
- Provide CMU Environmental Science and Geology student the option to take engineering courses to fill in any technical gaps they might have or want to address. Freshman/Sophomore courses are available but not upper division technical electives like GPS surveying, hydrology, hydraulics, environmental engineering, etc.
- A special summer course, J-term course, or workshop that focuses on GIS applications to solve hydrologic problems could offer a valuable skillset and interdisciplinary connection to prepare students for success in water-related jobs.
- A scientific writing class for Physical and Environmental Sciences would be a practical addition to water-related courses offered at CMU.
- Math and quantitative reasoning are significant hurdles for many students in the Geoscience Program. Currently, Calculus is required for B.S. Geology and B.S. Environmental Geology degrees. Special summer courses, J-term courses, or workshops designed to assist students in the development of applied quantitative reasoning skills (e.g., Statistics for Geoscientist, Math for Geoscientist) required for water-related jobs would be highly valued.
- The Study Abroad program could develop opportunities for students to go study water systems in international settings including water projects, ecosystems with water, ecosystems in a drought, international advocacy and international water law. They could also develop exchange opportunities for faculty and staff with international universities that specialize in water related subjects. Student organizations such as Engineers Without Borders and the Social Work program could engage in water related service learning projects.
- Bryan Reed at WCCC teaches several courses incorporating regenerative agriculture techniques and principles that are targeted toward soil moisture and water savings. He could be connected with Dr. Greg Baker in geology to team teach or research soil hydrology as it relates to irrigation and agricultural practices.
- CMU could partner with other universities to share lectures and courses offered virtually.

Field Skills and Professional Experiences

- Link more students to the professional water community via mentorship and internship programs, as well as field-based training. Mentorships could link students with water professionals who meet to chat on a quarterly basis and conduct a job shadow.
- Field skills: partner with local agencies to conduct field data collection trainings. This could fill in gaps that we currently have and could be targeted at students and local professionals, with instruction provided by CMU faculty and/or local experts lead (could be a partnership). Quarterly field trainings on different subjects could be provided.

Continuing Education

- Additional seminars and trainings on water resources management could be targeted to students and local water professionals and community members. These could be hosted by Hutchins Water Center and funded by sponsors and local agencies. Content could cover water law, hydrology, climate change, water quality, policy and regulations, as well as other relevant topics. This could be a monthly series that could draw on expertise from across the state as well as locally and be coordinated with the Bureau of Reclamation, Colorado State University and other agencies.

Community Awareness

- McInnis Canyons National Conservation Area has a series of interpretive signs along the Devil's Canyon trail focusing on geology as a theme. We could partner with Professor Suzie Garner in Graphic Design to illustrate a series of panels for another trail in MCNCA focusing on the water and hydrology visible from the trail, perhaps the Rabbit Ear trail in the western side of the NCA, students from hydrology classes could work in conjunction with hydrology faculty to develop the text.
- Outdoor Programs could focus on water education for the public by sponsoring and guiding a series of "town floats" on the Colorado River segments to point out interconnection of water on the river such as irrigation infrastructure, recreation, riparian corridors, fish, water treatment, energy production, residential and commercial development in such places as Las Colonias.

Conclusion

The Grand Valley's water sector and Colorado Mesa University already collaborate in many ways, to the benefit of both students and employers. Closer and more systematic communication and coordination can expand and enhance these opportunities, further benefiting students' career options and our community's ability to address water challenges.

Appendix A

Detailed information on selected Colorado Mesa University and Western Colorado Community College programs.

Biology

Information provided by Dr. Eriek Hansen

CMU's Biology Program offers a number of courses that meet needs identified in the Grand Valley Water Workforce Needs Assessment.

Fish Biology Lecture and Lab (BIOL 336 & 336L)

Fish biology lecture addresses evolution, anatomy, physiology, behavior, ecology, and conservation. Students write and orally present a paper on a fish species addressing the course topics. The lab covers the same topics but includes identification and an introduction to field techniques. In the lab students collect and analyze data and write lab reports.

This class also addresses the following general skill needs identified: math, writing, and oral communication.

