CAP
CENTRAL ARIZONA PROJECT

CLIMATE ADAPTATION PLAN
2018

www.CentralArizonaProject.com

Contents

1.0 Introduction and Background

The Central Arizona Project (CAP) provides renewable water supply to central and southern Arizona, where about 80 percent of the population of Arizona resides. This water supply comes from the Colorado River Basin and is subject to priority administration during drought. Recent drought, as well as studies on the potential impacts of climate change, have put a fine point on the need for CAP to be prepared for changing conditions. A prolonged shortage in the Colorado River Basin due to persistent drought could cause CAP to suffer a reduction in water diversions from the river. In addition, drier and warmer conditions may have broader effects on water demand, the economy, and the financial security of CAP. It follows that climate change could have far-reaching effects throughout the CAP organization. The purpose of the climate adaptation project described herein is to investigate the potential effects of climate change across CAP departments, and develop a plan to increase the resiliency of CAP.

This section provides background information about CAP, climate change in general, and specific climate change concerns for CAP. Following this background section, this report contains the following sections:

- Approach to plan development
- Summary of drivers, scenarios, potential impacts, and adaptation strategies/portfolios
- Analysis and identification of critical vulnerabilities and robust adaptation strategies
- Conclusions
- Next steps

1.1 Central Arizona Project

1.1.1 History and Mission

During the early 1900s, the seven states of the Colorado River Basin, Arizona, California, Nevada, New Mexico, Wyoming, Colorado and Utah, apportioned Colorado River water. In 1922, representatives from the seven Basin States and the United States government created the Colorado River Compact, which divided the states into Lower and Upper Basins and gave each basin 7.5 million acre-feet of water to apportion. Arizona[1], California, and Nevada were sectioned into the Lower Basin, and were instructed to divide their 7.5 million acre-foot allotment among themselves.

Arizona was in dispute over its share of the river, however, and was the last state to approve the Compact in 1944. Today in the Lower Basin, Arizona has rights to 2.8 million acre feet of Colorado River water per year, California is entitled to 4.4 million acre feet per year and Nevada has an annual allocation of 300,000 acre feet. One acre foot of water equals 325,851 gallons, the annual amount used by three families of four.

In 1946, the Central Arizona Project Association was formed to educate Arizonans about the need for the CAP and to lobby Congress to authorize its construction. It took the next 22 years to do so, and in 1968, President Lyndon B. Johnson signed a bill authorizing construction of the CAP. The bill directed the Secretary of the Interior to construct the CAP and contract for delivery of the CAP water supply and repayment of reimbursable costs.

In 1971, at the request of the Secretary, the Central Arizona Water Conservation District (CAWCD) was created to provide a single entity to repay the federal government for the reimbursable costs of construction and contract for the delivery of CAP water. Construction began at Lake Havasu in 1973 and was completed 20 years later south of Tucson. Now, the CAP is the steward of central Arizona's Colorado

[1] A small portion of Arizona's Colorado River Water comes from the Upper Basin Apportionment.

River water entitlement, roughly 1.5 million acre feet, and a collaborative leader in Arizona's water community.

CAP's service area is comprised of three counties in central and southern Arizona – Maricopa, Pinal and Pima. This 24,000 square mile area (approximately 20 percent of the state), includes 5.3 million people, which is approximately 81 percent of the state's population. The CAP system serves a variety of water users within the service area, including 55 municipal subcontractors, 10 Native American tribes, and a number of agricultural and excess water customers every year.

CAP's Mission:

CAP is the steward of central Arizona's Colorado River water entitlement and a collaborative leader in Arizona's water community.

CAP's Vision:

The CAP will be a collaborative, innovative leader in the management and the delivery of water to central Arizona. It will enhance the state's economy and quality of life and ensure sustainable growth for current and future populations of Arizonans.

1.1.2 Organizational Structure

CAP's organizational structure is managed by the CAP Management Council which includes the General Manager, the Deputy General Manager, General Counsel, and several Directors. The Management Council oversees the following groups within the organization:

Water Policy

The Water Policy Group manages and oversees long-range planning, policy analysis and development and program implementation for the CAP Service Area, the Colorado River, and the Central Arizona Groundwater Replenishment District (CAGRD).

The CAGRD helps property owners and water providers in the Phoenix, Tucson, and Pinal Active Management Areas (AMAs) without access to sufficient renewable water supplies to demonstrate the required 100-year assured water supply under Arizona law. Currently, 23 water providers and cities, as well as more than 260,000 homes, rely on the CAGRD for this purpose. For more than 20 years, the CAGRD has played a critical role in the state's successful water management program and has contributed to the State of Arizona's economic growth and development. The CAGRD is statutorily obligated to develop or acquire renewable water supplies as needed to replace the groundwater pumped by its members. The CAGRD uses a variety of water supplies to meet this obligation.

The Colorado River Programs department works collaboratively with stakeholders in Arizona, the Colorado River Basin States, and the federal governments of the United States and Mexico to ensure reliable water supplies are available to meet CAP's customers' needs. Colorado River Programs support CAP's strategic objectives by influencing the management of the Colorado River system to optimize the supply available to CAP, developing new water supplies to augment the Colorado River, protecting CAP's Colorado River water supply, evaluating and managing risks posed to CAP from climate change and prolonged drought, and implementing water management programs to reduce the risk of shortages to CAP.

Resource Planning and Analysis staff perform a variety of long-range water resource planning activities within the CAP service area, including supply and demand forecasting, shortage impact and reliability analyses, and projections of CAGRD's replenishment obligation. Resource Planning and Analysis staff are also actively engaged in a number of specific processes, including development of a framework for wheeling non-Project water, recovery of credits stored by the Arizona Water Banking Authority, and development of the CAGRD's Plan of Operation. To support CAP's long-range planning activities, Resource Planning and Analysis develops and maintains models, planning data, and GIS capabilities.

Operations and Engineering

The Operations and Engineering Group is responsible for operational control of the water supply facilities, deliveries to customers, accounting for water diversion and deliveries, engineering support for maintenance and capital improvement of CAP's facilities, administration of CAP lands, and management of CAP power and transmission resources. The group consists of three departments, discussed below.

Engineering Administration is comprised of Engineering Services, Engineering Resources, and Engineering Project Management. The mission of Engineering Services is to provide engineering expertise, direction, service, and support to CAP. Engineering Resources is responsible for the design of asset modifications, code compliance review and adoption, support of construction projects, and the creation and maintenance of standard operating procedures. Engineering Project Management provides construction management services for all major capital improvements. Engineering administration services also include oversight of CAP land and technical records, land surveying, inspection services, and drafting services.

The Water Operations Department (which includes Water Control and Water Systems) is dedicated to the safe operation of the CAP system in order to protect people, property, and equipment while optimizing CAP's water resources. The Water Operations department is responsible for the safe and efficient operation of the CAP canal and all its facilities. In addition to efficiently operating the canal and pumping plants to deliver CAP water to central Arizona customers, Water Operations also provides water accounting, water use forecasting, and hydraulic and hydrologic engineering services.

In conjunction with Water Operations, the Power Programs department performs forecasting and accounting of energy use, transmission, and generation for the CAP system. Power Programs also manages CAP's energy portfolio, including rights to Navajo Generation Station power, contracts to power from Hoover Dam, and power marketing contracts.

Maintenance and Reliability

Maintenance and Reliability is responsible for the effective application of industry best practices in the delivery of maintenance and equipment reliability. It consists of departments that protect and preserve the integrity and capacity of CAP's water delivery system and related infrastructure through proactive reliability-based maintenance practices.

Reliability Engineers are responsible for the preventive maintenance programs and reliability of CAP's assets. They monitor the performance and reliability of the water delivery system and adjust the preventive maintenance procedures, frequencies, and technologies to improve reliability and cost effectiveness as needed. Maintenance Engineers are responsible for Reliability Centered Maintenance (RCM) implementation and preventive maintenance procedures. They serve as a liaison between Reliability Engineers and the maintenance groups to ensure the proper execution of routine and reoccurring maintenance activities as well as individual, extraordinary maintenance activities as required to ensure the reliable function of CAP's infrastructure.

Maintenance Planning coordinates the maintenance business processes and serve as "hub" of the maintenance operation. Maintenance Planners develop work packages, job plans, and schedules as required to coordinate manpower, materials, tools, specialty equipment, contracts, and permits in order to provide execution ready work that can be completed in the most efficient manner possible. Maintenance Planning is involved in all maintenance work at CAP including preventive activities, corrective work, asset modifications, and predictive technologies.

Work Execution personnel are the primary resource responsible for preserving equipment reliability. Decentralized crews are generally focused on preventive maintenance inspections, general repairs, and operational activities. Centralized crews travel project-wide to support the decentralized crews. Centralized support crews are staffed and equipped to perform heavy overhaul and specialty trades work that is outside the normal workload of the employees assigned to the decentralized crew.

Field Maintenance

Working cooperatively with the Maintenance and Reliability Group, the Field Maintenance Group also protects and preserves the integrity and capacity of CAP's water delivery system and infrastructure. The Field Maintenance Group is primarily composed of decentralized crews that are generally focused on preventive maintenance inspections, general repairs, and operational activities. The Field Maintenance Group also includes CAP's Electrical Safety Program.

Field Maintenance crews are organized to work on both the west and south area of the CAP water delivery system. Both sets of crews are responsible for maintaining the integrity, capacity and reliability of pumping plants, aqueducts, check and turnout structures, recharge facilities, pipelines, siphons, tunnels, operations and maintenance roads, cross-drainage structures, fencing, protective dikes, and other related facilities. CAP's electrical safety program manages CAP's hazardous energy control and electrical safety to ensure the safety of CAP personnel working in hazardous field locations.

Public Affairs

The mission of Public Affairs is to strategically advance CAP's mission by developing a consistent and unified voice and by building collaborative relationships internally and externally. There are four departments within Public Affairs that work to achieve that goal: Board Relations, Communications, Legislative Affairs and Stakeholder Relations.

Board Relations works directly with the Board, increasing opportunities for interaction with stakeholders and peers and equipping them to effectively represent CAP and its positions. Communications creates consistent messaging for various audiences, develops and deploys a consistent employee communications plan, enhances public awareness for target audiences and improves knowledge and visibility of CAP. This is done by providing information, perspectives, and programs that help influence public opinion and enhance CAP's reputation as a strategic partner in the management, delivery and protection of Colorado River water. Legislative Affairs directs development and implementation of CAP's state and federal legislative agendas, oversees and coordinates state and federal contract lobbyists and manages communications with legislators, legislative staff, lobbyists and other water interests on legislative matters of interest to CAP. Stakeholder Relations regularly meets with customers and stakeholders, developing new relationships and strengthening existing ones to improve overall relationships.

Technology

The Technology Group is responsible for developing and maintaining highly effective, reliable, and secure technology systems to support CAP's mission.

Information Technology works with CAP employees to improve business practices through the use of technology by providing technical support, business tools, and services. Information Technology maintains application and systems infrastructure and provides technology project management. The Information Technology department automates business processes where possible, thereby reducing manual operations and enabling efficient workflow.

The Operational Technology department is responsible for the operations and maintenance of the hardware and software systems that monitor and control physical assets. Operational Technology executes engineered maintenance plans for physical assets associated with security, fire, communications, HVAC, and power.

Legal Services

The Legal Services group serves as a legal support function to CAP, including and not limited to providing legal advice to CAP's departments and Board of Directors, negotiating/drafting/reviewing contracts, managing litigation, and providing legal review of policies. Legal Services also assures compliance with laws, regulations, and policies that are applicable to CAP.

Finance and Administration

Finance and Administration is responsible for managing financial and administrative activities of CAP, including finance and accounting, enterprise risk, records, resiliency, supply chain, and facilities services. Finance and Administration ensures the accuracy and integrity of financial reporting, including planning, rates, budget, and reserves as well as compliance with records management standards, purchasing policy and oversight of insurance operations.

CAP's Enterprise Risk, Records and Resiliency Management is responsible for alternative and traditional risk transfer and financing, loss prevention, and claims management, better enabling CAP to meet its strategic objectives. Records focuses on regulatory compliance of records and information, providing the right records at the right time, and creating and maintaining a pipeline for good information flow. Resiliency maintains preparedness for business disasters and threats to CAP's operations, and regularly tests for readiness and continuity of operations.

The Finance and Accounting department provides oversight and accountability in regard to CAP's finances. Financial Planning and Analysis is responsible for financial analysis and reporting, oversight of budget development and forecasting, long-range financial planning, cash and treasury management, accounts receivable and accountable property, and strategic reserve planning. Accounting responsibilities include statement reporting according to generally accepted accounting principles, annual financial audits, and matters related to accounts receivable and payable, and payroll.

The Supply Chain and Facilities departments within Finance and Administration address the procurement of goods and services, inventory control, distribution of materials/supplies/equipment to other CAP departments and locations, as well as providing facilities services.

Employee Services

The Employee Services Group provides strategic support and services necessary for CAP to maintain a productive, safe, healthy and secure environment with competitive pay and benefits that encourages employees to work at their optimum level. Employee Services enhances the effectiveness of CAP employees by increasing their knowledge, skills, and abilities though continued learning, growth and development opportunities. The Employee Services Group thus enables CAP to remain an employer of choice that can recruit and retain highly qualified workers.

Central Learning and Development manages, designs, and implements CAP's learning strategy, which includes training, organizational development, and employee engagement programs. These programs and processes ensure that CAP has skilled talent available to meet current and future business needs.

Human Resources strives to maintain CAP as a desirable workplace environment and capable organization by recruiting and hiring highly qualified employees, providing good customer service to all employees, and enhancing organizational performance through employee training, career development guidance, and succession planning. Human Resources also oversees general issues related to staffing, compensation, benefits, performance management, and employee relations and policies.

Protective Services is responsible for protecting CAP's employees, facilities, the canal, surrounding property, the environment and wildlife in order to keep Colorado River water flowing to CAP's customers. The mission of Protective Services is to provide CAP with a safe and secure work environment.

The Environmental Department leads CAP in being a good steward of the environment, and collaborates with all departments to minimize CAP's negative impacts on the environment. The Safety Program supports health and safety in both the workplace and at home. The team of safety and health professionals partner with CAP managers and employees to uphold the highest safety standards resulting in an accident and injury free workplace.

1.2 CAP's Climate Change and Adaptation Activities

CAP staff in the *Colorado River Programs* department routinely keep track of seasonal changes to climate indicator signals such as sea surface temperature, ENSO (El Nino Southern Oscillation), and PDO (Pacific Decadal Oscillation) to predict potential impacts to winter precipitation in the Upper Colorado River Basin. In addition, there have been previous studies and current work efforts that CAP has been involved in that incorporate the potential impacts of climate change. These activities include:

- Modeling Colorado River water supply and use through the Colorado River Simulation System (CRSS)[2]. Input into the CRSS model includes several water supply hydrologies, one of which is derived from downscaled General Circulation Model (GCM) projections and is referred to as the Downscaled Climate hydrology (see Section 1.3.1 for more information on General Circulation Models and downscaled hydrology).
- Exploring dynamic downscaling using data from the Coupled Model Intercomparison Project (CMIP) as a method to improve climate GCMs in their ability to simulate precipitation. As part of the project steering committee, CAP oversaw and provided input into the project that was conducted by the University of Arizona using the Colorado River Basin as a test watershed to gauge the success of the methodology.
- Attempting to improve mid to near term prediction of streamflow in the Upper Colorado River Basin by connecting sea surface temperatures to winter storms in the Upper Basin using synoptic storm patterns. This is achieved by analyzing the predictability in the Winter Jet Stream position over the Upper Colorado Basin based on Sea Surface Temperature. CAP solely funded this project that was produced by the Desert Research Institute (DRI).
- Exploring the sensitivity and correlation of hydrological variables (e.g. precipitation, snow water equivalent, and streamflow) in the Upper Colorado River Basin to Lake Powell inflow and storage from a historical perspective. This CAP-funded study that is being generated by DRI is attempting to extrapolate definitive trends from the historical record that can help inform future and current hydrological conditions in the Colorado River Basin.
- Participating in the Water Utility Climate Alliance (WUCA). WUCA is composed of 12 water agencies (Austin Water, CAP, Denver Water, MWD, NYCDEP, Philadelphia Water Department, Portland Water Bureau, San Diego CWA, San Francisco PUC, Seattle Public Utilities, SNWA, and Tampa Bay Water) that are collaboratively assessing the challenges water utilities face in adapting to climate change. WUCA also provides an avenue to engage climate scientists on how to enhance the usefulness of climate science and tools for climate adaptation by water utilities. CAP currently serves as the Vice Chair for WUCA.

1.3 Climate Change and Projected Effects on CAP

This section provides a very brief introduction to climate change and a full description of the primary impacts of climate change on CAP. More detailed summaries on the science of climate change, methods used to project climate change and effects on hydrology, climate projections in the Colorado River Basin (CAP water supply) and Arizona (CAP service area), and references to climate change assessments, globally, regionally, and locally, is presented in Appendix A.

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[2] CRSS is an object-oriented surface water model developed in the RiverWare modeling environment and maintained by the United States Bureau of Reclamation. CRSS incorporates important aspects of the Colorado River Basin; including reservoirs, flows, diversions, and operating rules.

Climate change is the change to the Earth's surface and air temperatures, atmospheric compositions, and radiation absorption that occur over time periods longer than several decades. Climate change is driven by both natural factors (Earth's orbital patterns, solar radiation changes, plate tectonics, ocean circulation and heat redistribution, cloud cover, chemical composition of the atmosphere) and factors influenced by human activities (chemical composition of the atmosphere)[3].

Climate change can be observed through examining data on surface temperature, global sea level, precipitation, and global ice. Since direct measurements of these characteristics only go back to around the 19th century, indirect methods such as tree-ring analysis (dendroclimatology) and ice cores are used to estimate historical climate conditions.

1.3.1 Primary Climate Change Concerns for Central Arizona Project

The Colorado River Basin generates CAP's water supply, so warmer and drier conditions caused by prolonged climate change-induced drought in the watershed, with reduced snowpack and streamflow, is a major challenge that requires active management. Increased warming in the CAP service area also results in inflated water demand from customers, and extreme weather events such as flooding negatively impact CAP's water infrastructure.

Drought in the Upper Colorado River Basin

Prolonged drought conditions in the Colorado River Basin can impact the annual water supply available for water users in the basin. Reliability of Colorado River water supply is strongly influenced by hydrologic conditions in the Upper Colorado River Basin, since 92 percent of annual Colorado River flow is generated there. As such, annual Colorado River flow is dependent on winter precipitation, snowpack accumulation, and spring runoff that occurs in the Upper Basin.

Snowpack accumulation season for the Colorado River Basin occurs between October and April, when winter storms produce precipitation that is then retained by the snowpack due to cooler temperatures. Drier and hotter conditions due to drought may reduce the accumulation of snow during the winter season due to fewer precipitation events and increased sublimation and melting of the existing snowpack. In addition, excessively warm winter temperatures coupled with winter precipitation may cause rain instead of snow to fall on the snowpack. This has the effect of reducing the size of the winter snowpack.

The spring runoff season takes place between the months of April and July, where snow accumulation shifts to snow melt. The volume of runoff generated in this period is critical in determining inflow into Lake Powell and subsequently the active storage of the Colorado River system.

Water stored in Lake Powell and Lake Mead constitutes the large majority of system storage in the Colorado River Basin. The elevation and volume of the water stored in Lake Powell and Lake Mead factor into how much water is delivered to downstream users in the Lower Colorado River Basin. Per the 2007 Interim Guidelines[4], August projections[5] of reservoir conditions in January of the following year influence

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[3] While "climate change" refers to any change in Earth's surface and air temperatures, the term "global warming" refers specifically to anthropogenic heating linked to the levels of greenhouse gases, such as carbon dioxide, in the atmosphere.

[4] The Record of Decision on the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 Interim Guidelines) was signed in 2007. The 2007 Interim Guidelines define how Lakes Powell and Mead are operated in coordination and was designed to manage the impacts of reduced water supplies to Lower Basin water users as Lake Mead declined in elevation. One of the measures outlined in the 2007 Interim Guidelines is how a Lower Basin shortage affects Arizona and Nevada's annual Colorado River allocation.