Freshwater Ecology Lecture and Lab (BIOL 414 & 414L)

Freshwater ecology lecture focuses on lakes and rivers, but also addresses wetlands. The broad course sections include physiography, biogeochemistry, and ecology. Within physiography we cover water properties, lake processes (e.g., stratification), fluvial geomorphology. Within biogeochemistry we cover chemical cycles with an emphasis on O, C, N, P, S. This section also includes trophic status and cultural eutrophication. The ecology section incorporates the previous sections but includes organisms with an emphasis on energy flow in aquatic systems. Students write and orally present a research paper where they test a hypothesis using a literature search. In lab, students are introduced to the methods used for the topics in lecture. They are required to maintain and submit a field notebook that includes descriptions of the techniques, data collected, and a field interpretation of the data. In lake systems students measure oxygen profiles, collect water samples for basic water quality, collect zooplankton (ID occurs in laboratory), collect phytoplankton (Chlorophyll a extraction occurs in laboratory). In river systems students measure discharge (multiple methods), slope, substrate (Pebble counts), periphyton, macroinvertebrate collection and identification. Basic riparian and wetland vegetation techniques are introduced (quadrats, line transects, point counts, canopy cover). Fish collection with CPW and USFWS. Restoration practices with CPW and Rivers Edge West.

This class addresses the following general skill needs: math, writing, and oral communication, ability to do field work, and basic hydrology.

Fisheries Management Lecture and Lab (BIOL 419 & 419L)

Fisheries management has been taught as a topics course and is currently going through the approval process to become a regularly taught course with the addition of a lab. The course addresses population dynamics, sport fish management and harvest, native species conservation and management, habitat management, policies and regulations, and socioeconomics. This course is very quantitative and student analyze fisheries data from CPW. Over the semester students analyze the data and write present a management plan for a waterbody.

This class addresses the following general skill needs: math, writing, and oral communication, environmental laws, and ability to do field work.

Winter Ecology (Topics course)

Winter ecology has been taught as a topics course both in-person and online. This course will eventually be converted to a regular course. The course addresses the flow of energy, properties of snow, and the response of organism to winter. Student write and present a species winter profile and design an experiment to address a knowledge gap in winter ecology. Students learn basic snow pit analysis techniques. In the context of this report the course address basic hydrology especially how the snowpack forms and changes over the winter. Evaluating the primary literature exposes students to how the snowpack can be impacted by climate change, pine beetles, dust, etc. and how these processes may affect spring runoff.

This class addresses the following general skill needs: math, writing, and oral communication, and ability to do field work, and basic hydrology.

Research, internships, independent study and topics courses

BIOL 387 Structured Research, BIOL 395 Independent Study, BIOL 396 Topics, BIOL 487 Advanced Research, BIOL 495 Independent Study, BIOL 496

These courses allow students to focus on more specialized topics. The Catalog descriptions are listed, but the content varies among student and mentors.

Engineering

Information provided by Dr. Joel Sholtes

The CMU-CU Engineering Partnership (Civil Engineering) Program trains students in water-related fields under the program's courses (most of which are required in the Civil Engineering curriculum). There are currently three professors in the program with backgrounds in water resources and environmental engineering. We focus on fundamentals as well as applications: uncertainty analysis, data collection, modeling, using engineering standards and guidelines in design, working with assumptions and engineering judgement, effective technical written and oral communication, and design applications.

Water-related Instruction

Below is a list of the water-related content areas on which the Engineering Program focuses.

- **Civil Engineering 3D Drafting**
- **Fluid Mechanics and Hydraulic Engineering:** fundamentals of fluid mechanics (physics) including laboratory measurements and data analysis. Hydraulic system design and modeling (pipes, pumps, open channel, stormwater). Uncertainty analysis and propagation to design.
- **Engineering Hydrology:** basics of Colorado River Compact, the water cycle, snow and water supply, climate change and water resources, hydrologic design, floodplain management, stormwater modeling and management, hydrologic statistics, floodplain modeling and management. Technical writing. Risk and uncertainty analysis.
- **Probability and Statistics:** Probability theory and distributions, statistical analysis and testing, risk and uncertainty analysis, computational data analysis and coding using R, applications to natural hazards and water resources.
- **Environmental Engineering:** regulatory framework of US environmental policies, mass balance simplification of contaminants or process-based chemical and biological constituents in environmental media (e.g., air, water, wastewater, and solid waste), standards-based design of unit processes in water and wastewater treatment facilities, basic water chemistry and kinetics, basic pathogen- and process-based microbiology, and health-based risk assessments. Field trips to water and wastewater treatment facilities and the uranium mill tailing legacy facility.
- **Water and Wastewater Treatment Design:** systematic iterative design of treatment trains in water and wastewater treatment facilities, drinking water treatment jar testing experience, hand-held water quality meter testing, and cost estimating. Field trips to complicated drinking and wastewater treatment facilities.
- **Geotechnical Engineering:** half of geotechnical engineering is understanding how water moves through the soil matrix. Students learn to model 2D groundwater flow, estimate seepage and well pumping rates relative to the hydraulic conductivity of soils, and estimate the duration of consolidation (water leaving a soil matrix) based on various applied loads to a soil mass.
- **Geomatics, GIS, and GPS Surveying for Engineers:** fundamentals and application of geomatics including auto-level and total station. GIS data and data analysis, hydrologic analysis, topographic data collection and analysis (GIS, GPS Surveying, Structure from Motion 3D modeling).
- **Senior Design:** students work in teams to work with clients to design alternatives, complete a detailed design on a preferred alternative, and write and present this to the client and their peers. These projects often involve a water related design component and are sponsored by agencies listed in this report.

Environmental Science

Information provided by Dr. Freddy Witarsa and Dr. Deborah Kennard

Environmental Science and Technology Program Overview - Department of Physical and Environmental Sciences

The Environmental Science and Technology program at CMU offers a B.S. and minor that provide students with the knowledge and skills necessary to work in the local water sector. Several interviewees mentioned employing Environmental Science graduates.

Besides the diversity of courses offered, the strength of the Environmental Science program is the hands-on practice students gain in the many field labs offered by the program. The major culminates in a senior capstone project that challenges students to apply the techniques learned during the major courses to address a local environmental issue for a local client. Some of these capstone research projects are aimed at helping local clients address local water issues (examples of projects can be found under *ENVS 492 capstone* class details below).

Of particular note, majors are required to take **ENVS 331/L Water Quality and Lab**, which exposes students to many of the desired knowledge and skills identified outlined in this report. In addition to ENVS 331/L, the program offers five other courses with a heavy emphasis on water resources. These six classes are briefly described below.

Courses with a heavy emphasis on water resources:

ENVS 221/L Science and Technology of Pollution Control and Lab (Required): This class is an introductory class that covers the scientific, engineering, and technical elements of pollution control. While this class covers different matrices, there is a large section of the class that covers the fate and transport of pollutants in groundwater, as well as the remediation and treatment techniques of contaminated water.

In the lab section, students go out to the field to learn how to sample groundwater, surface water, and soils, how to create water table elevation map to visualize groundwater flow, as well as techniques for remediating of contaminated groundwater and wastewater treatment processes.

In their semester-long project, students determine the effectiveness of lab-scale bioreactors that they build in treating (mock) contaminated water. At the end of the project, students write a technical report where they synthesize, analyze, and interpret their data.

ENVS 331 Water Quality and Lab (Required): This class covers the fundamental chemistry, ecology, hydrology, and morphology of aquatic systems, and learn how all these elements influence the quality or health of the system. Specifically, this class focuses on the movement of water in the watershed, stream classification and stability, lake circulation, aquatic ecology, chemistry and biology of natural and polluted waters, water quality monitoring, regulation and protection of surface water, and watershed assessment and management.

In the lab, students go out to the field and learn how to conduct velocity and discharge measurements, Rosgen stream classification, proper functioning condition (PFC) assessment of riparian systems, macroinvertebrates assessment as indicators of water quality, methods of sampling and preservation of surface water samples, and measurements of different water quality parameters such as pH, turbidity, DO, ammonia concentration, conductivity, and alkalinity using field meters and kits. The students are also required to use these field techniques to collect data and write a watershed assessment report for the Plateau Creek Watershed.

This class teaches students the ability to analyze and interpret data, write a technical report, and work as a team in the field.

ENVS 337 Stream Biomonitoring (Elective): This class examines the structure and organization of macroinvertebrate assemblages in streams and rivers. Field activities include sample collection, sample preservation, sample identification, and analysis using the State of Colorado multimetric index for assessing water quality.

ENVS 376 Ecological Design and Technology (Elective): This class examines ecosystem-based technologies that benefit both humans and the environment. Students learn about relevant ecological principles and how these are applied towards the treatment of wastewater and/or the management of stormwater runoffs. The systems covered include treatment wetlands, anaerobic digesters, ecological treatment systems (ETS), algal flow ways, rain gardens, green walls, and green roofs. Many of these systems are also of emerging interest due to their ability to simultaneously treat wastewater or manage water runoff and reduce our dependency on fossil fuel (water-energy nexus). As part of their semester-long project, students work in teams to design systems that can be used to treat a local water issue.