[5] These projections are published in the 24-month study. The 24-month study is a monthly report produced by the Bureau of Reclamation that provides a 2-year future outlook from the present month for reservoir conditions in the Colorado River system. The reservoir conditions are determined on a most probable inflow, based on the Colorado River Basin Forecast Center's most probable water supply forecast.

the volume of water released from Lake Powell downstream towards Lake Mead, and the volume of water released from Lake Mead to satisfy water users in the Lower Basin.

According to the 2007 Interim Guidelines, if the August projections of January Lake Mead elevation is below 1075 feet, then the Lower Basin will operate under shortage conditions for the subsequent calendar year (starting on January). Under three progressive tiers of shortage, Arizona suffers a reduction to its 2.8 MAF annual allocation. At 1075 feet elevation in Lake Mead, Arizona's Colorado River allocation drops to 2.48 MAF, at 1050 feet elevation it drops to 2.4 MAF, and at 1025 feet elevation it drops to 2.32 MAF.

Furthermore, entitlements for diverting Colorado River water in Arizona is organized under several orders of priority[6]. CAP is a junior Colorado River priority holder in Arizona, and due to the nature of its Colorado River entitlement[7] will be expected to absorb reductions to Arizona's Colorado River allocation due to shortage. This reduction propagates down to CAP's customers in central Arizona, which include cities, farms, and Indian communities[8].

Therefore, a primary effect of sustained drought due to climate change on the Colorado River Basin is reductions to precipitation, snowpack accumulation, and snow melt. When these outcomes are coupled with the operating framework of the Colorado River system (e.g. the 2007 Interim Guidelines) and cascaded downstream, Arizona, and more specifically CAP, bears the largest brunt of vulnerability in terms of cuts to its Colorado River water supply.

Increased Warming in the Lower Colorado River Basin

Rising regional temperatures associated with increased warming due to drought and climate change produce several effects relevant to CAP and its operations. Higher temperatures in the southwest translate to greater potential evaporation. For water stored in Lake Mead, this could mean an accelerated timetable towards Lower Basin shortage and reductions to Arizona and CAP's annual Colorado River diversion. Higher evaporation rates can also impact the volume of CAP water stored in Lake Pleasant, reducing CAP's flexibility in utilizing that stored water to meet CAP customer demands in central Arizona.

Higher temperatures tend to cause water use to inflate, especially for agricultural customers and particularly during the summer months. An inflation of water use for Colorado River water users in Arizona, reduces the volume of Colorado River water that CAP can divert and deliver to its customers in central Arizona. A similar effect can occur within CAP's framework of customer priority, such that higher priority users may utilize more CAP water, leaving less water available to lower priority contract holders.

In terms of CAP's infrastructure, an increase of monthly temperatures (but primarily over the already high temperatures of Arizona's summer months) can accelerate the degradation and lifespan of CAP's physical assets (e.g. CAP canal, pumping plants, and mechanical parts). Higher temperatures may also encourage algae growth and proliferation of aquatic nuisance species in the waters of the CAP canal, necessitating an increase in maintenance activities. In addition to the physical operations that experience high

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[6] Arizona has six Colorado River priorities. Priority 1 (P1) are defined as present and perfected rights. Priorities 2 and 3 (P2/P3) are co-equal and reflect contracts that are dated/executed on or prior to September 30, 1968. Priority 4 (P4); which includes CAP, are identified as contracts dated/executed after September 30, 1968. Priorities 5 and 6 (P5/P6) are for unused water and surplus water, respectively. P5/P6 entitlements can only be used if there is Colorado River water within Arizona's allocation that is unused by P1 through P4. Water for P5/P6 water users is rarely if ever available due to CAP's entitlement.

[7] CAP's Colorado River entitlement allows it to divert from the Colorado River any water that is unused by all other higher priority water users in Arizona (P1 to P4); such that Arizona's annual consumptive use (of all P1 to P4 users and CAP) will equal its state allocation of 2.8 MAF.

[8] CAP's customers are organized into several priority pools; some of which are long-term contracts and some which are for excess use. The highest priority belongs to on-river P3 water that is delivered to central Arizona customers through the CAP canal. The next priority pool is for Indian and M&I (municipal and industrial) contracts. The next priority pool is was originally designated for Non-Indian Agriculture (NIA), but has since been used to meet the demands of Indian and M&I customers. Beyond these priorities are the excess pools which include the agricultural pool and the other excess pool; which provides water to the Central Arizona Groundwater Replenishment District and the Arizona Water Banking Authority.

vulnerability due to increased warming, extreme temperatures also generate health risks and dangers to CAP's workforce, especially to CAP employees that work in the field and are exposed to these conditions on a daily basis.

Finally, a potential cost component that is driven by increased temperatures relates to power costs during peak temperature periods. As the largest consumer of energy in Arizona[9], the CAP system may endure higher energy costs during the summer months due to inflated costs associated with the peak energy demand portion of the year. Since CAP's operations generally cannot be scaled back to mitigate higher energy costs in the summer, CAP will have to factor for these power costs in the summer (May – September) when water and energy demand are both high.

Extreme Weather Events in the CAP Service Area

The primary concern for CAP when it comes to extreme weather events is directly related to the durability of its infrastructure and the safety of its employees. Central Arizona continues to experience extreme weather events such as haboobs (dust storms), heavy thunderstorms, flash flooding, and high winds with some periodic regularity. All of these types of extreme events can stress CAP's existing infrastructure, shortening the lifespan of physical assets and increasing the risk of failures in the system. When coupled with accelerated degradation of infrastructure due to warming, extreme events can cause significant damage to CAP infrastructure and require higher and more frequent levels of maintenance. The frequency and intensity of these extreme weather events also poses a safety risk to CAP employees, particularly for those that primarily work out in the field.

2.0 Approach

The impact of climate change on CAP is dependent on future conditions, which are by definition uncertain. To help shape policies that will ensure the resiliency of CAP and its ability to achieve its mission, a scenario planning approach was developed which considers a range of future conditions. Considering a range of future conditions allows CAP to be prepared for a variety of circumstances, mitigating uncertainty. This section describes the scenario planning approach in two parts: general approaches and specific approaches applied in development of this plan.

2.1 General Scenario Planning Approach

Scenario planning is a method of planning for an uncertain future by developing plausible future conditions, assessing gaps, and evaluating actions that may be necessary. Typically, a few sets of future conditions, or "scenarios," are defined. Scenarios are not intended to predict the future, rather they are intended to bracket a plausible range of future conditions.

Formal scenario planning or development is a step-wise process that typically involves several phases presented in Figure 1 and described as follows:

- Scenario definition. The first step in scenario planning is to define a focus issue, or the question that is driving the effort. Then, key drivers of change that capture the concerns of the focus issue are identified. Drivers are typically external to, and therefore beyond the control of, the entity performing scenario planning.
- Scenario construction. Based on the key drivers identified, scenarios are developed that capture a range of plausible future conditions. Future conditions, as relevant to the focal question, are further defined and may be quantified.

[9] CAP uses more than 2.8 billion kilowatt hours of energy per year to deliver more than 500 billion gallons of Colorado River water to 80 percent of Arizona's population.

- Scenario analysis. Consequences of interactions amongst drivers are explored, and trends are identified. Some analysis of uncertainty may also be performed.
- Scenario assessment. Key challenges and opportunities associated with each scenario, as related to the focus issue, are defined. In addition, potential management strategies are developed to address challenges and take advantage of opportunities.
- Risk management. Strategies are selectively implemented to reduce vulnerabilities and risk, and to increase resiliency.
- Monitoring and post-scenario development audits. Because the environment is always changing, scenarios are reviewed and plans are modified accordingly.

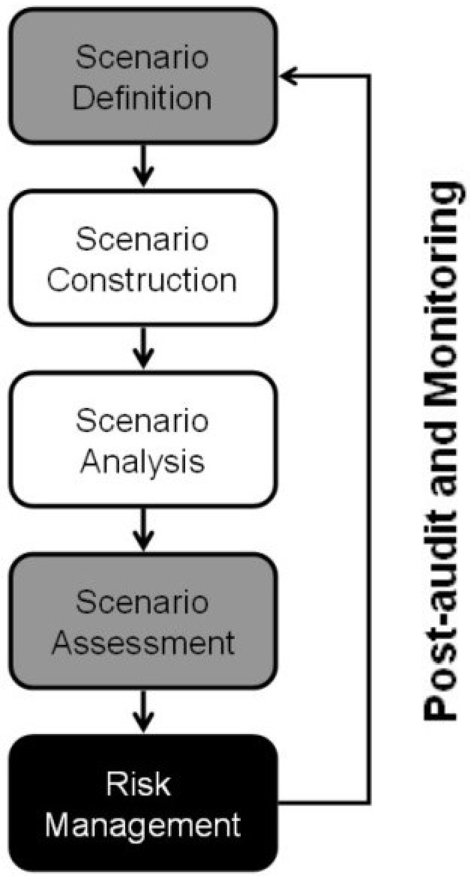

Figure 1: The progressive phases of scenario development
From Mahmoud et al. (2009), Figure 4.

2.2 Approach Used for the CAP Climate Adaptation Plan

The scenario planning process used for this study is a condensed version of the process described in Section 2.1. The process was centered around workshops attended by subject matter experts from within CAP. A summary of the process, described in the context of workshops, is as follows:

- **Develop focal questions and assemble the team**. Prior to the workshops, the focal questions were developed, and CAP experts were selected to participate in the workshops. To select the team, CAP's functions that are sensitive to climate change and that would likely be involved in adaptation efforts were identified. Functions represent key areas of the organization that carry out actions in support of CAP's mission. Functions may include specific departments, pairs of departments, or entire groups that were described in CAP's organizational structure (Section 1.1.2). Experts were selected from CAP's functions that were identified as having the greatest sensitivity to climate change impacts and potential adaptation efforts. Functions are listed below these bullets.

- **Develop drivers and scenarios**. The team identified potential drivers, or forces external to CAP that impact CAP operations or future conditions. The drivers were condensed into a set of "key drivers" that were deemed to have the most potential impact and whose outcomes were the most uncertain. Three scenarios were then developed, defined by a specific "state" of each key driver, representing plausible future conditions.
- **Develop implications**. For each scenario, the team identified potential implications to CAP across all CAP climate-sensitive functions. Implications are the potential effects of climate change on CAP.
- **Develop adaptation strategies**. For each scenario, the team identified potential specific actions that could be taken to adapt to each implication of climate change.
- **Develop robust solutions**. The team selected preferred adaptation strategies that could be implemented, in three categories:
    - "No regrets" strategies are those that provide a benefit with no or minimal downside of implementing, even if the future envisioned does not come to pass.
    - "Low regrets" strategies are those that are generally easy to implement, but the benefit to the organization is greater when the future envisioned does come to pass. Additionally, low regrets actions can preserve an opportunity for future implementation.
    - "Conditional" strategies are those that could be implemented in the future, under specific conditions.

Each step is discussed in more detail in its respective section below.

Key to development of this plan was active participation of the team, representing CAP's climate-sensitive functions. All drivers, implications, strategies, and robust solutions were developed by the team, in a collaborative fashion. In all workshops, the team was split into three to four groups for brainstorming sessions. The result was that the components of the CAP Climate Adaptation Plan were developed entirely by experts from within CAP. The CAP functions represented are as follows:

- Central Arizona Groundwater Replenishment District (CAGRD)
- Colorado River Programs
- Communications
- Engineering
- Environmental, Health and Safety
- Financial Planning and Analysis
- Human Resources
- Information Technology
- Legal Services
- Maintenance
- Operational Technology

- Protective Services
- Public Affairs (including the CAWCD Board of Directors)
- Resource Planning and Analysis
- Risk and Liability Management
- Water Operations and Power Programs

3.0 Workshop Results: Drivers, Scenarios, Implications, Adaptation Strategies, and Portfolios

This section summarizes the results of the planning workshops. The focal questions that CAP wants to answer through the scenario planning process are "how resilient is CAP to climate change?" and "how do we improve resiliency to climate change?" To answer these questions, CAP looked at how climate change could potentially affect their operations and supply and developed strategies to adapt to those effects.

3.1 Drivers and Scenarios (Workshop 1)

In the first workshop, drivers were identified, and scenarios were developed based on the drivers. Drivers are forces external to CAP, that impact CAP operations or future conditions. For this project, CAP is focusing on drivers related to climate change. Primary drivers include the physical components of climate change: temperature, precipitation, and streamflow. Secondary drivers flow from these and may affect what CAP does more directly. For example, temperature change (primary driver) could cause reduced population (secondary driver) in Phoenix, which could affect human resources by limiting the recruitment pool.

A group of "key drivers" was selected from the larger list of drivers. Key drivers are the most important and the most uncertain and may be either primary or secondary drivers. The team then "bracketed" the key drivers with a qualitative range of potential future conditions. The list of key drivers and their "low" and "high" bracket conditions is presented in Table 1.

It should be noted that all drivers identified by the team can be described in terms of one or more key drivers. For example, "biological changes in water quality" can be characterized by temperature (how warm the water is) and Colorado River supply (how much water there is). It follows that all drivers identified by the team are implicitly considered in the process. A complete listing of all drivers and their links to key drivers is presented in Appendix B.

Scenarios represent possible futures and are described by a defined "state" (high bracket or low bracket in Table 1) for each of the key drivers. To facilitate a robust adaptation plan, it is useful to define several plausible scenarios that together capture a range of potential future conditions. For this study, three scenarios were developed that capture a range of plausible futures (Table 2). Key elements of the scenarios are as follows:

- Scenario 1: Low water supply, high demand for water, with a strong economy.
- Scenario 2: High water supply, low demand for water, with a weak economy.
- Scenario 3: Low water supply, high demand for water, with a weak economy.

Scenarios 1 and 2 were selected as end-members of the plausible potential futures, respectively. Scenario 3 is similar to scenario 1, with additional challenges not found in the first two in the form of a weak economy.

Table 1: Key drivers

Key Driver	Low Bracket	High Bracket
Colorado River supply	Frequent deep shortages	Normal CAP supply, with some infrequent excess supply above historical amount
Temperature	Warmer overall, but potentially seasonally cooler	Significantly warmer
Local precipitation	Historical	More extreme events (drought or rain)
Demand changes	Low contract demand (full CAP use)	Full contract demand (full CAP use)
Population of Central Arizona	Low growth	High growth
Regulatory/legal/policy	Restrictive	Flexible
Interagency coordination/collaboration	Competitive/combative	Collaborative
Economic health	Weak economic growth	Strong economic growth
Technology	Status quo. Current level of technology and capacity for technological improvements	Rapid technological advances; mainstreaming; higher capacity of utilization

Table 2: Scenarios

Key Driver	Scenario 1	Scenario 2	Scenario 3
Colorado River supply	Frequent deep shortages	Normal CAP supply, with some infrequent excess supply above historical amount	Frequent deep shortages
Temperature	Significantly warmer	Warmer overall, but potentially seasonally cooler	Warmer overall, but potentially seasonally cooler
Local precipitation	More extreme events (drought or rain)	Historical	More extreme events (drought or rain)
Demand changes	Full contract demand (full CAP use)	Low contract demand (full CAP use)	Full contract demand (full CAP use)
Population of Central Arizona	High growth	Low growth	Low growth
Regulatory/legal/policy	Restrictive	Flexible	Restrictive
Interagency coordination/collaboration	Competitive/combative	Collaborative	Collaborative
Economic health	Strong economic growth	Weak economic growth	Weak economic growth
Technology	Rapid technological advances; mainstreaming; higher capacity of utilization	Status quo. Current level of technology and capacity for technological improvements	Status quo. Current level of technology and capacity for technological improvements

3.2 Climate Change Implications (Workshops 2-3)

Implications are the potential effects of the climate change scenarios on CAP. Implications may be challenges, opportunities, or both. The team split into three groups, one per scenario, to develop potential implications of each scenario. Each group then presented implications to the team for discussion. In some cases, additional implications were added by the team during the discussion.

All potential implications were reviewed and finalized by the team. The effort included the following:

- Removing items that are better described as tools or strategies, rather than implications.
- Consolidating implications that were identified for multiple scenarios in workshop 2.
- Finalizing drivers associated with each implication.
- Identifying other scenarios to which each implication may apply, considering the drivers.
- Identifying which CAP functions are affected by the implication.

The finalized list of implications, to be used in the developing of tools and strategies, is presented as Table 3. A summary of each scenario, based on both drivers and implications, is provided as follows:

Scenario 1 centers around a low supply on the Colorado River and high demand. Challenges result from higher temperatures and lower Colorado River supply causing issues ranging from reduced deliveries to low priority users and biological (i.e. algal) growth in water to increased health and safety issues for CAP employees. Opportunities, stemming from a higher regional population, include a larger tax base for capital improvements and increased technological advances to combat shortages and offset warmer temperatures.

Scenario 2 focuses on a high supply on the Colorado River and low demand. Decreased regional population means difficulty recruiting and maintaining staff along with decreased tax revenue for capital improvements. Excess supply causes the need for new recharge locations while bolstering state-wide groundwater storage. A flexible regulatory environment increases opportunities for collaboration with other agencies and the ability to pursue regulatory changes that benefit CAP.

Like scenario 1, scenario 3 centers on low Colorado River supply and high demand. Extreme weather in scenario 3 presents challenges in the form of infrastructure issues (such as canal resiliency and risk insurance) and a change in seasonal supply and demand patterns. Low population growth limits CAP's ability to recruit and maintain talent. However, this scenario presents opportunities for more collaboration and technological advances, such as desalination, among lower basin states and increased water conservation.

Table 3: Implications

Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications	Implication Number	Implication	Challenge	Opportunity	Driver(s)	Number of Strategies	Ease of Implementation, Scenario 1	Ease of Implementation, Scenario 2	Ease of Implementation, Scenario 3	Scenario 1	Scenario 2	Scenario 3
x														x	x	1	Increased cost to customers - supply driven	x		Colorado River supply (low)	9	E-D		E-D	x		x
x														x	x	2	Increased cost to customers - power driven	x		Regulatory/legal/policy (restrictive)	10	E-D		E-D	x		x
x														x	x	3	Increased cost to customers - demand driven	x		Demand (low)	13		E-D			x	
x														x	x	4	Reduced ability of customers to pay rates	x		Economic health (weak)	11		E-D	E-D		x	x
x												x		x	x	5	Rate instability	x		Colorado River supply (low)	9	E-D		E-D	x		x
x														x	x	6	Decreased tax base	x		Population (low growth)	9		E-D	E-D		x	x
x												x				7	Financial reserves drawn down	x		Precipitation (increase extreme events)	6	E-D		E-D	x		x
x	x	x		x	x							x				8	Pressure to defer capital projects and technological advances	x		Demand (low) Economic Health (weak)	6		E-D			x	
			x			x		x					x	x	x	9	Reduction in deliveries to low priority users	x		Colorado River supply (low)	7	E-D		E-D	x		x
x								x								10	Limited or no excess water for CAGRD	x		Colorado River supply (low) Demand (high)	7	E-D		E-D	x		x
								x								11	CAGRD potentially out of credits / Limited ability to acquire on-river supply	x		Colorado River supply (low) Demand (high)	5	E-D		E-D	x		x
x																12	Difficulty projecting long-range rates	x		Regulatory/legal/policy (flexible)	2		M			x	
						x	x	x								13	Higher priority Colorado River users using full entitlement	x	x	Colorado River supply (low)	4	E-D		E-D	x		x
						x	x	x								14	Higher priority CAP users increase water demand	x		Colorado River supply (low) Demand (high)	4	E-D		E-D	x		x
			x				x									15	Limited diversions from Colorado River because Lake Mead is low	x		Colorado River supply (low)	5	E-D		E-D	x		x
			x			x						x	x	x		16	Physical challenges to storing excess water due to long-term groundwater level rise	x	x	Colorado River supply (high) Demand (low)	4		E-D			x	
								x								17	Low obligations from CAGRD		x	Economic health (weak) Population (low growth)	3		E-M	E-M		x	x
								x								18	Good supply for CAGRD		x	Colorado River supply (high) Demand (low)	2		E-M			x	
x														x	x	19	Increased tax base		x	Population (high growth)	5	E-D			x		
x			x													20	Increased power supplies / reduced power cost		x	Technology (rapid growth)	3	E			x		
	x		x													21	Biological: increased algae, aquatic vegetation, terrestrial weeds, invasive species	x		Temperature (hotter or warmer)	8	E-D	E-D	E-D	x	x	x
	x		x												x	22	Degraded water quality - weather driven	x		Precipitation (increase extreme events)	9	E-D		E-D	x		x
	x		x												x	23	Degraded water quality - supply driven	x		Colorado River supply (low)	8	E-D		E-D	x		x
	x		x	x												24	Increased sedimentation issues	x		Precipitation (increase extreme events)	6	E-M		E-D	x		x
	x	x	x	x	x											25	Increased O&M on equipment (pumps, etc.) and facilities	x		Temperature (hotter)	3	E-M			x		

Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications	Implication Number	Implication	Challenge	Opportunity	Driver(s)	Number of Strategies	Ease of Implementation, Scenario 1	Ease of Implementation, Scenario 2	Ease of Implementation, Scenario 3	Scenario 1	Scenario 2	Scenario 3
	x		x	x								x	x		x	26	Land subsidence near canal	x		Colorado River supply (low) Demand (high)	4	E-D		E-D	x		x
	x	x	x	x	x				x		x	x			x	27	Potential damage to CAP infrastructure and facilities, from weather	x		Precipitation (increase extreme events)	5	E-M		E-D	x		x
			x												x	28	Low elevations at Lake Pleasant / Waddell Dam	x		Colorado River supply (low) Demand (high)	6	E-D		E-D	x		x
	x	x	x													29	Decreased operational head	x		Colorado River supply (low) Demand (high)	5	E-D		E-D	x		x
	x		x	x												30	Increased O&M for recharge	x		Colorado River supply (high) Demand (low)	2		M			x	
x	x			x		x						x				31	New facilities needed: wells, potential treatment	x		Colorado River supply (low) Demand (high)	4	E-M		M-D	x		x
x			x													32	Reduced power production	x		Colorado River supply (low)	3	E-D		E-D	x		x
	x	x	x	x	x											33	Interruptions in power service (transmission)	x		Precipitation (increase extreme events)	3	E-D		E-D	x		x
x		x	x						x							34	Air quality regulations affect how and when power can be used	x		Regulatory/legal/policy (restrictive)	3	E-D		E-D	x		x
					x											35	Limited IT resources: responding to problems, fewer refreshes, technology lagging behind	x		Technology (maintained growth) Economic health (weak) Population (low growth)	3		E-M	E-M		x	x
	x		x			x										36	Change in seasonal demand curve	x	x	Temperature (warmer or hotter)	5	E-M	E-M	E-M	x	x	x
			x			x		x								37	Increased turn-back water / short-term demand reduction		x	Precipitation (increase extreme events)	2	E-M		E-M	x		x
	x	x	x	x												38	Increased operational efficiency		x	Technology (rapid growth)	2	E			x		
	x	x	x	x												39	Increased maintenance efficiency		x	Technology (maintained growth or rapid growth)	3	E-M	E-M	E-M	x	x	x
	x	x	x	x												40	Increased operational and maintenance flexibility		x	Colorado River supply (low)	2	E		E	x		x
	x								x	x	x	x				41	Increased health and safety issues - temperature driven	x		Temperature (warmer or hotter)	6	E-D	E-D	E-D	x	x	x
	x								x	x	x	x				42	Increased health and safety issues - accidents	x		Precipitation (increase extreme events)	4	E-M		E-M	x		x
										x						43	Employee recruitment challenges	x		Population (low growth)	10		E-D	E-D		x	x
						x	x	x					x	x		44	Increased difficulty seeking legislative/regulatory solutions without partners	x		Regulatory/legal/policy (restrictive) Interagency coordination (competitive)	3	E-M			x		
						x	x	x		x			x	x		45	Difficulty collaborating due to lack of staff, including legal staff	x		Economic health (weak) Interagency coordination (collaborative) Population (low growth)	5		E-M	E-M		x	x
			x			x	x	x						x	x	46	More scrutiny placed on planning	x		Regulatory/legal/policy (restrictive)	5	E		E	x		x
	x		x								x	x	x			47	More attempts at illegal diversions on canal	x		Colorado River supply (low) Demand (high)	3	E		E-M	x		x
	x			x							x	x	x			48	Increasing encroachment on CAP lands	x		Population (high growth)	3	E-M			x		

Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications	Implication Number	Implication	Challenge	Opportunity	Driver(s)	Number of Strategies	Ease of Implementation, Scenario 1	Ease of Implementation, Scenario 2	Ease of Implementation, Scenario 3	Scenario 1	Scenario 2	Scenario 3
	x	x			x						x	x	x			49	Increased theft of copper / vandalism	x		Economic health (weak)	3		E-M	E-M		x	x
			x										x	x	x	50	Increased lawsuits - contract challenges	x		Colorado River supply (low) Demand (high)	5	E-D		E-D	x		x
	x						x		x				x	x		51	Challenges meeting environmental requirements	x		Regulatory/legal/policy (restrictive)	5	E-M		E-M	x		x
	x		x	x					x				x			52	Increased permitting time/cost	x		Regulatory/legal/policy (restrictive)	3	E-M		E-D	x		x
	x		x	x			x		x	x		x	x			53	Continuous adjusting to regulatory environment	x		Regulatory/legal/policy (flexible)	4		E-M			x	
														x	x	54	Ongoing need to manage perceptions (public image)	x		multiple combinations of drivers; all scenarios	2	E	E	E	x	x	x
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	55	Cutbacks to other agencies resulting in need for CAP to do others' work	x	x	Economic health (weak) Interagency coordination (collaborative)	4		E-D	E-D		x	x
														x		56	Increased pressure on legislature to enact solutions to water supply/demand imbalance	x	x	Colorado River supply (low) Demand (high) Regulatory/legal/policy (restrictive)	4	E-M		E-M	x		x
										x						57	Increased staff retention		x	Economic health (weak)	3		E-M	E-M		x	x
						x	x	x					x	x	x	58	Increased non-traditional public/private partnerships		x	Interagency coordination (competitive)	7	E-D			x		
						x	x	x					x	x	x	59	Collaborative planning environment		x	Interagency coordination (collaborative)	11		E-M	E-M		x	x
										x						60	Larger talent pool		x	Population (high growth)	3	M			x		
						x	x	x								61	Less urgency for short-term water policy planning, affording flexibility and proactive, not reactive, response		x	Colorado River supply (high) Demand (low)	2		E			x	

3.3 Climate Change Adaptation Strategies (Workshop 4)

Adaptation strategies are specific actions that can be taken to adapt to climate change. The team split into three groups to develop potential adaptation strategies, for the list of implications by scenario. The meeting was split into three sessions, allowing each group to identify potential adaptation strategies for a subset of the implications in each scenario. The groups generally picked up where the previous group left off, such that all implications were evaluated. In some cases, multiple groups identified potential strategies for the same implication.

For each adaptation strategy, the groups identified the "ease of implementation," defined as easy (E), moderate (M), or difficult (D), as well as a listing of all implications in the scenario to which the adaptation strategy could apply.

Overlapping strategies were then consolidated and grouped by common themes. Table 4 presents a final list of all strategies, what implications they address and in which scenarios they apply, which functions would be involved in each strategy, and ease of implementation. Table 3 summarizes the number of adaptation strategies that were identified for each implication, along with their ease of implementation. Together, Table 3 and Table 4 were used in portfolio development to select portfolios composed of strategies that address numerous implications, but also implications that present the biggest risk to CAP.

In addition to the adaptation strategies summarized in Table 4, the team also identified an additional strategy that was applicable for almost any implication, regardless of the scenario. This strategy is described as "Do Nothing". The "Do Nothing" strategy in itself is not an adaptation strategy because it requires no adaptive action. Rather this strategy implies that by doing nothing in the face of an implication, CAP is willing to pay fines and penalties as needed, suffer the full consequences of a challenging implication, or not capitalize on an opportunity. The "Do Nothing" strategy also recognizes that there may be implications so dire or extreme that it may be more palatable for CAP to not invest resources to adapt for them. Since doing nothing is not considered an adaptation strategy, it was excluded from Table 4. However, in terms of portfolio development, the team considered the "Do Nothing" strategy (as evident in Section 3.4).

Table 4: Adaptation strategies

Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications	Strategy Number	Adaptation Strategy	Scenario	Ease of implementation	Implications (See Table 3: Implications)											Total Number of Implications Addressed	Scen 1	Scen 2	Scen 3	Total Scenarios
x																1	Rate stabilization fund using taxes	all	M-D	1	2	3	5	19							5	M	D	D	3
x																2	Early rate increases to decrease rate shock	all	M	1	2	3	5								4	M	M	M	3
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	3	Decrease level of service	all	D	1	2	3	7	8	21	22	23	43			9	D	D	D	3
															x	4	Communicate potential for increased rates to customers	all	E	1	2	3	5	6							5	E	E	E	3
x																5	Look at refinance options	all	M	1	2	3	4	5	6						6	M	M	M	3
x			x	x		x						x				6	Alternative (non-project) water supply in canal, to help share costs over more customers	all	M	1	2	3	4	5	6						6	M	M	M	3
			x										x	x		7	Lobby for ability to generate power to offset power costs	all	D	1	2	3	4	5	6						6	D	D	D	3
x													x	x		8	Increase tax authority / increase tax rate percentage	all	D	1	2	3	4	5	6	7					7	D	D	D	3
						x	x						x	x		9	Find other supplies, e.g. desalination, weather modification, etc. (augmentation)	all	D	1	2	4	5	6	9	10	15	28	29	50	11	D	D	D	3
x																10	Energy rate stabilization fund	1, 3	M-D	2	19										2	M		D	2
			x			x		x								11	Bank water	all	E	3	37										2	E	E	E	3
			x													12	Reduce operations / lower power costs	2	E	3											1		E		1
										x						13	Workforce restructuring / reduction	2	D	3											1		D		1
x																14	Pre-emptively increase financial reserves	all	D	3	4	6	7	19							5	D	D	D	3
x								x								15	Explore other sources of revenue for CAGRD	2, 3	D	3	4										2		D	D	2
														x	x	16	Public campaign advocating for value/importance of water	2, 3	E	4											1		E	E	2
x													x			17	Rate tier restructuring	2, 3	M	4											1		M	M	2
x													x			18	Subcontractor finance program: review payment timing	2, 3	M	4											1		M	M	2
x				x												19	Reprioritize non-critical capital improvement projects to future budget	all	E	4	5	6	7	8							5	E	E	E	3
x													x			20	Additional service charges	2, 3	D	6											1		D	D	2
x																21	Issue bond	1, 3	M	7											1	M		M	2
x																22	Increase rates to build reserves	1, 3	M-D	7											1	M		D	2
										x						23	Outsource general needs	2, 3	E-M	8	43	55									3		M	E	2
x		x			x											24	Create technology replacement fund	all	E	8	19	35									3	E	E	E	3

Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications	Strategy Number	Adaptation Strategy	Scenario	Ease of implementation	Implications (See Table 3: Implications)											Total Number of Implications Addressed	Scen 1	Scen 2	Scen 3	Total Scenarios
x														x		25	Incentives for stakeholder's own projects in service area	2	D	8											1		D		1
			x	x										x		26	Increase collaboration with others on infrastructure	2, 3	M	8	59										2		M	M	2
						x		x								27	Firm more water supplies	1, 3	D	9											1	D		D	2
						x	x	x					x			28	Authority to move non-CAP tribal water off river	1, 3	D	9	10										2	D		D	2
						x							x			29	Look at new water collection options, e.g. stormwater in extreme events	1, 3	D	9	10	11	13	14	15						6	D		D	2
						x	x						x	x		30	Try to renegotiate water rights	1, 3	D	9	10	11	13	14	15						6	D		D	2
						x	x						x	x		31	Increase conservation programs	1, 3	D	9	10	11	13	14	15						6	D		D	2
								x								32	Look to CAGRD to help supplement other areas	all	E	9	10	11	13	14	15	17					7	E	E	E	3
x								x								33	Increased developer fees for CAGRD, e.g., enrollment and activation	1, 3	M-D	10	11										2	M		D	2
x																34	Explore alternate rate projection model	2	M	12											1		M		1
x															x	35	Publish adaptive rate structure, use ranges	2	M	12											1		M		1
x			x	x		x		x								36	Infrastructure investment: groundwater facilities	2	D	16											1		D		1
			x				x									37	More intentionally created surplus (ICS) in Lake Mead	all	E	16	17	24									3	E	E	E	3
						x	x						x	x		38	Interstate and intrastate water exchanges / sales	all	M	16	17	37									3	M	M	M	3
			x						x			x				39	Monitor changes to prepare for changes	all	E	16	34	51	53								4	E	E	E	3
x								x								40	Buy long-term storage credits	2	M	18											1		M		1
								x								41	Reduce CAGRD water supply acquisition	2	E	18											1		E		1
x																42	Increased budget	1	E	19	20										2	E			1
			x													43	Operational flexibility and shift to low-cost power	1, 3	E	20	32										2	E		E	2
x															x	44	Decrease rates and communicate rate decrease	1	E	20											1	E			1
	x	x														45	Apply new technology / projects, e.g. UV treatment	all	M-D	21	22	23	24								4	M	D	D	3
	x		x													46	Operational flexibility to facilitate maintenance	all	E	21	22	23	24								4	E	E	E	3
	x															47	Increase environmental O&M: invasive species, weed removal, sedimentation, etc.	all	E-M	21	22	23	24								4	E	M	M	3

Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications	Strategy Number	Adaptation Strategy	Scenario	Ease of implementation	Implications (See Table 3: Implications)											Total Number of Implications Addressed	Scen 1	Scen 2	Scen 3	Total Scenarios
									x	x						48	Increase environmental compliance staff	all	E-M	21	51										2	E	M	M	3
															x	49	Share water quality management with customers / manage customer expectations	all	E	21											1	E	E	E	3
														x		50	Seek partnerships / federal grants	all	M-D	21	58										2	D	M	M	3
															x	51	Increase external/internal communications on water quality	all	E	21	22	23	24								4	E	E	E	3
	x	x	x		x											52	Add more real-time water quality monitors and sampling on canal	1, 3	E	22	23										2	E		E	2
			x												x	53	Increase frequency of water quality reporting (website / customers)	1, 3	E	22	23										2	E		E	2
x				x												54	Infrastructure improvements to mitigate water quality issues due to weather effects	1, 3	M-D	22											1	M		D	2
	x		x													55	Develop plan for water quality issues due to severe weather incidents	1, 3	M	22	23										2	M		M	2
x		x	x	x												56	Pursue infrastructure improvements to minimize specific sedimentation impacts to operations	1, 3	M-D	24											1	M		D	2
		x	x	x												57	Upgrade, update, or modify equipment for new issues	1, 3	M-D	25	27										2	M		D	2
	x									x						58	Changing staffing resource distribution, functions, responsibilities, possibly mothball equipment	all	M	25	27	36	39	43	45	49	53	55	57		10	M	M	M	3
	x			x												59	Increase facilities/infrastructure maintenance	1, 3	E-M	25	29										2	E		M	2
	x			x												60	Increase engineering and maintenance resources to address subsidence issue	1, 3	M	26											1	M		M	2
												x				61	Analysis of criticality / vulnerability	1, 3	E	26	27										2	E		E	2
													x	x		62	Pursue legislation to further minimize subsidence	1, 3	D	26											1	D		D	2
				x												63	Specific infrastructure improvements to limit damage to CAP infrastructure and facilities (e.g., from subsidence and weather)	1, 3	M-D	26	27	33									3	M		D	2
									x	x					x	64	Increase training, awareness, safety campaigns regarding weather issues/conditions	all	E	27	41	42									3	E	E	E	3
			x													65	Operational flexibility to address low supply in CAP system	1, 3	E	28	29										2	E		E	2

Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications	Strategy Number	Adaptation Strategy	Scenario	Ease of implementation	Implications (See Table 3: Implications)										Total Number of Implications Addressed	Scen 1	Scen 2	Scen 3	Total Scenarios
			x											x		66	Collaborate with others (public or private) to store more water at Lake Pleasant or meet customer demands	all	M-D	28	29	58	59							4	D	M	M	3
			x													67	Redirect recharge to Lake Pleasant	1, 3	D	28	29									2	D		D	2
			x													68	Increase/utilize Reach 1 for storage	1, 3	E	28										1	E		E	2
														x	x	69	Public awareness campaign for recreational impacts (potential partnership for communications plan)	1, 3	E	28										1	E		E	2
x																70	Create recharge storage fee that applies to every customer	2	M	30										1		M		1
						x								x		71	Collaborate with agencies to recharge outside of AMA for future wheeling, if aquifer storage in AMA is full	2, 3	M	30	59									2		M	M	2
x				x												72	New capital projects	1, 3	E-M	31										1	E		M	2
			x	x		x		x								73	Implement recovery plan	1, 3	M-D	31										1	M		D	2
	x	x	x		x					x						74	Outsource O&M and IT needs	all	E-M	31	35									2	E	M	M	3
	x	x	x		x					x						75	Increase O&M and IT staff	all	E-M	31	35									2	E	M	M	3
			x													76	Increase power generation, capture, and storage	1, 3	D	32										1	D		D	2
x			x											x		77	Increase open market power purchases	1, 3	E	32										1	E		E	2
			x											x		78	Interagency collaboration / partnerships for power transmission infrastructure	all	E-D	33	58	59								3	D	E	E	3
															x	79	Messaging re: power interruptions	1, 3	E	33										1	E		E	2
			x													80	Operational flexibility to meet regulations	1, 3	E	34										1	E		E	2
													x	x		81	Pursue regulatory changes	1, 3	D	34										1	D		D	2
			x													82	Flexible operation to respond to changes in seasonal demand	all	E	36										1	E	E	E	3
	x															83	Change maintenance schedule to reduce costs	all	E	36										1	E	E	E	3
x			x											x		84	Enforce existing contract condition that limits monthly supply to 11 percent of annual supply	all	E	36										1	E	E	E	3
x																85	Decrease rates due to increased operational and/or maintenance efficiency	all	E	36	38	39	40							4	E	E	E	3
			x													86	Implement more flexible and efficient operational practices	all	E	38	39	40								3	E	E	E	3

Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications	Strategy Number	Adaptation Strategy	Scenario	Ease of implementation	Implications (See Table 3: Implications)											Total Number of Implications Addressed	Scen 1	Scen 2	Scen 3	Total Scenarios
									x	x						87	Shift schedules / alternative work schedule	all	E	41	43										2	E	E	E	3
									x	x						88	Increased and mandatory use of safety equipment and personal protective equipment	all	E-M	41											1	E	M	M	3
												x				89	Increase insurance coverage	all	M	41	42	49									3	M	M	M	3
	x	x	x	x												90	Automate resources / equipment	all	D	41											1	D	D	D	3
	x		x						x	x						91	Staff subject to exposure; take days off when conditions are dangerous	all	E	41											1	E	E	E	3
									x	x						92	Increase incentive programs for worker safety	1, 3	E-M	42											1	E		M	2
												x				93	Increase risk management	1, 3	M	42											1	M		M	2
										x						94	Increase internal training	2, 3	M	43											1		M	M	2
										x						95	Employee recruitment incentives such as relocation incentives	2, 3	M	43											1		M	M	2
										x						96	Internship to full time employment program	2, 3	E	43											1		E	E	2
										x						97	Rotational program for existing staff	2, 3	M	43											1		M	M	2
										x					x	98	Advertise employee benefits	2, 3	E	43											1		E	E	2
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	99	Prioritize work activities	all	E	43	44	45	46	55							5	E	E	E	3
														x		100	Increase lobbying efforts	1, 3	E	44	51										2	E		E	2
														x		101	Increased meetings between elected officials, e.g. board members meet with legislators	1	M	44											1	M			1
						x	x	x					x	x		102	Act without collaboration	2, 3	E	45											1		E	E	2
														x		103	Stakeholder workshops, collaboration, outreach	all	E	45	46	59									3	E	E	E	3
										x			x	x		104	Outsource legal and legislative staff	all	E-M	45	50	53									3	E	M	M	3
														x		105	Board outreach and education, on CAP's behalf	all	E	46	54	56									3	E	E	E	3
										x						106	Staff outreach and education (employees promote message), on CAP's behalf	all	E	46	50	54	56								4	E	E	E	3
						x	x	x						x	x	107	Increase transparency, documentation	1, 3	E	46											1	E		E	2
					x						x					108	Use technology: drones, remote monitoring	1, 3	E-M	47											1	E		M	2
											x					109	Increase security infrastructure	1, 3	E	47											1	E		E	2
											x					110	Increase patrolling / surveillance	all	E	47	48	49									3	E	E	E	3

Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications	Strategy Number	Adaptation Strategy	Scenario	Ease of implementation	Implications (See Table 3: Implications)											Total Number of Implications Addressed	Scen 1	Scen 2	Scen 3	Total Scenarios
											x					111	Cooperation with local authorities and law enforcement agencies	1	M	48	58										2	M			1
														x	x	112	Public awareness campaign communicating dangers of canal	1	E	48											1	E			1
														x	x	113	Communication with customers to work through contract issues and avoid lawsuits	1, 3	E	50											1	E		E	2
										x			x	x		114	Increase legal and legislative staff	all	E-M	50	53										2	E	M	M	3
x																115	Increase rates for MSCP costs, permits	1, 3	M	51											1	M		M	2
	x			X					x					x		116	Increase collaboration with other agencies to facilitate permitting and environmental compliance	all	E	51	52	59									3	E	E	E	3
	x			x					x							117	Increase planning timelines / timeframe for permitting	1, 3	E	52											1	E		E	2
	x			x					x	x						118	Increase staff to support permitting	1, 3	M-D	52											1	M		D	2
										x						119	Increase staff	2, 3	D	55											1		D	D	2
														x		120	Collaborate with difficult partners	all	M	56	58	59									3	M	M	M	3
						x	x	x						x		121	Collaborate with others to address water supply/demand imbalance	all	E	56	58	59									3	E	E	E	3
										x						122	Knowledge transfer and documentation	2, 3	M	57											1		M	M	2
										x						123	Reduced pay increases / reduced increases in benefits	2, 3	E	57											1		E	E	2
														x		124	Explore long-term partnership projects	1	E	58											1	E			1
						x	x	x						x		125	Strategic planning with others	2, 3	E	59	61										2		E	E	2
														x		126	Work with stakeholders on what to do with challenges	2, 3	E	59											1		E	E	2
													x	x		127	Support collaborative policy changes	2, 3	E	59											1		E	E	2
										x						128	Increase workforce diversity	1	M	60											1	M			1
										x						129	Analyze compensation methods and policies	1	M	60											1	M			1
										x						130	Evaluate hiring practices process	1	M	60											1	M			1
						x	x	x								131	More scenario planning	2	E	61											1		E		1

3.4 Portfolios (Workshop 5)

A portfolio is defined as a collection of strategies. Portfolios are used to help understand how individual strategies perform under different conditions. Some key considerations used by the team when selecting strategies for a portfolio are as follows:

- Does the strategy apply to multiple scenarios?
- Is the strategy easy to implement?
- Does the strategy address single or possibly many implications?
- Consider the implications the strategy addresses. Does the strategy reduce CAP's biggest vulnerabilities and risks? Vulnerabilities are defined as implications with few strategies to address. Risk can be assessed by considering vulnerability and the severity or criticality of the implications.
- Does the strategy increase flexibility? That is, does it reduce or increase the ability to implement other strategies in the future?

The team was split into three groups. Each group was charged with developing a portfolio of 10 strategies, and to assign one of the following categories to each strategy:

1. **No Regrets** strategies are easy to implement, and provide a net benefit whether or not the specific implication it targets comes to pass. No regrets strategies are those that CAP would generally adopt, and are very likely to adopt in the near-term; for example: mandatory safety equipment for all employees. As such, there is no risk of overinvestment with No Regrets strategies. These types of strategies provide no detriment to the organization, even if the implications they are meant to address do not materialize.
2. **Low Regrets** strategies are generally easy to implement, and generally provide a net benefit whether or not the specific implication it targets comes to pass. However, the benefit to the organization is higher when the specific implication occurs. There is little risk for overinvestment with Low Regrets strategies, but there could be significant risks if there is underinvestment in these types of strategies. An example of a low regrets strategy is to increase water conservation programs. While there is some cost to conservation programs, the risk of overinvestment is small.
3. **Conditional** strategies are those that would be implemented under very specific conditions. They tend to be difficult to implement, and typically only provide a benefit for a particular implication. If that implication does not transpire, the strategy should not be implemented. However, there may be an associated "option to preserve" – in which some action would need to be taken in the short term to "preserve" the ability to implement the conditional strategy should it be needed in the future. Conditional strategies have a high risk of overinvestment and generally address large scale and high-risk implications with extremely detrimental effects. An example of a Conditional strategy is the construction of a desalination plant, which is a very costly and lengthy process to provide water augmentation against severe drought conditions.

Each group was instructed to develop a portfolio that could be implemented across all scenarios. Groups were instructed to utilize all three categories of strategies (no regrets/low regrets/conditional), but additional direction on what makes a "good" portfolio was intentionally not provided.

3.4.1 Portfolios Developed

Portfolios developed by the team are presented in Table 5. Overall, there was a fair amount of overlap amongst the three groups' portfolios. Table 5 also highlights strategies that were selected across multiple portfolios. While these are just the specific strategies selected, it was noted that given the significant overlap amongst the strategies, there is more commonality amongst the groups' portfolios than initially apparent. For example, strategy #78 ("interagency collaboration/partnerships for power transmission infrastructure") is in substance similar to strategy #66 ("collaborate with others (public or private) to store more water at Lake Pleasant or meet customer demands"); since both strategies implement collaboration to address their respective implications. Likewise, strategy #112 ("public awareness campaign communicating dangers of canal"), selected by group A, and strategy #4 ("communicate potential for increased rates to customers"), selected by groups B and C utilize communication as a means to address their respective implications.

Table 5: Portfolios developed by groups

Group A			Group B			Group C		
Category	**Strategy Number**	**Adaptation Strategy**	**Category**	**Strategy Number**	**Adaptation Strategy**	**Category**	**Strategy Number**	**Adaptation Strategy**
No Regrets	5	Look at refinance options	Conditional	1	Rate stabilization fund using taxes	No Regrets	4	Communicate potential for increased rates to customers
Conditional	8	Increase tax authority / increase tax rate percentage	No Regrets	4	Communicate potential for increased rates to customers	Conditional	5	Look at refinance options
Conditional	9	Find other supplies, e.g. desalination, weather modification, etc. (augmentation)	Low Regrets	9	Find other supplies, e.g. desalination, weather modification, etc. (augmentation)	Conditional	6	Alternative (non-project) water supply in canal, to help share costs over more customers
Low Regrets	31	Increase conservation programs	Conditional	14	Pre-emptively increase financial reserves	Low Regrets	9	Find other supplies, e.g. desalination, weather modification, etc. (augmentation)
Conditional	33	Increased developer fees for CAGRD, e.g., enrollment and activation	No Regrets	46	Operational flexibility to facilitate maintenance	Low Regrets	31	Increase conservation programs
Low Regrets	47	Increase environmental O&M: invasive species, weed removal, sedimentation, etc.	Conditional	54	Infrastructure improvements to mitigate water quality issues due to weather effects	Conditional	55	Develop plan for water quality issues due to severe weather incidents
Low Regrets	57	Upgrade, update, or modify equipment for new issues	Low Regrets	57	Upgrade, update, or modify equipment for new issues	No Regrets	61	Analysis of criticality / vulnerability
Conditional	58	Changing staffing resource distribution, functions, responsibilities, possibly mothball equipment	Conditional	58	Changing staffing resource distribution, functions, responsibilities, possibly mothball equipment	Conditional	63	Specific infrastructure improvements to limit damage to CAP infrastructure and facilities (e.g., from subsidence and weather)
Low Regrets	78	Interagency collaboration / partnerships for power transmission infrastructure	Low Regrets	66	Collaborate with others (public or private) to store more water at Lake Pleasant or meet customer demands	No Regrets	66	Collaborate with others (public or private) to store more water at Lake Pleasant or meet customer demands
No Regrets	112	Public awareness campaign communicating dangers of canal	Conditional		Do nothing	No Regrets	82	Flexible operation to respond to changes in seasonal demand

LEGEND

Strategy common to two portfolios	Strategy common to three portfolios

4.0 Climate Adaptation Analysis

This section provides analysis of the key drivers, scenarios, implications, adaptation strategies, and portfolios that were generated by the team as part of this climate adaptation process. In addition, the impact of the implications and strategies on CAP's organizational functions is explored.

4.1 Key Drivers

Key drivers were developed in Workshop 1 and are summarized in Table 1 as well as by implication in Table 3. The drivers and their states (e.g. for population, states were low and high growth) that result in the most challenge implications are Colorado River supply (frequent shortages) and demand changes (full contract demand), while technology (rapid technological advances) and interagency coordination/collaboration (collaborative) result in the most opportunity implications.

Table 6 summarizes the number of implications for each key driver and each key driver's states, as well as whether the implications are challenges, opportunities, or mixed. The key driver that resulted in the most implications was Colorado River supply, specifically Colorado River supply with frequent and deep shortages. Out of the 22 implications that are primarily attributed to Colorado River supply, 18 of those implications are due to frequent deep shortages. Conversely, historical local precipitation and strong economic growth were not primary key driver states for any of the implications.

Frequent deep shortages in Colorado River supply generated the highest number of challenge implications, with full contract demand generating the next greatest number of challenges. Technology and interagency coordination/collaboration generate few challenges regardless of their state (though they do provide opportunities).

In general, there were fewer opportunities identified by the team. Rapid technological advances with mainstreaming and a higher capacity of utilization is associated with the largest number of opportunity implications. Furthermore, all the implications that are primarily influenced by rapid technological advances are opportunities; no challenges are associated with this key driver state.

Mixed challenge/opportunity implications are unique implications that simultaneously provide a challenge for CAP to adapt to and an opportunity that CAP can seize. While there are only a handful of this type of implication generated by the team (see Table 3), most of the key driver states generate a mixed challenge/opportunity implication.

Table 6: Number of implications influenced by key drivers

Key Driver	Number of Implications by Driver	State*	Number of Implications by Driver State	Challenge	Opportunity	Mixed
Colorado River supply	22	Frequent deep shortages	18	15	1	2
		Normal CAP supply, with some infrequent excess supply above historical amount	4	1	2	1
Temperature	4	Warmer overall, but potentially seasonally cooler	3	2	0	1
		Significantly warmer	4	3	0	1
Local precipitation	7	Historical	0	0	0	0
		More extreme events (drought or rain)	7	6	1	0
Demand changes	16	Low contract demand (full CAP use)	6	3	2	1
		Full contract demand (full CAP use)	10	9	0	1
Population of Central Arizona	8	Low growth	5	4	1	0
		High growth	3	1	2	0
Regulatory/legal/policy	9	Restrictive	7	6	0	1
		Flexible	2	2	0	0
Interagency coordination/collaboration	5	Competitive/combative	2	1	1	0
		Collaborative	3	1	1	1
Economic health	8	Weak economic growth	8	5	2	1
		Strong economic growth	0	0	0	0
Technology	4	Status quo. Current level of technology and capacity for technological improvements	2	1	1	0
		Rapid technological advances; mainstreaming; higher capacity of utilization	3	0	3	0

*red indicates the state that generates the most challenges

4.2 Scenarios

The scenarios are described in section 3.1 and are analyzed herein as to the relative risk each poses. The analysis is based on driver states discussed in the preceding sections, as well as the number of challenges that were identified in each scenario. Scenario 3 has the most relative risk, followed closely by Scenario 1, with Scenario 2 having notably less relative risk.

The three scenarios explore various combinations of key drivers' states (as summarized in Table 2). Table 7 shows the state that generates the greatest number of challenging implications (see Table 6) by driver for each scenario, and whether a given driver state was included in each scenario (check marks). Furthermore, the relative difference in number of challenges faced in alternate driver states is also shown. This table provides a qualitative indication of which scenarios present the most risk[10] for CAP, in terms of the number of most challenging driver states and associated challenges. Key conclusions are that Scenario 3 likely presents the most risk, and that risk is driven by low supply, high demand, increased precipitation events, and a restrictive regulatory environment.

Table 7: Occurrence of key driver states that generate the most challenges per scenario

Key Driver	State With Most Challenges	Number of Challenges (less challenging state / more challenging state)	Scenario 1	Scenario 2	Scenario 3
Colorado River supply	Frequent deep shortages	1 / 15	✓		✓
Temperature	Significantly warmer	2 / 3	✓		
Local precipitation	More extreme events (drought or rain)	0 / 6	✓		✓
Demand changes	Full contract demand (full CAP use)	3 / 9	✓		✓
Population of Central Arizona	Low growth	1 / 4		✓	✓
Regulatory/legal/policy	Restrictive	2 / 6	✓		✓
Interagency coordination/collaboration	Competitive/combative Collaborative	1 / 1	✓	✓	✓
Economic health	Weak economic growth	0 / 5		✓	✓
Technology	Status quo. Current level of technology and capacity for technological improvements	0 / 1		✓	✓

Scenario 3 was comprised of eight of the nine most challenging key driver states, followed by Scenario 1 (which had six of the nine most challenging key driver states). Scenario 2 had the least number of most challenging key driver states (four of the nine). Several of these key driver states were present in more than one of the three scenarios, with the exception of significantly warmer temperature, which only occurred in Scenario 1.

Figure 2 illustrates the number of challenge, opportunity, and mixed challenge/opportunity implications per scenario. Generally, all scenarios have approximately the same number of opportunity and mixed challenge/opportunity implications. However, both Scenario 1 and 3 have more than double the number of challenge implications than Scenario 2.

[10] Risk is based on severity of outcome and difficulty in mitigating that outcome. Risk was not explicitly assessed during this effort but is recommended for future assessment. Because risk was not assessed, the number of challenges is used as a proxy for risk. However, this is a qualitative assessment because challenges may differ in level of severity.

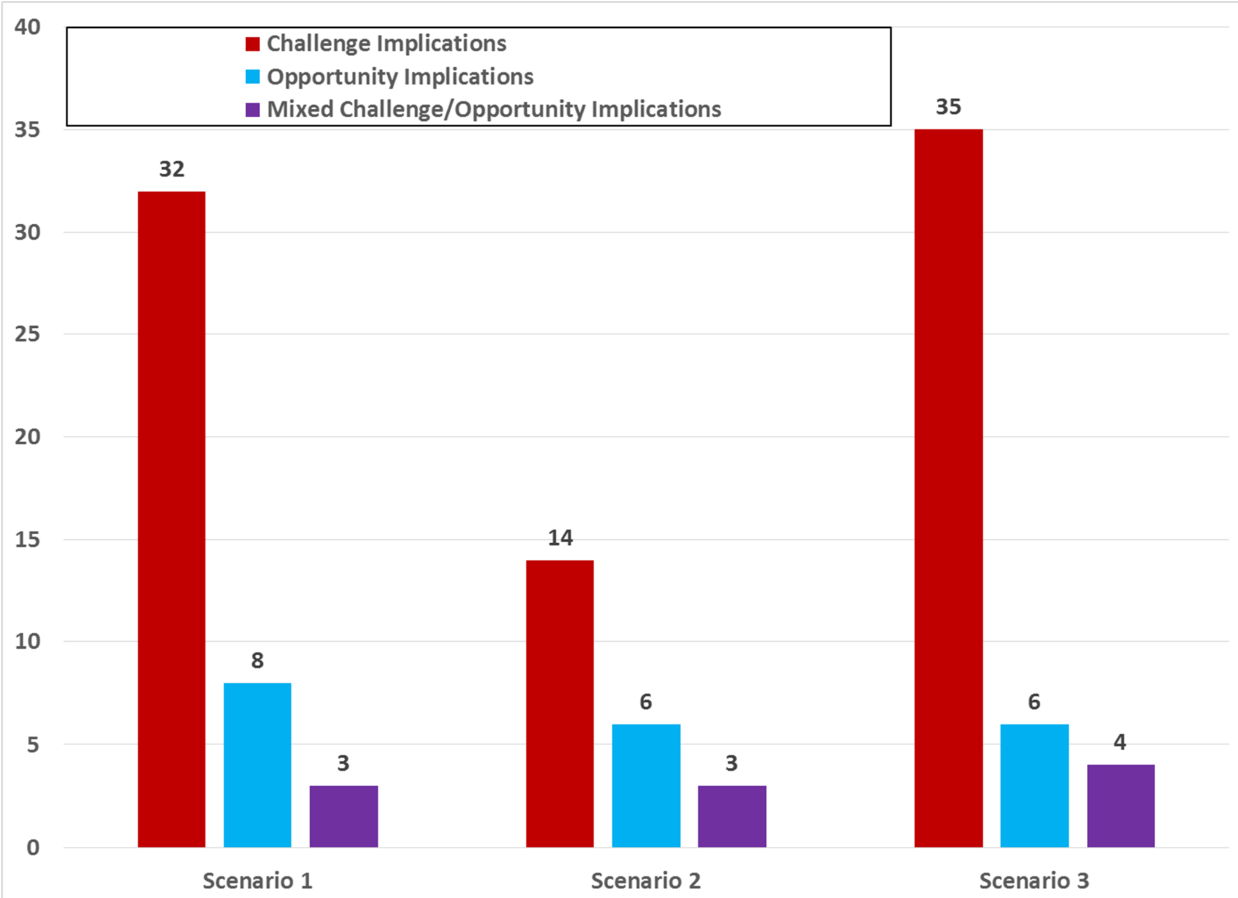

Figure 2: Number of implications per scenario

4.3 Implications

This section summarizes the implications generated with focus on two characteristics of the implications: 1) likelihood of implication occurring, and 2) ability to mitigate the implication. Together with severity of implications (see Section 6.0 Next Steps), these characteristics can be used to inform potential risk to CAP.

4.3.1 Occurrence of Implications Across Scenarios and Driver States

Table 8 lists the five implications that are present in all three scenarios. These implications represent issues that CAP either currently manages or will very likely need to address in the near future. The majority of these implications are driven by temperature conditions; all scenarios describe a warmer future (with Scenarios 1 and 3 being significantly warmer than Scenario 2). Both biological incursions impacting the canal system, and health/safety issues and accidents are outcomes directly associated with higher temperatures. Managing seasonal demand from customers is also related to increase in temperature (i.e. lengthening the "summer" season). Increased maintenance efficiency is an implication that is primarily attributed to technology. This opportunity presents itself regardless of the level of technological capacity available to CAP (status quo or more utilization). The use of technology inherently helps make maintenance more efficient and enables the completion of maintenance requirements more consistently. The last implication that is common to all scenarios is the ongoing need to manage perceptions about CAP and its public image. The need to maintain a positive CAP image to the public is an implication that must be considered both in the present and in the future, as it affects the organization's reputation and its ability to do business with its customers and partners.

Table 8: Implications that affect all scenarios

Challenge Implications	Opportunity Implications	Mixed Implications
#21. Biological: increased algae, aquatic vegetation, terrestrial weeds, invasive species. **#41.** Increased health and safety issues – temperature driven. **#54.** Ongoing need to manage perceptions (public image).	**#39.** Increased maintenance efficiency.	**#36.** Change in seasonal demand curve.

Another way to assess the risk/reward that a particular scenario may pose to CAP is to examine implications that are unique to each scenario. Scenario 1 had eight unique implications that were driven by several of the key driver states that were exclusively present in Scenario 1: high population growth, competitive interagency collaboration, and rapid technological advances (see Table 9).

Challenge implications unique to Scenario 1 were:

- Increased O&M on equipment (pumps, etc.) and facilities (implication #25). Increased O&M arises because of hotter temperatures.
- Increased difficulty seeking legislative/regulatory solutions without partners (implication #44). Since CAP is operating in a combative environment in this scenario, it is harder to find solutions in an already restrictive regulatory/legal/policy setting.
- Increasing encroachment on CAP lands (implication #48). Encroachment issues arise in this scenario due to high population growth that causes urban/rural development (spurred by strong economic growth) to move closer to the CAP canal and infrastructure.