ENVS 431 Water and Wastewater Treatment (Elective): This class covers the physical, chemical, and biological treatment technologies used for the treatment of drinking water and wastewater, as well as their process designs. Students learn about the different parameters that are used to monitor the effectiveness of the treatment processes, the Clean Water Act, and the Safe Drinking Water Act.

ENVS 433 Restoration of Aquatic Systems (Elective): This class covers the principles and techniques of restoring the functions and values of streams, ponds, and wetlands, addressing the physical, chemical, and biological aspects of these aquatic systems.

Courses that include water resources:

The Environmental Science program also offers the courses listed below that each contain one or more of the identified skills and/or knowledge relevant to water-related professions. For a complete list of the knowledge and skills taught in each course, please see the accompanying table. A basic summary of each course follows (courses required for the major or for one of the two concentrations within the major are noted with an *)

***ENVS 104 Environmental Science: Global Sustainability:** Introductory level course that includes a unit on the management of water resources, including: the hydrologic cycle, sustainable use of freshwater, the Colorado River Compact, water pollution, Clean Water Act, and the effects of climate change on water resources and aquatic systems.

***ENVS 204 Introduction to Ecosystem Management and Lab:** This course introduces students to the scientific management of natural resources in a changing environment, emphasizing techniques to increase ecosystem resistance and resilience to stressors. Students read a book on the history of federal land management that identifies the major challenges faced by different agencies in different regions of the country. The importance of NEPA and the Endangered Species Act on managing federal lands is discussed. In the lab, students learn the basics of vegetation monitoring, data collection and analysis, translating data into graphs, and technical writing. Students also learn how to identify local riparian and upland plants, both native and non-native.

ENVS 301 Environmental Project Management: Basic practices of effective project management, including proposal preparation, planning, scheduling, cost estimating, cost and progress tracking, and team building.

***ENVS 312/L Soil Science and Sustainability and Lab:** Physical, chemical and biological properties of soils. Function of soils emphasized. Application of soil science to sustainable use of soils in natural and agricultural settings.

ENVS 315 Mined Land Rehabilitation: Principles and practices of mined land reclamation. Topics include mining techniques, disturbances caused by mining, regulations, closure of mine features, soil preparation, revegetation, and monitoring.

ENVS 321 Environmental Risk Analysis: Assessment, management, and control of risk from toxic substances in the environment. Topics include basic elements of toxicity testing and epidemiology, chemical fate in the environment, exposure assessment, uncertainty in risk estimates, approaches to risk management, and risk communication.

ENVS 360/L Fire Ecology and Lab: This course examines the ecological effects of fire on forests, shrublands, and grasslands. It includes a unit on the effects of fire on soil, hydrology, and water quality. Students also learn about techniques to increase the resistance and resilience of different ecosystems to severe wildfire, including using fire as a restoration tool, post-fire rehabilitation treatments, and making homes and communities Firewise.

ENVS 373 Climate Change Adaptation: In this project-based course, students practice the steps used by natural resource professionals to assess the exposure, sensitivity and adaptive capacity of a site to climate change. After completing this assessment, students develop adaptation strategies for the site, including strategies for the built environment.

***ENVS 377 Systems Thinking in Environmental Science:** This course explores systems thinking as an approach to environmental issues. The topics covered include the meaning of systems and systems thinking, examining systems using the “triple P” framework (people, planet, profit), drawing system diagrams, conducting life cycle assessment and eMergy analysis to quantify environmental impacts. Students also learn how to use Excel to model systems.

ENVS 378/L Permaculture Design and Lab: Practical application of ecology to design sustainable human and agricultural systems. Topics include permaculture principles, design strategies, sustainable agriculture, natural building, cooperative economics, and neighborhood design. Students work in teams to complete a design project for a local site.

***ENVS 410 Environmental Regulatory Compliance:** Examination of regulatory requirements pertaining to air pollution, water pollution, hazardous materials, and radioactive materials. This class covers NEPA, the Clean Water Act, the Safe Drinking Water Act, and the Endangered Species Act. Additional topics include enforcement, compliance management systems, compliance auditing, and innovative approaches to regulation.

ENVS 413 Environmental Fate and Transport of Contaminants: Physical, chemical, and biological factors influencing the persistence and migration of chemicals in the environment. Includes consideration of air, surface water, soil, and ground water. Emphasis on quantitative problem solving.

***ENVS 420/L Pollution Investigation & Monitoring:** Survey of field sampling and analytical methods for study of environmental systems. Topics include sampling design, regulatory issues, quality assurance, quality control, data interpretation, and reporting. Three one-hour lectures and one three-hour laboratory per week.

***ENVS 455 Restoration Ecology:** Examination of principles and techniques for restoration of community characteristics and ecosystem functions (including hydrologic function) to disturbed lands. Lecture and lab emphasize practical application of ecological principles to restoration culminating in an independent project of designing a restoration project for a local area.

***ENVS 475 Experimental Design and Statistical Analysis in Environmental Science:** Examination of principles and techniques for designing experiments and analyzing data in environmental sciences. Emphasis on practical application of analysis techniques using environmental data with computer applications.

***ENVS 492 Capstone in Environmental Science and Technology:** Small-group environmental projects for outside organizations. Students prepare project proposals, plan and implement projects, write project reports, and give oral presentations to clients such as Mesa County, the BLM, and Western Water and Land, Inc. Some examples of these projects: 1) characterization and evaluation of the most likely sources of *E. coli* contamination in Leach Creek, 2) hydrologic characteristics and drainage capacity of a frequently flooded neighborhood in Mesa County, and 3) water quality study of mine-impacted stream in Ouray.

ENVS 101 Intro to Environ. Sci.
ENVS 104 Global Sustainability
ENVS 204/L Ecosystem Management
ENVS 221/L Sci. & Tech. of Poll. Cont.
ENVS 301 Project Management
ENVS 312/L Soil Sci. & Sustainability
ENVS 331/L Water Quality
ENVS 337 Stream Biomonitoring
ENVS 340 Applied Atm. Science
ENVS 370 Renewable Energy
ENVS 354 Forest Ecology
ENVS 360/460 Fire Ecology/Mang.
ENVS 373 Climate Change Adaptation
ENVS 376 Ecological Design and Tech
ENVS 410 Env. Reg. Compliance
ENVS 420 Pollution Invest. & Mon.
ENVS 455 Restoration Ecology
ENVS 431 Water & Wastewater Treat.
ENVS 433 Rest. of Aquatic Systems
ENVS 492 Capstone

Water management and regulations

U.S. water consumption patterns	X	X					X												
Colorado River Compact	X	X												X					
Clean Water Act (Overview)	X	X		X															
Clean Water Act In-Depth							X							X				X	
Safe Drinking Water Act				X										X				X	
NEPA			X											X					
Endangered Species Act			X											X					
Management and/or monitoring of water quality							X							X	X			X	

ENVS 101 Intro to Environ. Sci.
ENVS 104 Global Sustainability
ENVS 204/L Ecosystem Management
ENVS 221/L Sci. & Tech. of Poll. Cont.
ENVS 301 Project Management
ENVS 312/L Soil Sci. & Sustainability
ENVS 331/L Water Quality
ENVS 337 Stream Biomonitoring
ENVS 340 Applied Atm. Science
ENVS 370 Renewable Energy
ENVS 354 Forest Ecology
ENVS 360/460 Fire Ecology/Mang.
ENVS 373 Climate Change Adaptation
ENVS 376 Ecological Design and Tech
ENVS 410 Env. Reg. Compliance
ENVS 420 Pollution Invest. & Mon.
ENVS 455 Restoration Ecology
ENVS 431 Water & Wastewater Treat.
ENVS 433 Rest. of Aquatic Systems
ENVS 492 Capstone

Treatment Techniques or Technology

Wastewater and Drinking Water Treatment Processes (Biological, physical, and chemical concepts and techniques used)				X											X			X			
Anaerobic Digesters, Treatment Wetlands, and/or Algal Turf Scrubbers										X					X	X			X		
New and upcoming wastewater treatment technologies (for instance, anammox)								X							X				X		
Remediation techniques for polluted soil and/or groundwater				X		X															

Transferable Skills

Technical writing			X	X	X	X	X					X	X	X		X	X				X
Project management					X											X					X
Communication (oral)					X	X				X		X	X	X	X	X	X	X			X
Team work			X	X	X		X			X	X	X	X	X		X	X				X
Data analysis and interpretation	X	X	X	X	X	X	X	X		X		X	X	X		X	X				X

CMU Faculty Review of Grand Valley Water Workforce Needs Assessment

Completed by Dr. Kerry Riley, Instructor of Geology

Geoscience Program Overview - Department of Physical and Environmental Sciences

The Geoscience program offers six different B.S. degrees and one A.S degree resulting in a range of exposure to the program curriculum. The degrees offered include B.S. Geology, B.S. Environmental Geology, B.S. Geosciences, Secondary Education, Minor in Geology, Minor in Geographic Information Science and Technology (GIS&T), Minor in Watershed Science, and A.S. Geosciences. Degrees that are most applicable to water-related professions include B.S. Environmental Geology, Minor in Geographic Information Science and Technology (GIS&T), and Minor in Watershed Science. The current course offerings listed under the 'Relevance of selected water-related subject areas covered at CMU' section of the Workforce Needs Assessment identifies Hydrology and Geographic Information Systems (GIS) as relevant courses in the Geoscience Program. An extended list of courses taught in the Geoscience Program that support the development of skills and knowledge identified as highly important for water careers is listed below.