Opportunity implications unique to Scenario 1 were:

- Increased tax base (implication #19). An increased tax base is available in this scenario due to high population growth. This results in more funding available for capital improvements and other water reliability projects.
- Increased power supplies / reduced power cost (implication #20). With rapid technological growth, power may become less expensive.
- Increased operational efficiency (implication #38). More efficient operations for the CAP system is possible due to technology improvements, e.g. better methods to cool equipment and offset the effects of warmer temperatures.
- Increased non-traditional public/private partnerships (implication #58). With interagency collaboration being difficult, CAP may look to collaborate with partners it has not traditionally worked with to achieve its goals and objectives.
- Larger talent pool (implication #60). A byproduct of having high population growth in this scenario is that a larger population can provide more qualified candidates to recruit to CAP.

Table 9: Implications unique to Scenario 1

Challenge Implications	Opportunity Implications	Mixed Implications
#25. Increased O&M on equipment (pumps, etc.) and facilities **#44**. Increased difficulty seeking legislative/regulatory solutions without partners. **#48.** Increased encroachment on CAP lands.	**#19.** Increased tax base. **#20.** Increased power supplies / reduced power cost **#38.** Increased operational efficiency. **#58.** Increased non-traditional public/private partnerships. **#60.** Larger talent pool.	**N/A**

Much like Scenario 1, the eight implications that were unique to Scenario 2 (see Table 10) were mostly driven by key driver states that were exclusive to Scenario 2. The key driver states that were exclusively present in Scenario 2 include a normal CAP supply, low contract demand, and a flexible regulatory/legal/policy framework. Historical precipitation was also a key driver state that was only present in Scenario 2 but, as Table 6 confirms, historical precipitation did not primarily influence any of the implications that were generated.

Challenge implications unique to Scenario 2 were:

- Increased cost to customers – demand driven (implication #3). Having a low water demand from CAP long-term contract water users, coupled with low population growth and a weak economy, decreases the ability of customers to pay increased water rates.
- Pressure to defer capital projects and technological advances (implication #8). Even with a normal CAP supply, a weak economy and low water demand translates to reduced revenue generation from water sales, thus only high priority projects are slated for implementation.
- Difficulty projecting long-range rates (implication #12). With flexible regulations, it is difficult to anticipate the future regulatory environment thus affecting the ability to project long-range rates.
- Increased O&M for recharge (implication #30). There are increased operation and maintenance challenges with continued or increased recharge.
- Continuous adjusting to regulatory environment (implication #53). There are legal and legislative challenges related to adjusting to continuous regulatory changes in a lax regulatory environment. Furthermore, these shifting regulatory changes can challenge CAP's ability to meet its mission and have negative effects on CAP.

Opportunity implications unique to Scenario 2 were:

- Good supply for CAGRD (implication #18). With low demand obligations from long-term contract CAP water users, there will be an abundant water supply available for the CAGRD.
- Less urgency for short-term water policy planning, affording flexibility and proactive, not reactive, response (implication #61). With a normal to high water supply and low water demand, there is more time available for planning and collaboration without the pressure of executing short-term planning solutions.

The only mixed challenge/opportunity implication unique to Scenario 2 was:

- Physical challenges to storing excess water due to long-term groundwater level rise (implication #16). There will be future challenges from regularly managing the storage of excess water resulting from long-term low water demand and high water supply. There will also be a need for new recharge locations due to long-term rising groundwater levels and the reduced ability to recharge water in existing recharge locations.

Since all of the key driver states that comprise Scenario 3 exist in either Scenario 1 or 2, there are no implications that are unique to Scenario 3.

Table 10: Implications unique to Scenario 2

Challenge Implications	Opportunity Implications	Mixed Implications
#3. Increased cost to customers – demand driven. **#8.** Pressure to defer capital projects and technological advances. **#12**. Difficulty projecting long-range rates. **#30.** Increased O&M for recharge. **#53.** Continuous adjusting to regulatory environment.	**#18.** Good supply for CAGRD. **#61.** Less urgency for short-term water policy planning, affording flexibility and proactive, not reactive, response.	**#16.** Physical challenges to storing excess water due to long-term groundwater level rise.

4.3.2 Ability to Mitigate Implications

Another aspect of interest to examine is the ability to mitigate or adapt to a particular implication. The number of adaptation strategies available as options to address a single implication can be used to estimate the ability to mitigate or adapt to that implication[11]. The more strategies available per implication, the greater planning flexibility CAP possesses in addressing that implication. This is especially true if the suite of options available include strategies with varying levels of ease of implementation, thus enabling CAP to explore easy strategies before considering more difficult ones.

The following are the top five implications that had the greatest number of strategies:

1. Increased cost to customers – demand driven (implication #3)
    - 13 adaptation strategies
2. Reduced ability of customers to pay rates (implication #4)
    - 11 adaptation strategies
3. Collaborative planning environment (implication #59)
    - 11 adaptation strategies
4. Increased cost to customers – power driven (implication #2)
    - 10 adaptation strategies
5. Employee recruitment challenges (implication #43)
    - 10 adaptation strategies

Three of the top five implications that had the largest number of strategies associated with them deal with challenges related to costs (due to demand and power changes) and the ability of CAP customers to pay these costs. The other two implications focus on CAP operating in a collaborative planning environment, and tackling hurdles related to recruiting new CAP employees. Being in a collaborative planning environment is a broad implication that provides numerous opportunities (through adaptation strategies). It adds flexibility for CAP to put into action planning projects and activities with a wide array of willing partners, hence the large number of strategies available to implement in response. Employee recruitment challenges can be mitigated by adopting different internal staffing or employment policies that can attract and retain CAP employees through incentives such as improved work-life balance, better benefits, and competitive compensation.

Just as implications with many strategies may be easy to adapt to, implications with few strategies may be more difficult to adapt to. All implications that were generated by the team have at least two potential strategies. Table 11 lists the eight implications that only have two strategies.

Six of the eight implications with only two available strategies are connected to water operations and maintenance, and water supply planning. All of these six implications are also opportunities – with the exception of increased operations and maintenance due to increased recharge. Additionally, most of these implications are associated with a single scenario (excluding implications #37, 40, and 54), which could be a factor in the lower number of strategies connected to them. Conversely, the ongoing need to manage public perceptions (implication #54) is common to all scenarios (see Table 8).

[11] Ability to mitigate would also depend on the ease of implementation of strategies, not solely the number of strategies, that address an implication. Using the number of adaptation strategies is an approximation, and the approach could be refined in a subsequent phase of work.

Table 11: Implications with the lowest number of strategies (two strategies per each implication)

Challenge Implications	Opportunity Implications	Mixed Implications
#12. Difficulty projecting long-range rates. **#30.** Increased O&M for recharge. **#54.** Ongoing need to manage perceptions (public image).	**#18.** Good supply for CAGRD. **#37.** Increased turn-back water/short-term demand reduction. **#38.** Increased operational efficiency. **#40.** Increased operational and maintenance flexibility. **#61.** Less urgency for short-term water policy planning, affording flexibility and proactive, not reactive, response.	**N/A**

4.4 Adaptation Strategies

This section summarizes strategies to mitigate the implications discussed in the previous section. It focuses on three key characteristics of adaptation strategies, each discussed in subsections below: 1) ease of implementation, 2) applicability of strategies across scenarios, and 3) effectiveness of strategy to address multiple implications and/or key vulnerabilities to CAP. These characteristics can help prioritize strategies and inform whether the strategies are no regrets, low regrets, or conditional.

4.4.1 Ease of Implementation of Strategies

Adaptation strategies were developed by the team in response to the implications that were generated. Each adaptation strategy is an action meant to mitigate a challenge or capitalize on an opportunity. Adaptation strategies were assigned an ease of implementation (easy/medium/difficult) that corresponds with how easy or difficult it is to implement a strategy in a given scenario. Having a strategy that can be implemented in more than one scenario also makes it possible for that strategy to have different levels of ease of implementation in the different scenarios (e.g. a strategy can be easy to implement in one scenario but difficult to implement in another scenario).

The number of strategies, and the strategies' ease of implementation (easy/medium/difficult), per scenario is summarized in Figure 3. The ease of implementation for a strategy is highly dependent on the scenario, due to the combination of key driver states that constitute that scenario. Scenario 1 had the highest number of easy to implement strategies, while Scenario 3 had the highest number of difficult to implement strategies. Scenario 2 had the smallest number of potential strategies. Likewise, Scenario 2 also had the smallest number of total available implications.

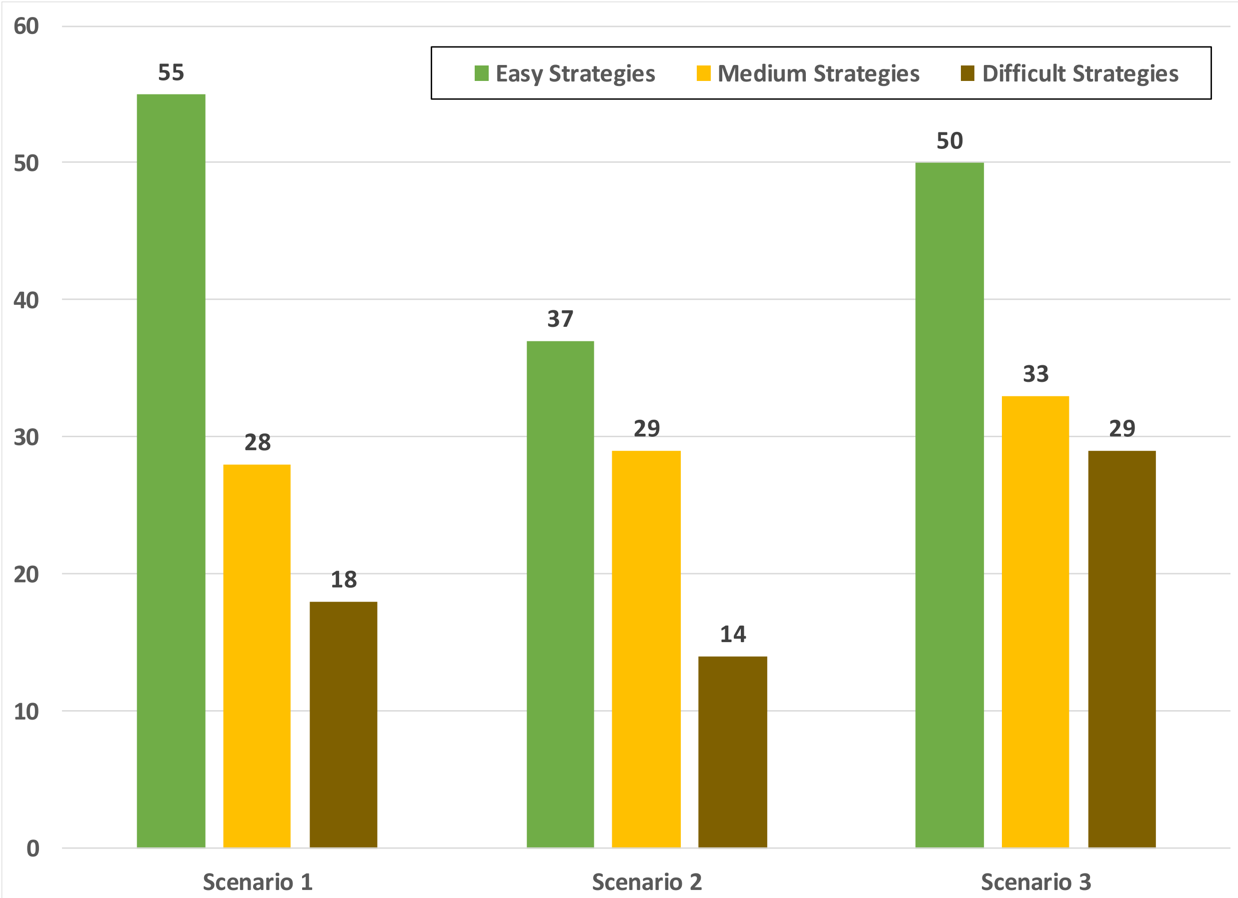

Figure 3: Number of strategies per scenario

Figure 4 illustrates the distribution of the ease of implementation for all adaptation strategies. Easy to medium strategies are strategies that are applicable in at least two scenarios, where the strategy is easy to implement in one scenario and medium difficulty to implement in another scenario. Similarly, medium to difficult strategies are strategies that are applicable in more than one scenario where the strategy is medium to implement in one scenario and difficult to implement in another scenario. Easy to difficult strategies are also applicable in more than one scenario where the ease of implementation ranges between easy and difficult.

Figure 4 reveals that the majority of strategies are uniformly easy, medium, or difficult in the scenarios they are applicable to – with uniformly easy to implement strategies being the most prevalent (42 percent of all strategies). Strategies with varying levels of ease of implementation across multiple scenarios are much fewer in number, only accounting for 20 percent of all strategies. In that subset of strategies with varying levels of ease of implementation, there is only one strategy that can vary from easy to difficult implementation across different scenarios: Interagency collaboration/partnerships for power transmission infrastructure (strategy #78). Ease of implementation of strategy #78 is highly dependent on the state of the key driver interagency collaboration. If interagency collaboration is competitive and combative (Scenario 1), strategy #78 would be difficult to implement, whereas if interagency collaboration is collaborative (Scenarios 2 and 3), strategy #78 would be easy to implement.

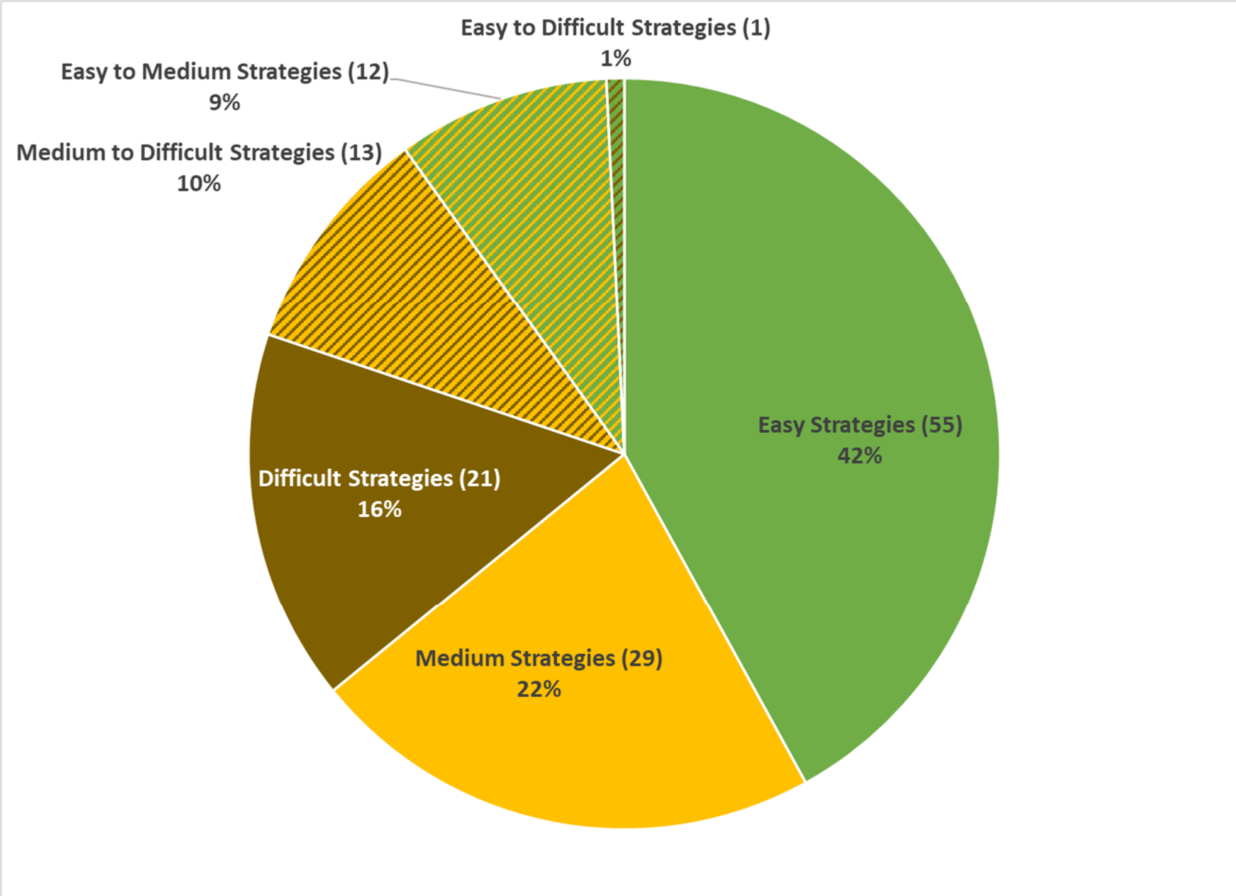

Figure 4: Distribution of adaptation strategies with different levels of ease of implementation

4.4.2 Applicability of Strategies Across Scenarios

Less than half of all the adaptation strategies (38 percent) are applicable to all three scenarios. Of these 50 strategies, 25 are easy to implement, seven are medium to implement, and six are difficult to implement. Table 12 through Table 14 list the strategies that are uniformly either easy, medium, or difficult to implement across all three scenarios, respectively.

Strategies that are uniformly easy to implement (Table 12) can be considered no regrets strategies because they are both easy to implement and can be applicable to any scenario. A review of the strategies in Table 12 suggests strategies that CAP is either currently implementing (such as banking water, creating intentionally created surplus, and collaborating with others to address water supply/demand imbalance) or can easily implement with little to no additional resources or staff time (such as increasing communications on water quality, staff and board outreach, and prioritizing work activities). Sixteen of the 25 strategies in Table 12 address opportunity and/or mixed implications.

Table 12: Strategies that are uniformly easy to implement in all scenarios

#4. Communicate potential for increased rates to customers. **#11.** Bank water. **#19.** Reprioritize non-critical capital improvement projects to future budget. **#24.** Create technology replacement fund. **#32.** Look to CAGRD to help supplement other areas. **#37.** More intentionally created surplus (ICS) in Lake Mead. **#39.** Monitor changes to prepare for changes. **#46.** Operational flexibility to facilitate maintenance. **#49.** Share water quality management with customers/manage customer expectations.	**#51.** Increase external/internal communications on water quality. **#64.** Increase training, awareness, safety campaigns regarding weather issues/conditions. **#82.** Flexible operations to respond to changes in seasonal demand. **#83.** Change maintenance schedule to reduce costs. **#84.** Enforce existing contract condition that limits monthly supply to 11 percent of annual supply. **#85.** Decrease rates due to increased operational and/or maintenance efficiency. **#86.** Implement more flexible and efficient operational practices. **#87.** Shift schedules/alternative work schedule.	**#91.** Staff subject to exposure; take days off when conditions are dangerous. **#99.** Prioritize work activities. **#103.** Stakeholder workshops, collaboration, outreach. **#105.** Board outreach and education, on CAP's behalf. **#106.** Staff outreach and education (employees promote message), on CAP's behalf. **#110.** Increase patrolling/surveillance. **#116.** Increase collaboration with other agencies to facilitate permitting and environmental compliance. **#121**. Collaborate with others to address water supply/demand imbalance.

Strategies with uniformly medium level ease of implementation in all scenarios are listed in Table 13. These seven strategies, mostly associated with issues of cost, are thematically similar in that they are pre-emptive measures. They are not direct responses to the implications they address, but are actions that need to be put into place before an implication fully manifests. For example, early rate increases, refinancing, interstate water sales, and alternative water in the canal are all strategies meant to minimize large jumps in inevitable water rate increases (due to factors outside of CAP's control such as inflation affecting cost of business). Similarly, changing staff and resource distribution and responsibilities, as well as working with difficult partners are not ideal actions to implement, but doing so mitigates a more drastic action later (such as unrecoverable loss of resources and staff or prolonged conflict with difficult partners that will cost more time and resources).