GEOL 202 – Introduction to Field Methods	GEOL 415 – Groundwater
GEOL 204 – Computer Applications in Geology	GEOL 496 - Climate Change: The Science
GEOL 250 - Environmental Geology	GEOL 402 – Geomorphology
GEOL 333 – Geology of Canyon Country	GIST 150 - Introduction to GIS
GEOL 355/455 - Hydrology / River Dynamics	GIST 321 – Introduction to Remote Sensing
GEOL 351 – Applied Geochemistry	GIST 375 – GPS for GIS

Current skills and knowledge offered by the Geoscience Program within the Department of Physical and Environmental Sciences

The Geoscience program currently provides students with a solid background in Earth Sciences and curriculums address many of the skills and knowledge identified as important across multiple water-related professions. Geosciences is particularly strong at providing students with fieldwork experience, math and quantitative reasoning skills, practice in scientific writing and oral communication, foundational skills in Geographic Information Systems (GIS), and experience mapping and surveying using multiple techniques. Brief descriptions of courses currently offered in the Geoscience Program and how they apply to water-related jobs are described below.

GEOL 202 – Introduction to Field Methods is a practical course that provides students with basic skills for the collection, analysis, and presentation of geologic field data. The curriculum does not cover water-related issues directly but does provide fieldwork experience that involves many skills applicable to water-related jobs. Students learn how to read maps, make field observations, and apply geometry and trigonometry to solve spatial problems. Students use topographic maps and field surveys to make quantitative measurements of landscape characteristics. Students learn how to write a geologic sample description in the field, use aerial photographs to map geology, constructing geologic cross sections,

engage in project planning and report writing. A significant amount of this class is spent outside in the field. Most projects involve collaboration and working in teams.

GEOL 204 – Computer Applications in Geology provides students with basic quantitative methods to analyze and professionally present Geoscience data on the computers with MS Office, MS PowerPoint, MS Excel, and ARCG GIS. The final project involves working with water-table elevation data. Students are asked to use ArcGIS to create a water surface profile in a specific region of an unconfined aquifer. They analyze a water surface profile in comparison to the present-day land-elevation surface and to presence (or absence) of ponds/lakes in interdune areas. Students think about changes in the water-table elevation (typically decreases) and propose hypotheses that explain the drop in water table surface.

GEOL 250 - Environmental Geology introduces students to the study of water-related natural hazards and natural resources including mass wasting, flooding, soil degradation, water quality, and water supply. This course emphasizes the magnitude of future water supply challenges and the role of water infrastructure and land use planning. The current curriculum briefly discusses policies governing water, Colorado water law, and other Environmental laws such as the Clean Water Act. There is opportunity for a more in-depth policy discussion. The curriculum has a large writing and oral communication component and includes many group projects. There is opportunity to include an emphasis on project management skills.

GEOL 333 – Geology of Canyon Country is an informal course structured around a 6-day river trip on the Green River through Labyrinth Canyon. Water-related topics discussed during the trip include Colorado River hydrology, Colorado/Green River stakeholders, and water supply challenges in the west. Seasonality of natural and human-influenced streamflow is discussed in the context of the Yampa and Green Rivers. Channel narrowing is discussed regarding flow regulation. Students choose topics that relate to Labyrinth Canyon, conduct a brief literature review, and present on the topic during the river trip.

GEOL 351 – Applied Geochemistry is required for Watershed Science minors and provides students with a set of tools that they can apply to geochemistry problems across many fields. The course covers topics including thermodynamics in the context of minerals and geochemical fluids, the influence of rocks and soils on water chemistry, and the use of isotopes as environmental tracers. The course includes a student-directed research project addressing a geochemical topic. Students research a topic, write a paper, and present their findings in an oral presentation.