Table 13: Strategies that are uniformly medium to implement in all scenarios

#2. Early rate increases to decrease rate shock. **#5.** Look at refinance options.	**#6.** Alternative (non-project) water supply in canal, to help share costs over more customers. **#38.** Interstate and intrastate water exchange/sales.	**#58.** Changing staffing resource distribution, functions, responsibilities, possibly mothball equipment. **#89.** Increase insurance coverage **#120.** Collaborate with difficult partners.

Only six strategies are uniformly difficult to implement in all scenarios (see Table 14). That said, the range of difficulty will vary by the specific action taken. For example, while finding other water supplies (through water augmentation) may be a difficult task, generating new supplies through weather modification is significantly easier to accomplish than water desalination. CAP is currently participating in weather modification programs, while it takes on average 20 years to bring a desalination plant from concept to operation. Similarly, the specific actions associated with decreasing CAP's level of service may vary in difficulty depending on what service is being decreased. Shifting CAP water operations and maintenance to less than optimal levels of service is far more difficult and consequential than reducing the frequency of CAP's communication to the public and its customers (both are generally difficult from a strategy standpoint, but one action is more difficult to undergo and apply).

Table 14: Strategies that are uniformly difficult to implement in all scenarios

#3. Decrease level of service. **#7.** Lobby for ability to generate power to offset power costs.	**#8.** Increase tax authority/increase tax percentage. **#9.** Find other supplies, e.g. desalination, weather modification, etc. (augmentation).	**#14.** Pre-emptively increase financial reserves. **#90.** Automate resources/equipment.

Analyzing strategies that are only applicable in a single scenario provides a measure of the adaptation efforts that are exclusively required in that scenario. Only nine strategies could be exclusively applied to Scenario 1 (see Table 15). These include beneficial financial strategies due to the presence of strong economic growth, necessary increases in public partnerships to compensate for competitive interagency collaboration, and staffing opportunities due to high population growth in central Arizona. There were no difficult strategies that were exclusively applicable to Scenario 1.

Table 15: Strategies exclusively applicable in Scenario 1

Easy Strategies	Medium Strategies	Difficult Strategies
#42. Increased budget. **#44.** Decrease rates and communicate rate decrease. **#112.** Public awareness campaign communicating dangers of canal. **#124.** Explore long-term partnership projects.	**#101.** Increased meetings between elected officials, e.g. board members meet with legislators. **#111.** Cooperation with local authorities and law enforcement agencies. **#128.** Increase workforce diversity. **#129.** Analyze compensation methods and policies. **#130.** Evaluate hiring practices process.	**N/A**

There were 10 strategies that were exclusively applicable to Scenario 2 (see Table 16). These 10 strategies cover topics such as alternative financial and water supply planning, groundwater storage and recharge, and reduction in staffing and operation capacity. These 10 unique strategies respond to the combination of the key driver states of a normal CAP supply, low water demand, low population growth, and weak economic growth.

No strategies were exclusively applicable to Scenario 3. This is due to the fact that Scenario 3 also did not have any unique implications associated with it.

Table 16: Strategies exclusively applicable in Scenario 2

Easy Strategies	Medium Strategies	Difficult Strategies
#12. Reduce operations/lower power costs. **#41.** Reduce CAGRD water supply acquisition. **#131.** More scenario planning.	**#34.** Explore alternate rate projection model. **#35.** Publish adaptive rate structure, use ranges. **#40.** Buy long-term storage credits. **#70.** Create recharge storage fee that applies to every customer.	**#13.** Workforce restructuring/reduction. **#25**. Incentives for stakeholders' own projects in service area. **#36.** Infrastructure investment: groundwater facilities.

4.4.3 Effectiveness of Strategies in Addressing Multiple Implications

The following are the top three strategies that individually address the largest number of implications:

1. Find other supplies, e.g. desalination, weather modification, etc. (augmentation) (strategy #9)
    - 11 implications
2. Changing staffing resource distribution, functions, responsibilities, possibly mothball equipment (strategy #58)
    - 10 implications
3. Decrease level of service (strategy #3)
    - Nine implications

All of these strategies represent broad categories with various actions that can be implemented (e.g. different supplies for strategy #9, assorted types of changes to staffing resources for strategy #58, and various ways to decrease levels of service for strategy #3). This broad applicability also lends itself to allowing these strategies to provide solutions to numerous and disparate implications. For example, finding other water supplies (strategy #9) provides adaptive response to increasing cost issues due to a reduction in available water supply to market, insufficient water supply to meet customer demands, and sub-optimal operation of the CAP system due to not conveying adequate volumes of water. Strategy #58 (Changing staffing resource distribution, functions, and responsibilities) also broadly addresses distinct implications, such as impacts to infrastructure, operations, and employees, all of which will require individually designed actions. Similarly, decreasing CAP's level of service (strategy #3) is an overall strategy to deal with shortcomings in various implications, due to reduced financial and physical resources to meet customer obligations and/or CAP's mission.

In contrast, there are 64 strategies that target only one implication (49 percent of all strategies). Of these 64 strategies, 42 percent were easy, 28 percent were medium, and 16 percent were difficult to implement in the scenarios they were applicable to. Table 17 focuses on a subset of these single implication strategies by highlighting the strategies that were uniformly difficult to implement.

Difficult strategies that only target one implication can be considered conditional strategies because they are only applicable when a particular implication or set of conditions arises and their implementation difficulty can limit the frequency of their application. Fully automating equipment (strategy #90) and increasing the system capacity of generating and storing power (strategy #76) both require huge financial investment in physical assets and lengthy implementation timelines to complete. Similarly, pursuing legislation and regulatory changes (strategies #62 and 81 respectively) will require persistent lobbying efforts that will likely not yield results in the near-term. Other strategies in Table 17 reflect diverse strategy applications on similar issues. For example, strategy #27 emphasizes firming more water supplies (through recovery of stored groundwater) while strategy #36 focuses on developing groundwater facilities. Both strategies tackle a different aspect of groundwater supplies, but both will require costly expenditures, either to build groundwater recovery infrastructure (for strategy #27) or to add groundwater storage facilities (for strategy #36). The contrast between strategies #13 and #119 is also stark. Increasing staff (strategy #119) and reducing or reorganizing staff and their duties (strategy #13) require wholly disparate actions to execute. However, both of these strategies will require extensive internal evaluations and analysis to make recommendations on how and where to optimally increase or reduce/restructure staff, making them time-intensive strategies.

Table 17: Difficult strategies that only address a single implication each

#13. Workforce restructuring/reduction. **#20.** Additional service charges. **#25.** Incentives for stakeholders' own projects in service area.	**#27.** Firm more water supplies. **#36.** Infrastructure investment: groundwater facilities. **#62.** Pursue legislation to further minimize subsidence.	**#76.** Increase power generation, capture, and storage. **#81.** Pursue regulatory changes. **#90.** Automate resources/equipment. **#119.** Increase staff.

4.5 Portfolios

Portfolios are a suite of adaptation strategies that provide diverse adaptation coverage for a wide number of future implications. Table 5 summarized the three portfolios developed by Group A, B, and C (three groups formed from the team), respectively. The intent of portfolio development was to filter available strategies into a smaller subset in order to identify preferred strategies. Preferred strategies are defined as strategies that were included in multiple portfolios.

This section presents analysis of the three portfolios developed by the team. First, portfolio composition is presented and commonalities across the three portfolios are summarized and evaluated. Next, a summary of which functions are involved with each portfolio is presented. Taken together, this information can be used to help develop a plan of action for CAP to adapt to climate change.

4.5.1 Portfolio Content and Commonalities

Each group was instructed to identify 10 different strategies that could be implemented across the scenarios. Each strategy was also assigned a category (no regrets/low regrets/conditional) that indicates the risk to CAP of implementing each strategy in a given portfolio. Groups were instructed to utilize all three categories of strategies, but additional direction on what makes a "good" portfolio was intentionally not provided.

Figure 5 compares portfolios A, B, and C with respect to the composition of their strategy categorization (no regrets/low regrets/conditional), the ease of implementation of their strategies (easy/medium/difficult), and the implication types that their strategies address (challenges/opportunities/mixed challenges-opportunities). Generally speaking, it appears that Group A focused on selecting strategies that addressed the most implications, which came at the expense of more difficult strategies and fewer no regrets strategies. Group C appears to have focused more on ease of implementation and no regrets strategies, at the expense of addressing fewer implications. Group B appears to have taken a more balanced approach.

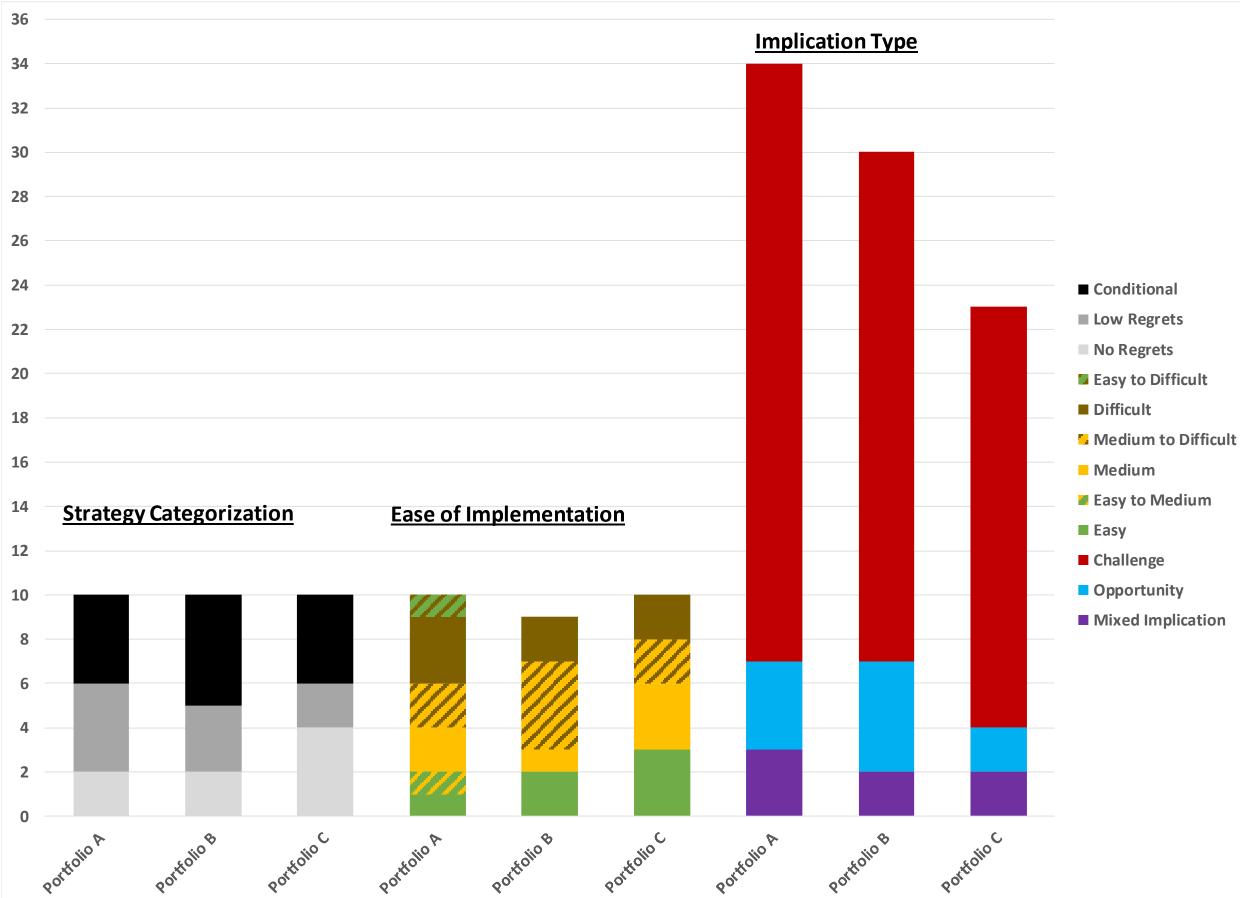

Figure 5: Comparison of group portfolios A, B, and C

Table 18 presents strategies that were common to two or more of the three portfolios developed by the team. Strategies identified in multiple portfolios can be considered preferred strategies as they were independently selected by multiple groups. This section summarizes the common strategies and why they were selected, and also discusses the categorization (no regrets, low regrets, or conditional) of each common strategy.

Only one adaptation strategy was common to all three group portfolios:

- Strategy #9: Find other supplies, e.g. desalination, weather modification, etc. (augmentation). Strategy #9 was selected because 1) it addresses key implications that affect CAP's mission of delivering water, particularly implication #15: Limited diversions from Colorado River because Lake Mead is low, 2) it addresses 11 implications, the most of any strategy, and 3) it addresses implications that occur in all three scenarios.
    - Only Group A considered this strategy to be conditional; both groups B and C categorized this strategy as low regrets. This difference in categorization may be due to the assorted types of water augmentation options available under this strategy (e.g. weather modification can be considered low regrets due to lower costs of operation versus desalination which is associated with higher costs and longer timelines to implement).

Six adaptation strategies were common to two portfolios:

- Strategy #5: Look at refinance options. Strategy #5 addresses six implications, is applicable in all scenarios, and has medium ease of implementation.
    - Group A considered this strategy to be no regrets; Group C considered it conditional. The exploration of refinance options may be a no regrets strategy if the available options for refinancing are only investigated and not adopted. However, looking at refinance options for the specific purpose of implementing one of them could be deemed a conditional strategy; resorting to refinancing CAP's debt repayment obligation to address issues associated with increased costs is a significant undertaking.
- Strategy #66: Collaborate with others (public or private) to store more water at Lake Pleasant or meet customer demands. Strategy #66 addresses four implications, is applicable in all scenarios, and is considered medium to difficult to implement depending on the scenario. It addresses key implications that are critical to CAP's mission, and capitalizes on two opportunities: implications #58 and #59: increased non-traditional public/private partnerships and collaborative planning environment.
    - There is a less pronounced difference in how strategy #66 is categorized between Group B and C. For group portfolio B this is a low regrets strategy, but for Group C the same strategy is considered no regrets. This is because storing more water in Lake Pleasant and/or meeting customer demands is considered a beneficial strategy for CAP (making it a low regrets strategy only if too little or too much water is stored In Lake Pleasant or not enough water is utilized to meet customer demands).
- Strategy #4: Communicate the potential for a rate increase to customers. Strategy #4 addresses five implications, is easy to implement, and is applicable in all scenarios.
    - This strategy was categorized as a no regrets strategy by groups B and C in their respective portfolios. Communicating potential rate increases to customers is an easy to implement strategy and one that CAP has already done in the past and will continue to do when appropriate. There is generally no detriment in informing CAP customers of potential increases in water rates – in fact, alerting customers of a likely rate increase in the near future provides customers more time to prepare for that outcome.
- Strategy #31: increase conservation programs. Strategy #31 addresses six implications, is difficult to implement, and is applicable in Scenarios 1 and 3, in which there is low supply and high demand.
    - Strategy #31 was classified as low regrets by groups A and C. Increasing water conservation programs is a somewhat pre-emptive strategy; conserving more water in the present (and reducing Colorado River diversions, thereby minimizing lake level reductions in Lake Mead) mitigates the impact of water reductions in the future (either by delaying the onset of a shortage or diminishing the severity of a water shortage). There is also little risk of overinvestment in this strategy; reasonably conserving more water can help to mitigate the effects of future shortages. But underinvestment in water conservation programs can yield earlier onsets of water shortage or deeper reductions to CAP's annual diversion from the Colorado River.
- Strategy #57: upgrade, update, or modify equipment for new issues. Strategy #57 addresses two implications, including one that is critical to CAP's mission (implication #27, potential damage to CAP infrastructure and facilities, from weather, which could preclude CAP from being able to deliver water).
    - Strategy #57 was classified as low regrets by both groups A and B. It is continuously being implemented at CAP to either keep equipment in good operating condition or to modify

equipment to meet the developing challenges that CAP has to manage. It is almost a no regrets strategy; however, the strategy is medium to difficult to implement, suggesting there is risk of overinvestment.

- Strategy #58: changing staffing resource distribution, functions, responsibilities, possibly mothball equipment. This strategy was selected because it addresses 10 implications (second most of any strategy) and is applicable in all scenarios. Ease of implementation is medium.
    - Strategy #58 was categorized as a conditional strategy in group portfolios A and B. What makes this strategy conditional is that it represents a comprehensive reorganization of existing CAP functions, departments, staff, and equipment due to challenges such as increased work activities with limited staff and/or resources. Mothballing equipment is also an indication of reduced organizational capacity, either from a staffing or infrastructure perspective. Additionally, not implementing this conditional strategy could lead to detrimental outcomes (e.g. being unable to meet the demands of increased operations, maintenance, facilities repairs, and/or canal security).

Table 18: Strategies common to the portfolios

Strategies common to Group Portfolios A, B, and C	Strategies common to Group Portfolios A and B	Strategies common to Group Portfolios B and C	Strategies common to Group Portfolios A and C
#9. Find other supplies, e.g. desalination, weather modification, etc. (augmentation).	**#57.** Upgrade, update, or modify equipment for new issues.	**#4.** Communicate potential for increased rates to customers.	**#5.** Look at refinance options.
	#58. Changing staffing resource distribution, functions, responsibilities, possibly mothball equipment.	**#66.** Collaborate with others (public or private) to store more water at Lake Pleasant or meet customer demands.	**#31.** Increase conservation programs.

4.5.2 Portfolios and Functions

This section discusses which CAP functions are involved with implementing strategies in the portfolios, and which functions' implications are mitigated. The portfolios generally mitigate implications affecting all CAP climate-sensitive functions, but not all functions are involved with implementing the portfolios' strategies.

In terms of the number of CAP functions that are associated with the strategy composition of each portfolio, portfolio B was the only portfolio that contained strategies that involved all CAP functions. This is primarily due to the inclusion of the "do nothing" option which is applicable to all functions for any type of implication. However, when the "do nothing" option is removed, five functions (*Information Technology*; *CAGRD*; *Environmental, Health and Safety*; *Protective Services*; and *Risk and Liability Management*) are not involved with portfolio B's selected strategies. The strategies in portfolio C involve all of the CAP functions in this report except six: *Operational Technology*; *Information Technology*; *CAGRD*; *Environmental, Health and Safety; Human Resources*; and *Protective Services*. Portfolio A only excludes four CAP functions from its strategies: *Information Technology*; *Environmental, Health and Safety; Protective Services*; and *Risk and Liability Management*. However, the intent of portfolio development was to identify *preferred* strategies, not a full suite of strategies that could be implemented. As such, functions not involved with strategies selected in portfolios may be involved with a broader suite of strategies to adapt to climate change.

When exploring the implications that the strategies in these three portfolios address and the functions that are affected by these implications, the implications that are addressed by the portfolios affect all CAP functions. The only exception was group portfolio C, which does not address implications that affect *Human Resources*.

4.6 Organizational Functions

This section summarizes how CAP organizational functions could be affected by climate change and CAP's climate adaptation plan. It has three subsections: first, it summarizes the relative balance of each function between being affected by climate change implications versus being involved with the selected adaptation strategies; second, it summarizes how implications may affect multiple functions; lastly, it summarizes how strategies may be implemented by functions, either individually or across multiple functions.

Summaries of how individual functions may be affected by climate change and CAP's climate adaptation plan can be found in Appendix C.

4.6.1 Functions Sensitivity to Climate Change and Responsiveness to Climate Change

A function's sensitivity to climate change can be approximated by the number of implications affecting that function. Figure 6 summarizes the number and type of implications affecting each CAP function. *Water Operations and Power Programs* is the most sensitive (28 implications), with *Maintenance* being affected by the second highest number of implications (25). On the other end of the spectrum, *Protective Services* and *Information Technology* were the least sensitive in terms of total number of implications (seven).

In terms of challenge implications, *Water Operations and Power Programs* and *Maintenance* were both associated with the highest number of challenge implications (20) out of all CAP functions. *Human Resources* was associated with the fewest challenge implications (five).

In terms of mixed challenge/opportunity implications, *Resource Planning and Analysis* had the most mixed challenge/opportunity implications (four). *Environmental, Health and Safety*, *Human Resources*, *Engineering*, *Financial Planning and Analysis*, *Communications*, and *Protective Services* were all affected by the lowest number of mixed challenge-opportunity implications (one).