GEOL 355/455 – Hydrology and River Dynamics is required for Watershed Science minors and provides students with a basic understanding of surface-subsurface interactions. The course introduces students to basic hydraulics and simple hydrologic modeling, requires quantitative reasoning and math skills, and conducts fieldwork using standard stream surveying techniques. Students survey channel cross sections and longitudinal profiles using a stadia rod and total station. Students use field equipment (Marsh-McBirney Flo-Mate) to measure velocity of streams. Students combine field data to quantify streamflow. Seasonality of natural and human-influenced streamflow is discussed in the context of the upper and lower Colorado River Watershed. Students apply local parameters to preconstructed models of radiation, snowmelt, and evaporation. The current curriculum exposes students to a variety of stream classification systems. Emphasis can be placed on the Rosgen stream classification system if it is the most applicable to water-related jobs.

GEOL 415 – Groundwater is required for Watershed Science minors and provides students with an introduction to surface and groundwater hydrology and aqueous geochemistry in natural systems. It provides students with the ability to identify a hydrogeologic problem and think through the steps required to solve it. The course is divided into three roughly equal parts: surface water hydrology, groundwater hydrogeology, and aqueous geochemistry. The course covers basic hydrogeology concepts such as Darcy's Law, hydraulic conductivity, transient groundwater flow, and solute transport and contamination are discussed and investigated.

GEOL 402 – Geomorphology focuses on Earth surface processes and incorporates theory and methods from remote sensing, sedimentology, hydrology, soil science, and engineering geology. The course provides students with basic understand of hydrology to understand why hillslopes transition to channels and the dynamics of fluvial processes. Students interpret topographic maps and manually delineate a watershed, quantify watershed metrics, and map depositional landforms such as alluvial fans. Students utilize spreadsheets and basic math to analyze surveyed data and create longitudinal profiles. Students experiment with a model of longitudinal profile evolution toward the graded stream. Students impose a variety of disturbances (e.g., faulting, base-level changes) on the model and assess how different scenarios influence slope, concavity, and aggradation/degrading over time. Students complete a soil description of the Colorado River 100-meter terrace, analyzes clay content, and relate observations to hydroclimate and water scarcity. The course helps students develop writing and oral communication skills and provides students with experience doing fieldwork.

GEOL 496 - Climate Change: The Science is a special topics class that provides students with an understanding of how Earth's heat budget, hydrologic cycle, carbon cycle, paleoclimate, and atmospheric and oceanic circulation are all part of climate change science. The course concentrates on the scientific method, and how climate scientist predictions and conclusions are based on evidence from physics, chemistry, biology, and geology components of our Earth system. The first third of the course provides background knowledge on weather and climate change and the knowledge is applied to the new findings published in the IPCC 2021: The Physical Science Basis report. The latter part of the course involves student-lead presentations and discussions.

GIST 321 – Remote Sensing Systems and Application provides students with a basic understanding of remote sensing applications in the Geosciences. The curriculum focuses on characteristics of photographs and interpretation of scanner and radar imagery. This course utilizes free-of-charge imagery provided by NASA. Students interpret and classify aerial photographs for land use based on land cover. Students learn how to use ENVI (remote sensing image analysis software). Students develop vegetation and burn severity indices that inform boundary conditions and parameters needed for hydrologic models.

GIST 332 - Introduction to GIS provides students with a basic understanding of GIS and digital mapping, including basic GIS skills and an introduction to geospatial databases and analyses. The course demonstrates that GIS is a useful and flexible tool that can be used to answer and solve a wide range of geographic questions and problems. This course is suitable for a variety of disciplines.

GIST 375 – GPS for GIS provides students with an understanding of how the Global Positioning System (GPS) works/ potential problems and error sources and applies student understanding by collecting high-quality spatial data. Students learn how to plot GPS coordinates in a GIS map and be able to assess and assign appropriate geographic coordinate systems, projections, and geodetic datums. Students coordinate a GPS data collection effort that is processed, synthesized, and used to produce a final GIS map product. Students use both recreational and mapping-grade GPS units to collect high-quality positional data and associated attributes in the field, transfer positional data from a GPS unit to a PC, export GPS data into GIS software, and differentially correct GPS data using Trimble Pathfinder Office.

Capacity Assessment Review of Grand Valley Water Workforce Needs Assessment Report

Dr. Tim Casey, Professor of Political Science, Director of Natural Resource Center

March 2022

POLS and NRC response to current needs

The POLS program and Social and Behavioral Sciences Department in general support the work of the Water Center primarily through a focus on water policy and water law from the needs identified in the report. It should be noted that the report does not focus primarily on policy or water law, but mentions it several times. There are many skills and opportunities for expanded engagement from SBS and other non-water science or technical skill sets that are the main focus of the report. It is assumed that the report was compiled from interviews of practitioners in the water field, so they may not perceive a need for the policy management aspects of water.

Regarding basic skills, POLS classes and other SBS classes emphasize “strong writing and oral communication skills” as well as GIS training in several courses offered by our Geography department including GIS for the Social Sciences and other physical geography courses. We also address “Colorado water Law” in POLS 488: Environmental Politics and Policy as well as case studies in POLS 236: State and Local Government. POLS 488 also addresses in great depth “Environmental laws (Clean Water Act, National Environmental Policy Act and Endangered Species Act)”. Another course in POLS curriculum that is currently not being offered, but could address these if offered is POLS 353: Politics of Human and Natural Resources whose catalog description reads “Study of politics and public policy surrounding natural resource allocation, preservation, development and consumption by human social systems. Emphasis on challenges of public policy formation and implementation in areas of land, water, energy, minerals, food and habitat at domestic and global levels.”. Water issues are also addressed in case studies in POLS 354: Political Geography (an extensive case study on the Colorado River) and POLS 471: Politics of Global Governance which focuses on international water management issues as some of the case studies. The report also identifies public attitudes and awareness of water issues and policy. The assessment of public attitudes on policy features prominently in each of the courses mentioned already and in courses such as POLS 351: Public and Elite Behavior. If you consider disaster effects from hydrometeorological cycle, then there are several additional courses in Emergency Management and Disaster Planning such as EMDP 211: Introduction to Emergency Management, EMDP 321: Hazard Preparedness and Mitigation; EMDP 331: Disaster Response and Recovery that deal with the impacts of drought, climate change, flooding and damage to water infrastructure. Distribution policies and water rights as well as the Doctrine of Prior Appropriation are addressed in depth in POLS 488, POLS 353 as well as in theory in POLS 151: Introduction to Political Ideas and POLS 453: Modern Political Theory as examples of property rights. These issues might also arise in History and Sociology courses, but since I don’t teach them, I cannot say for sure.

Regarding Natural Stewardship and regulation, POLS 488 is largely focused on these issues, POLS 353 is also designed to address regulation of natural resources and resource stewardship. This would include education of visitors. These courses also identify nonprofit organizations as key stakeholders and train students in the policy making process and the skills needed for advocacy. POLS 354 has a significant

component focused on landscapes in the Western United States. The section on nonprofits and advocacy in the original report is very short. CMU has the capacity to expand learning and training in these areas, but the report has not emphasized this section beyond a few lines. Some of the sources for the report identified internships as a source of partnerships. CMU has engaged interns on natural resource advocacy and management issues for several years. We would like to continue and enhance those offerings.

Several of the POLS and SBS classes identified earlier address stakeholder perspectives, collaboration and conflict. This is at the heart of many of our courses in SBS and they could be valuable for the effort to “learn how to work with people with different objectives.” These stakeholder skills are elaborated on in the Mesa Conservation District of the report. Dr. Tammy Parece in Geography can be helpful with all GIS skills in the report as well as transferring old maps from BOR into GIS. Her courses are an important part of the GIS certificate program that would address GIS needs throughout the report.

Finally, the report addresses realtor education courses which I think is a brilliant idea, but most of the discussion in that section deals with irrigation rights. There should be room to also educate them on water use and conservation issues so they can help newcomers to the valley to fully understand the implications of their water use (domestic and irrigated) in such an arid climate.

Western Colorado Community College Programs

WCC's **Agriculture Science Program** provides students with a solid foundation of agricultural knowledge based on principles of stewardship and stockmanship, an expanded outlook on the agricultural industry and practical skills required for a wide variety of fields. With this skill set, students are well prepared to successfully pursue their chosen agricultural career.

Full details can be found at <https://www.coloradomesa.edu/wccc/programs/agriculture.html>

WCC's **Land Surveying and Geomatics Program** students learn the fundamental measuring techniques and the associated mathematical and analytical principles to determine geospatial locations. They also become familiar with professional tools such as computer aided drafting and geographical information systems. Students learn the statute and common law roots of boundary law, as well as how to apply those laws to interpret boundaries, and the importance of accurate record research.

Full details can be found at: <https://www.coloradomesa.edu/wccc/programs/land-surveying-geomatics.html>

WCCC's Water Quality Program is no longer accepting new students for the Associate of Applied Science in Water Quality Management, but continues to offer several certificate programs related to water and wastewater treatment.

Full details can be found at <https://www.coloradomesa.edu/wccc/programs/water-quality-management.html>