In terms of opportunity implications, *Protective Services*, *Environmental, Health and Safety*, *Information Technology*, and *Risk and Liability Management* were the only four functions that did not have any opportunity implications. *Human Resources*, *Legal*, and *Financial Planning and Analysis* were affected by the lowest number of opportunity implications (two). *CAGRD* was associated with the highest number of opportunity implications (six).

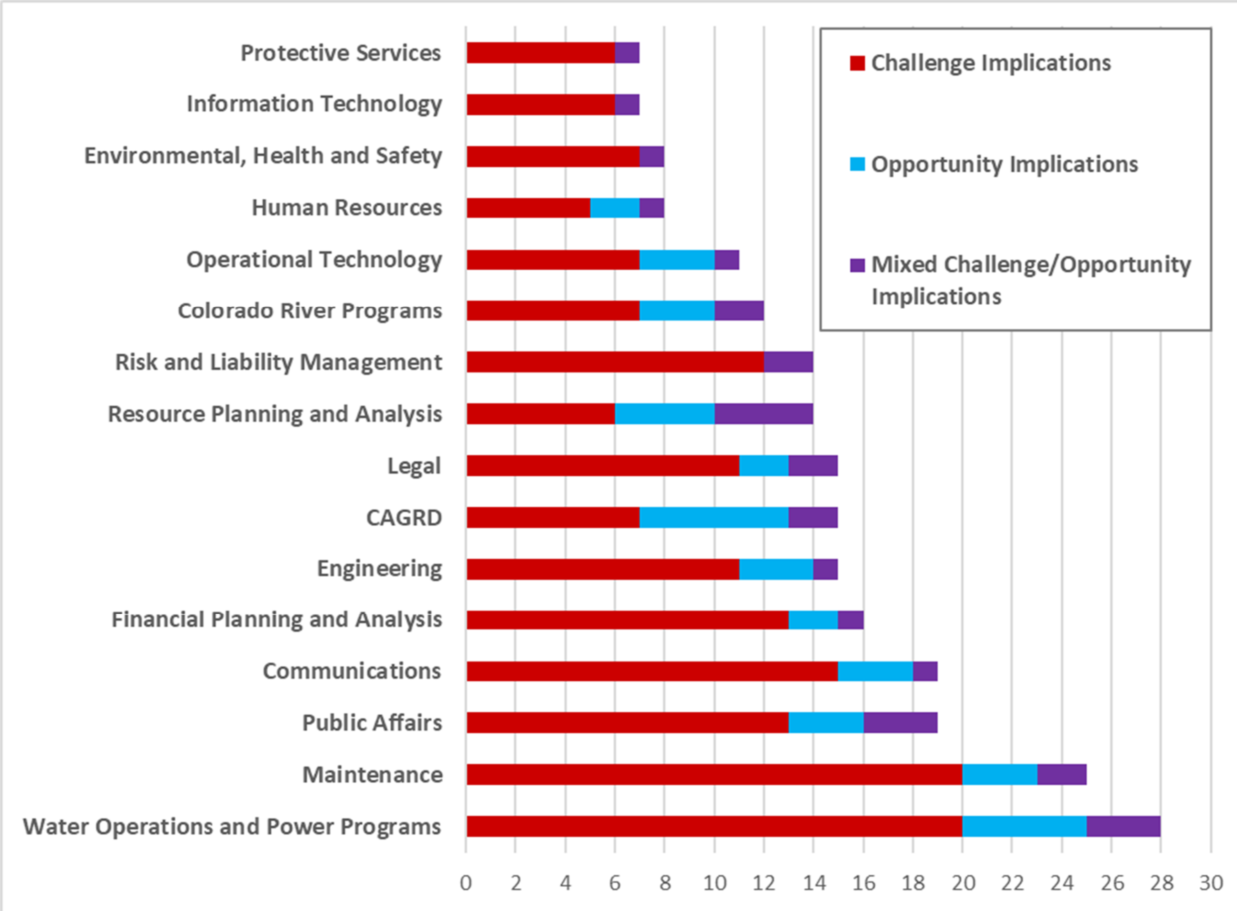

Figure 6: The number and types of implications affecting each CAP function

A function's ability to respond to climate change can be approximated by the number of strategies that function is involved with. Figure 7 shows the range of ability to respond across the functions. *Public Affairs* is the most responsive (37 strategies), followed by *Financial Planning and Analysis* and *Water Operations and Power Programs* (33 strategies each). At the other end of the spectrum, *Protective Services* is the least responsive, with six strategies.

Beyond the number of total strategies, some functions may have an easier or more difficult time implementing the strategies, as measured by the ease of implementation. Relative difficulty can be assessed based on the average difficulty of the strategies, or based on the number of easy or difficult strategies.

Based on average difficulty, *Communications* has strategies that are easiest to implement (88 percent are easy), and *Legal* has strategies that are most difficult to implement (58 percent are difficult). Between these, *Risk and Liability Management* has the greatest percentage, 43 percent, of medium strategies.

Based on magnitude, the following summarizes functions based on specific levels of ease of implementation:

- **Easy strategies**. Five functions share the lowest number of easy strategies (three): *Protective Services*, *Information Technology*, *Risk and Liability Management*, *Operational Technology*, and *Legal*. On the other hand, *Public Affairs* was associated with the highest number of easy strategies (18), and the highest number of strategies overall (37).

- **Medium strategies.** *Financial Planning and Analysis* was associated with the highest number of medium strategies (11). Three functions, *Information Technology*, *Operational Technology*, and *Environmental, Health and Safety* were not involved with any medium strategies.
- **Difficult strategies**. *Protective Services*, *Information Technology*, *Risk and Liability Management*, *Environmental, Health and Safety*, and *Communications*, were all involved with only one difficult to implement strategy each. The highest number of difficult to implement strategies (11) belonged to *Legal*.
- **Strategies with variable ease of implementation.** *Water Operations and Power Programs* and *Public Affairs* were the only functions involved in strategies across each possible level of ease of implementation (easy, easy to medium, medium, medium to difficult, difficult, and easy to difficult). *Risk and Liability Management*, *Communications*, and *Colorado River Programs* were not connected to any strategies that varied across scenarios, their associated strategies were either uniformly easy, medium, or difficult to implement.

Using a combination of specific implementation levels, *Public Affairs*-associated strategies appear to be easiest to implement (highest combination of easy, easy to medium, and medium strategies – 25) and *Financial Planning and Analysis*-associated strategies appear to be most difficult to implement (highest combination of medium, medium to difficult, and difficult strategies – 24).

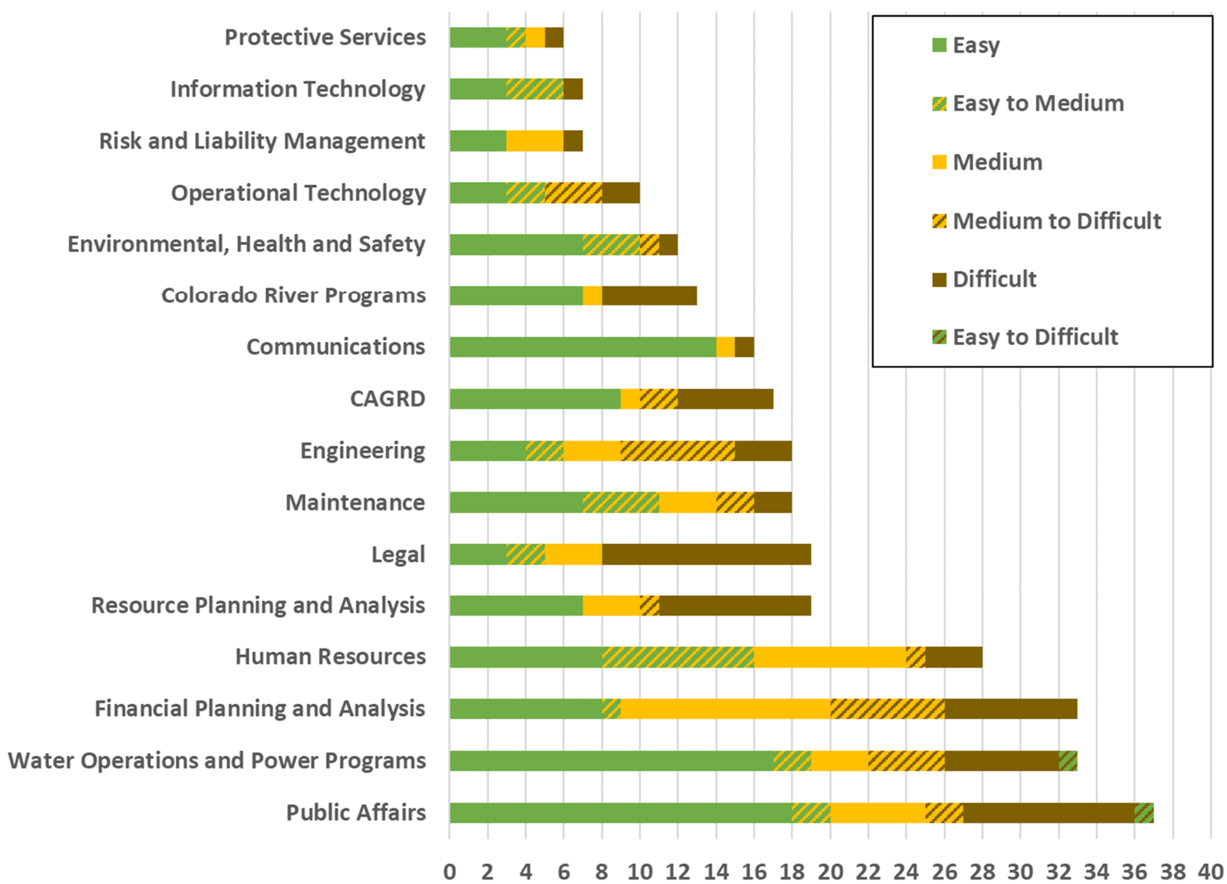

Figure 7: The number and types of strategies involving each CAP function

The relative balance between sensitivity to climate change and responsiveness to climate change can be approximated using an "adaptation capacity score," which is, for each function, the ratio of adaptation strategies to implications. It is a contrasting measure of the number of strategies that a function is involved in (responsiveness) to the number of implications that affect a function (sensitivity). Adaptation capacity scores greater than one indicate that a function is involved in more strategies than the number of implications that affect it. Otherwise, if a function is affected by more implications than strategies it is involved in, then the adaptation capacity score will be less than one.

Five CAP functions had adaptation capacity scores with values less than one. *Risk and Liability Management* yielded the lowest score value of all CAP functions (0.5), as it was affected by 14 implications but was only involved in seven strategies. For functions with score values greater than one, *Human Resources* had the highest score (3.5) and was significantly higher than other CAP functions (the closest function being *Financial Planning and Analysis* with a score of 2.06). *Human Resources* was affected by eight implications but was involved with 28 strategies. *Financial Planning and Analysis* and *Public Affairs* have lower adaptation capacity scores (both about two) than *Human Resources* but have a similar magnitude difference between number of strategies and implications as *Human Resources* does, as can be seen by their distance above the red dashed line in Figure 8.

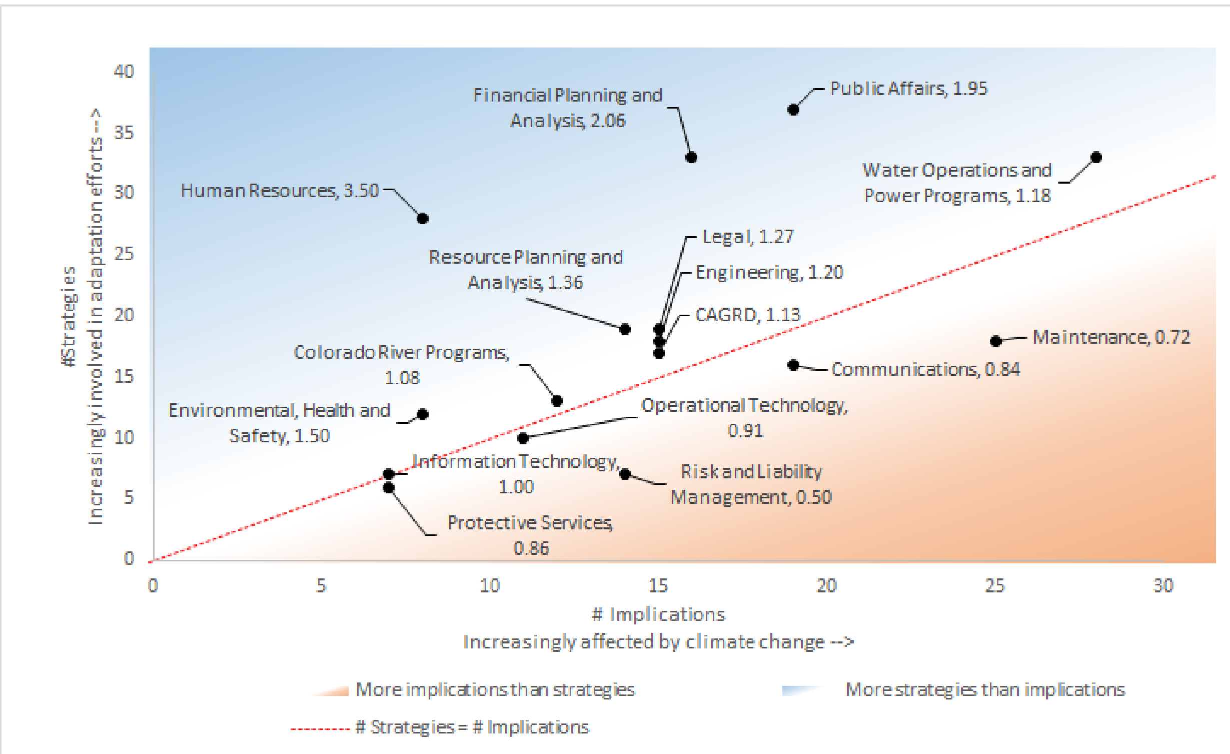

Figure 8: Adaptation capacity scores of each CAP function (ratio of strategies to implications)

4.6.2 Implications, Analyzed by Functions

This section summarizes implications in terms of functions. The purpose of this section is to understand on an organizational level how climate implications affect the organization. The section first summarizes how many functions are affected by individual implications, then focuses on implications that either affect all of CAP's climate-sensitive functions or single functions, and finally summarizes common groups of functions that share common implications.

Of the 61 implications, a little over half affect three or fewer functions (Figure 9). Only 15 percent affect single functions. Aside from one implication that affects all functions, the maximum number of functions affected by an implication is nine.

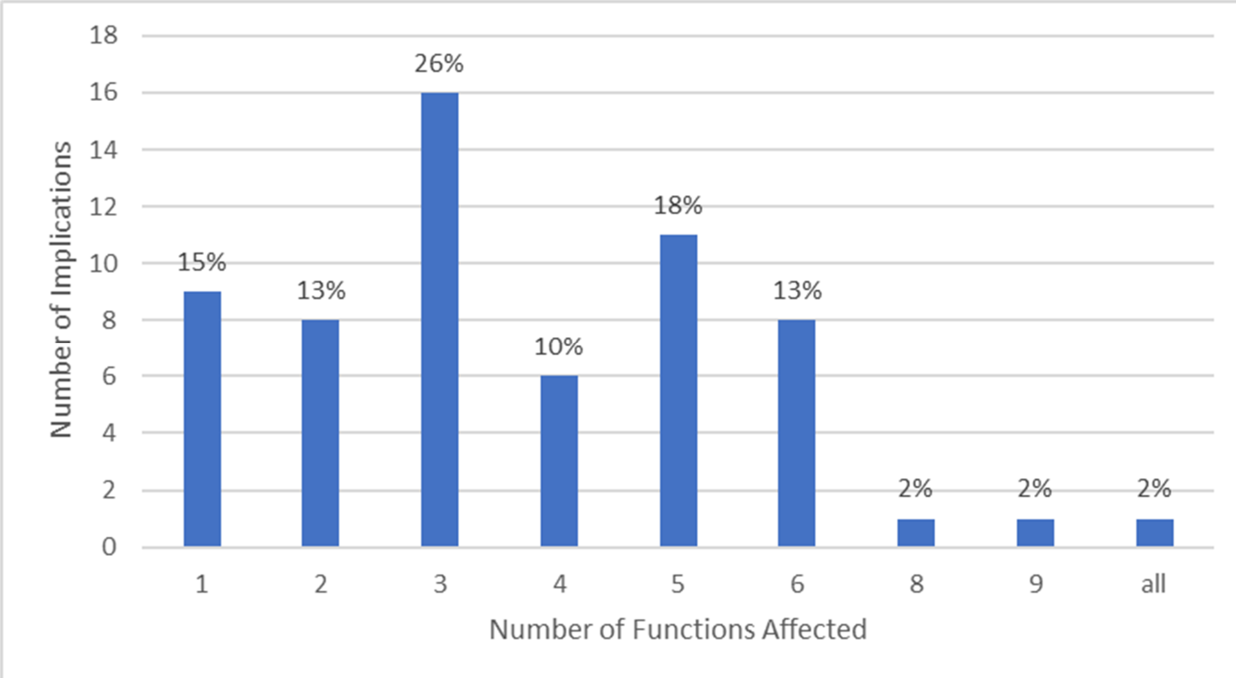

Figure 9: Implications summarized by number of functions affected

There was only one implication that affects all 16 of CAP's climate-sensitive functions: cutbacks to other agencies resulting in need for CAP to do others' work (implication #55). This was a mixed challenge/opportunity implication driven by weak economic health and a collaborative state of interagency coordination. These key driver conditions necessitate CAP to take on a larger role and workload from fellow agencies because economic conditions prohibit these partner agencies from having enough staff for them to adequately meet objectives shred with CAP. Having highly collaborative relationships and coordination with CAP's partners creates an environment where this work distribution shift is possible. It is a mixed implication because it allows CAP to have more influence and voice in the multi-party work it performs, but can burden its own staff with an amplified workload.

For implications that only affect one CAP function, Table 19 provides information on the functions they affect and the implications' respective type (challenge/opportunity/mixed). There are a total of nine specific implications that individually are only relevant to one function. With the exception of *CAGRD* and *Human Resources* (both of which have three implications that solely affect each of them), all other functions in Table 19 have just one implication that specifically affects them. And although *CAGRD* and *Human Resources* are affected by more of these single-function implications, the strategies necessary to adapt to those implications may require the participation of more than one function or other functions besides *CAGRD* and *Human Resources*. In addition to being single-function implications, three of these implications (implications #12, #18, and #60) are also single-scenario implications, making them exclusively germane to a single function and a scenario.

Table 19: Implications that only affect one function

<table>
<tr><th>Function</th><th>Challenge Implications</th><th>Opportunity Implications</th><th>Mixed Implications</th></tr>
<tr><td>CAGRD</td><td>#11. CAGRD potentially out of credits/limited ability to acquire on-river supply.</td><td>#17. Low obligations from CAGRD.

#18. Good supply for CAGRD.</td><td rowspan="4">N/A</td></tr>
<tr><td>Human Resources</td><td>#43. Employee recruitment challenges.</td><td>#57. Increased staff retention.

#60. Larger talent pool.</td></tr>
<tr><td>Financial Planning and Analysis</td><td>#12. Difficulty projecting long-range rates.</td><td rowspan="3">N/A</td></tr>
<tr><td>Information Technology</td><td>#35. Limited IT resources: responding to problems, fewer refreshes, technology lagging behind.</td></tr>
<tr><td>Public Affairs</td><td>N/A</td><td>#56. Increased pressure on legislature to enact solutions to water supply/demand imbalance.</td></tr>
</table>

For implications affecting multiple functions, commonalities were evaluated. Table 20 summarizes the number of implications that pairs of functions would be affected by. Table 20 suggests that there are certain combinations of functions that may frequently be affected by the same implications. For example, there are 18 implications that are associated with both *Maintenance* and *Water Operations and Power Programs*, due to the mutual function emphasis on the CAP canal.

	Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications
Financial Planning and Analysis	**16**	3	3	4	3	2	2	1	2	2	1	1	5	1	8	8
Maintenance	3	**25**	10	18	15	6	3	3	1	7	4	7	11	8	2	5
Operational Technology	3	10	**11**	9	8	6	1	1	1	3	1	3	4	2	1	2
Water Operations and Power Programs	4	18	9	**28**	12	4	6	4	4	5	2	3	6	8	5	9
Engineering	3	15	8	12	**15**	5	2	2	1	4	2	3	7	5	1	3
Information Technology	2	6	6	4	5	**7**	1	1	1	2	1	3	4	2	1	2
Resource Planning and Analysis	2	3	1	6	2	1	**14**	9	11	1	2	1	3	7	8	5
Colorado River Programs	1	3	1	4	2	1	9	**12**	9	3	3	1	2	7	7	4
CAGRD	2	1	1	4	1	1	11	9	**15**	1	2	1	1	6	7	5
Environmental, Health and Safety	2	7	3	5	4	2	1	3	1	**8**	4	4	5	4	2	2
Human Resources	1	4	1	2	2	1	2	3	2	4	**8**	3	4	3	2	1
Protective Services	1	7	3	3	3	3	1	1	1	4	3	**7**	7	4	1	2
Risk and Liability Management	5	11	4	6	7	4	3	2	1	5	4	7	**14**	7	3	4
Legal	1	8	2	8	5	2	7	7	6	4	3	4	7	**15**	9	6
Public Affairs	8	2	1	5	1	1	8	7	7	2	2	1	3	9	**19**	14
Communications	8	5	2	9	3	2	5	4	5	2	1	2	4	6	14	**19**

Table 20: Number of implications affecting pairs of functions

White boxes represent total number of implications affecting each function. Blue boxes represent number of implications that affect both of the functions identified by the respective row and column header. Darker shades of blue represent more shared implications.

4.6.3 Adaptation Strategies, Analyzed by Functions

This section summarizes adaptation strategies in terms of functions. The purpose of this section is to understand on an organizational level how climate adaptation would be implemented. The section first summarizes how many functions are involved with individual strategies, then focuses on strategies that either involve all CAP climate-sensitive functions or single functions, and finally summarizes common "teams" of functions that could be organized to implement adaptation strategies.

Of the 131 strategies, over 40 percent are single-function strategies, over 70 percent are associated with one or two functions, and only two strategies include more than five functions (Figure 10).

The two strategies that involve all 16 CAP functions described in this process are decrease level of service (strategy #3) and prioritize work activities (strategy #99). Both of these strategies are broad enough to involve all functions, as they directly relate to work performance. However, they both aim to achieve converse results under the same pressure of challenges associated with staffing issues. Prioritizing work activities (strategy #99) is an effort to optimize work performance by completing the most pertinent work deliverables first, while still aiming to complete all necessary work tasks. As such it is considered an easy strategy to implement because it entails shifting existing work activities into an approach that more efficiently prioritizes the most important elements to meeting CAP's mission. Decreasing CAP's level of service on the other hand is a strategy that reflects an inability to meet all work tasks due to the overwhelming burden of having insufficient staff and an inflated workload. In this strategy, CAP accepts the difficult decision to not operate at peak performance, from a staff and customer service perspective, in order to fulfill its most basic and essential responsibilities. This is a difficult strategy to implement because it requires scaling back aspects of operations, capital project development, and deliverables, which also has negative consequences to CAP's reputation and public image (both to customers and potential employees).

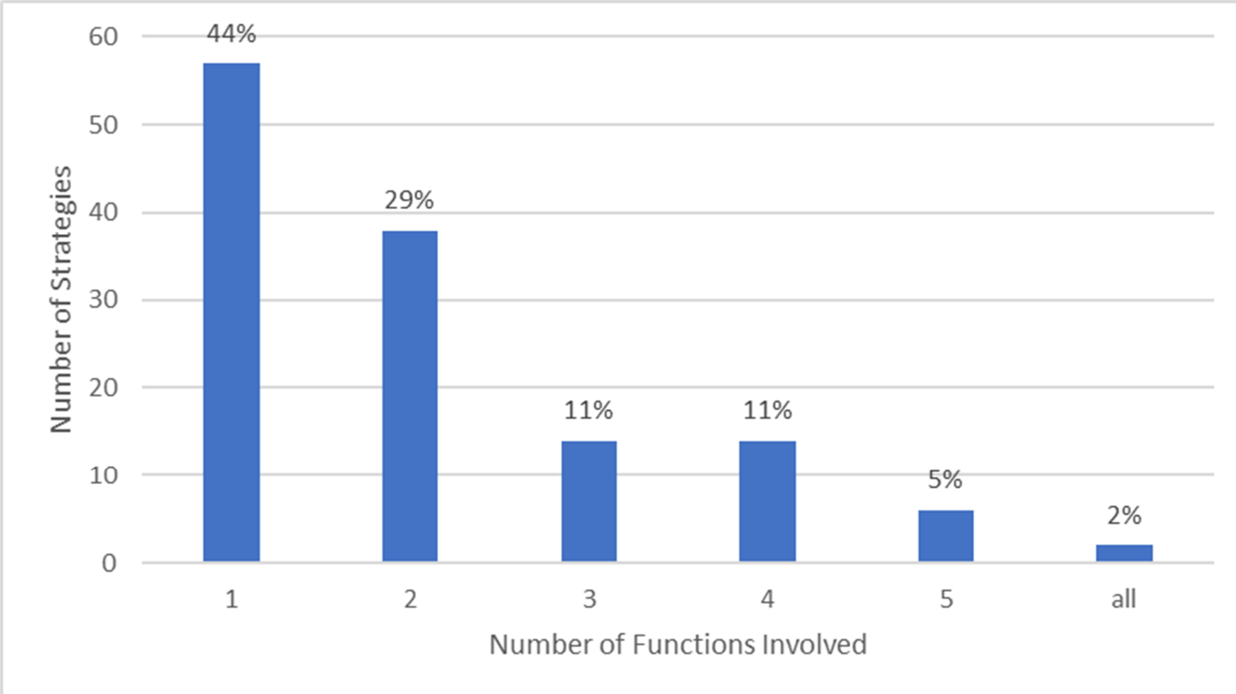

Figure 10: Adaptation strategies summarized by number of functions involved

Regarding strategies that only require one CAP function to implement (single-function strategies), there are 57 strategies that meet this criterion (which is 44 percent of all generated strategies). Only 10 of the 16 CAP functions identified in this process were connected to strategies that exclusively involved them (see Figure 11). *Human Resources* was associated with the highest number of single-function strategies overall, and had the highest number of single-function strategies with a medium level ease of implementation. Both *Human Resources* and *Water Operations and Power Programs* had the highest number of difficult single-function strategies. *Water Operations and Power Programs* also was associated with the highest number of easy to implement single-function strategies. *Engineering* was involved with only one single-function strategy. All of the single-function strategies that are associated with *CAGRD* and *Communications* were easy to implement strategies.

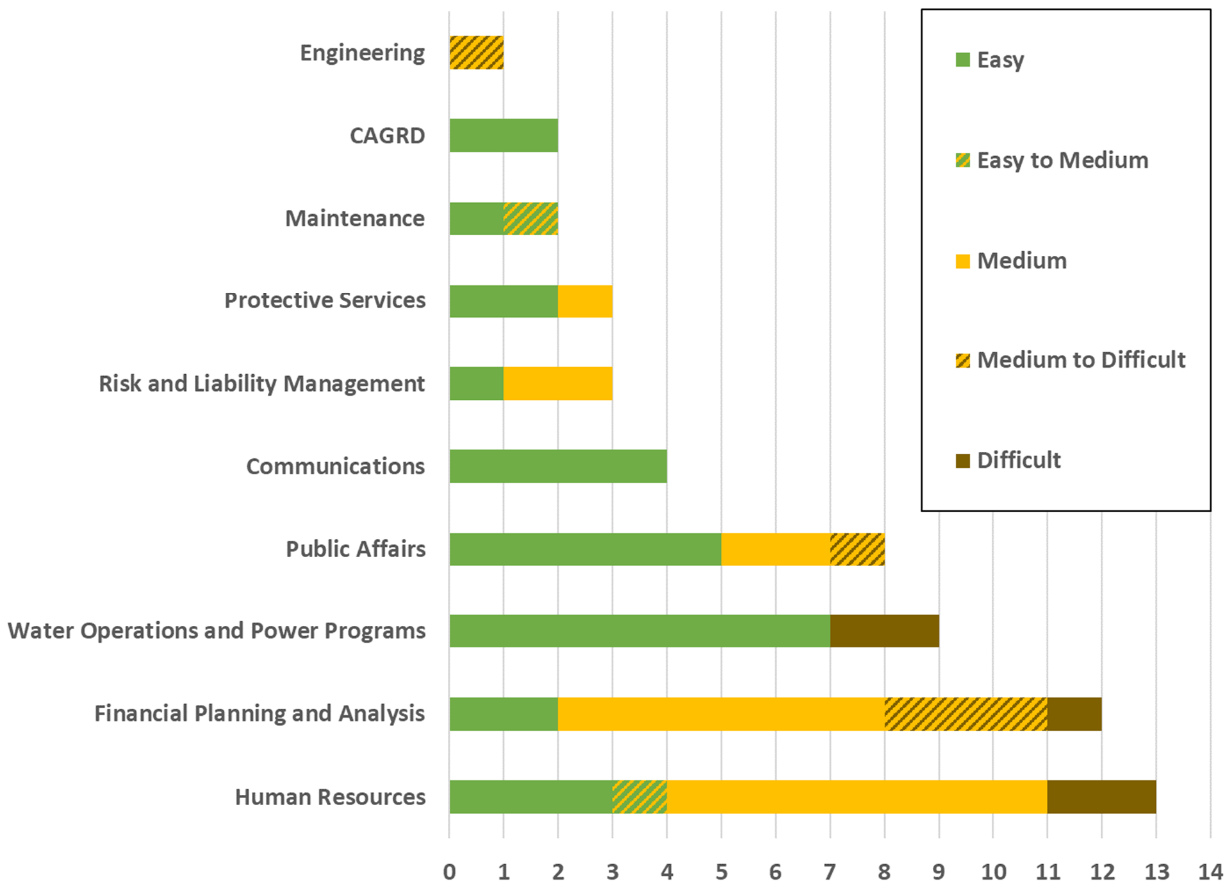

Figure 11: Functions with single-function adaptation strategies

For the almost 60 percent of strategies that involve multiple functions, commonalities were evaluated. Table 21 summarizes number of strategies that pairs of functions would implement together. Table 21 suggests that there are certain combinations of functions that may frequently be involved in implementing strategies together. For example, there are 14 strategies that are associated with both *Legal* and *Public Affairs*, suggesting these two functions could work closely together in climate adaptation. Table 21 also reveals potential multi-function teams, such as *Resource Planning and Analysis*, *Colorado River Programs*, and *CAGRD*; each of these pair combinations has at least eight shared strategies. These commonalities are fairly well correlated with the commonalities of implications (Table 20); that is, the paired or multi-function teams would both be sharing implications as well as strategies to address those implications.

	Financial Planning and Analysis	Maintenance	Operational Technology	Water Operations and Power Programs	Engineering	Information Technology	Resource Planning and Analysis	Colorado River Programs	CAGRD	Environmental, Health and Safety	Human Resources	Protective Services	Risk and Liability Management	Legal	Public Affairs	Communications
Financial Planning and Analysis	**33**	2	4	7	8	3	4	2	6	2	2	2	3	6	6	4
Maintenance	2	**18**	7	9	8	5	2	2	2	6	7	2	2	2	3	2
Operational Technology	4	7	**10**	8	5	6	2	2	2	2	4	2	2	2	2	2
Water Operations and Power Programs	7	9	8	**33**	9	5	6	3	5	4	5	2	4	3	8	3
Engineering	8	8	5	9	**18**	2	5	2	4	5	3	2	3	2	4	2
Information Technology	3	5	6	5	2	**7**	2	2	2	2	4	3	2	2	2	2
Resource Planning and Analysis	4	2	2	6	5	2	**19**	12	12	2	2	2	3	9	11	3
Colorado River Programs	2	2	2	3	2	2	12	**13**	8	2	2	2	2	8	10	3
CAGRD	6	2	2	5	4	2	12	8	**17**	2	2	2	2	4	6	3
Environmental, Health and Safety	2	6	2	4	5	2	2	2	2	**12**	9	2	3	2	3	3
Human Resources	2	7	4	5	3	4	2	2	2	9	**28**	2	2	4	4	4
Protective Services	2	2	2	2	2	3	2	2	2	2	2	**6**	2	2	2	2
Risk and Liability Management	3	2	2	4	3	2	3	2	2	3	2	2	**7**	2	2	2
Legal	6	2	2	3	2	2	9	8	4	2	4	2	2	**19**	14	2
Public Affairs	6	3	2	8	4	2	11	10	6	3	4	2	2	14	**37**	7
Communications	4	2	2	3	2	2	3	3	3	3	4	2	2	2	7	**16**

Table 21: Number of strategies involving pairs of functions

White boxes represent total number of strategies that each function is involved with. Blue boxes represent number of strategies that involve both of the functions identified by the respective row and column header. Darker shades of blue represent more shared strategies.

5.0 Conclusions

This climate adaptation plan was developed by team members that represented CAP's climate-sensitive functions. While it was led and facilitated by a smaller group, all of the information came from team members through a series of workshops. All team members were actively engaged and participated throughout the process. In addition to resulting in a robust plan, the process allowed staff to get better integrated and to learn about how the different functions work together as a whole to meet CAP's mission.

Key conclusions reached through this process are as follows:

- Drivers
    - Relative influence of drivers was estimated based on the number of challenges or opportunities associated with each driver state.
    - Colorado River supply and demand changes are the two most influential drivers in terms of challenges.
    - Technology is the most influential driver in terms of opportunities.
    - Two driver states result in no implications: strong economic growth and historical precipitation.
- Scenarios
    - Scenarios 1 and 3 are the most challenging to CAP in terms of number of implications, in large part due to low Colorado River supply and full CAP contract demand. Scenario 3 is more challenging than Scenario 1 due to weak economic growth and less technological advancement.

    - Scenario 2, which has normal CAP supply and low contract demand, has less than half as many challenge implications as Scenario 1.
- Implications
    - Three key characteristics of implications can be used to inform potential risk to CAP: 1) likelihood of implication occurring, 2) severity of implication, and 3) ability to mitigate the implication:
        - Implications that are present in all scenarios represent issues that CAP either currently manages or will very likely need to address in the near future. Five of this type of implication were identified, mostly related to increasing temperature.
        - Severity of implications was evaluated qualitatively during portfolio development, where conditional strategies were selected to address the "most important" implications, or those implications that would preclude CAP's mission of delivering water. Importance or severity of implications could be examined further in a subsequent phase of work.
        - Ability to mitigate was evaluated based on number of strategies available to address an implication, as well as the ease of implementation of those strategies. Ease of implementation was evaluated qualitatively; costs and other considerations could be quantified in a subsequent phase of work.
- Strategies
    - Three characteristics of adaptation strategies can help prioritize and inform whether the strategies are no/low regrets or conditional: 1) ease of implementation, 2) applicability of strategies across scenarios, and 3) effectiveness of strategy to address multiple implications and/or key vulnerabilities to CAP.
    - No regrets strategies are those that provide a benefit with no or minimal downside of implementing, even if the future envisioned does not come to pass. Twenty five strategies were identified that are easy to implement and are applicable in all scenarios, characteristics that are common to "no regrets" strategies. CAP is currently implementing many of these, such as banking water, creating intentionally created surplus, and collaborating with others to address water supply/demand imbalance. Implementation of the others should be considered in the near-term.
    - Low regrets strategies are those that are generally easy to implement, but the benefit to the organization is greater when the future envisioned does come to pass. An example low regrets strategy identified by the team in portfolio development is strategy #31: increase conservation programs. It has little risk of overinvestment, and is somewhat pre-emptive: conserving water in the present mitigates the impact of water reductions in the future.
    - Conditional: conditional strategies are those that are only needed under a specific set of circumstances, and have a high risk of overinvestment. An example of a conditional strategy identified by the team in portfolio development is strategy #58: changing staffing resource distribution, functions, responsibilities, possibly mothball equipment.
- Portfolios
    - The team developed three portfolios of strategies, including no regrets, low regrets, and conditional strategies. The team noted that some conditional strategies were selected to address what the team viewed as the most important implications.
    - Strategies selected by the groups can be considered preferred strategies, particularly those that were selected by more than one group. One strategy was selected in all three portfolios: strategy #9, Find other supplies, e.g. desalination, weather modification, etc.

(augmentation). Six additional strategies were common across two of the three portfolios.

- Functions
    - Different functions have varying levels of sensitivity to climate change, as approximated by the number of implications for each function. *Water Operations and Power Programs* and *Maintenance* are the two most sensitive functions, while *Protective Services* and *Information Technology* are the two least sensitive functions.
    - Different functions have varying levels of responsiveness to climate change, as estimated by the number of adaptation strategies for each function. *Public Affairs* is the most responsive function, while *Protective Services* is the least responsive function.
    - The relative balance between sensitivity to climate change and responsiveness to climate change was approximated using an "adaptation capacity score," which is, for each function, the ratio of number of adaptation strategies to number of implications. All functions are affected by climate change, but there is wide variation across functions in adaptation capacity scores. That is, some will see the direct effects of climate change more (more sensitive), and some will be more involved with implementing adaptation strategies (more responsive). *Risk and Liability Management* has the lowest adaptation capacity score (more implications than strategies), while *Human Resources* has the highest adaptation capacity score (more strategies than implications).
    - Most strategies (more than 70 percent) involve one or two functions; only two strategies involve more than five functions.
    - For strategies requiring multiple functions to implement, there are certain combinations of functions that frequently share both implications and strategies. These combinations could result in formation of multi-function teams (two to three functions) to implement strategies.
    - Planning for climate change, and funding of adaptation strategies, should be done at an organizational level, because different functions are affected by climate change differently. Implementing strategies, once identified and funded, would generally be done either at the functional level or a multi-function team level.

6.0 Next Steps

Sixty-one potential implications of climate change are presented in this report, along with 131 adaptation strategies. Additional in-depth analysis of implications and strategies is recommended to identify and prioritize the most important adaptation strategies. The analysis could be used to support an implementation plan that highlights what strategies should be implemented and how to implement them, along with a plan for monitoring conditions to inform additional future action. Additional analysis and the implementation plan are described in more detail below.

The analysis would be used to assess risk to CAP and form the basis of an implementation plan. Risk could be quantified by assessing the likelihood of implications occurring, the severity of the implications, and the ability to mitigate the implications. Costs and benefits of strategies could be assessed, using a triple bottom line or other multi-criteria evaluation approach.

The implementation plan would be based on the refined analysis. The following is an example list of actions that could be included in the plan:

- Identify and implement no regrets strategies and select low regrets strategies.
- Identify options to preserve based on important conditional strategies, develop conditions of implementation, and implement as appropriate.

- Develop a plan to identify procedures and processes for implementing strategies, including identification of functions and teams of functions that will implement strategies and an approach for identifying timing and sequencing of strategy implementation.
- Develop key conditions to monitor, based on the most influential drivers, to support subsequent plan updates. Monitoring is intended to support triggering of strategies, either through identifying conditions that change strategies from conditional to low regrets or no regrets, or otherwise supporting sequencing of strategy implementation.
- Develop a plan for revisiting and updating the analysis ("continuous planning"). Generally, the plan should be revisited frequently enough that if changing conditions result in the need to implement a conditional strategy (that is, it becomes no regrets or low regrets), there is sufficient time to implement that strategy.

7.0 References

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Appendix A: Climate Change Background

This appendix summarizes climate change science, climate change projections, climate change references, and supporting detail on projected climate change in the CAP service area.

A.1 Science of Climate Change

Climate change has been defined as a long-term change to the attributes that constitute the state of the climate; e.g. surface and air temperatures, atmospheric composition, and radiation absorption. What makes climate change significant is that the change to climatic conditions persists over long periods of time (at scales larger than several decades). Short-term climate variability that occurs because of periodic fluctuations such as teleconnection patterns; e.g. El Nino, La Nina, and Pacific Decadal Oscillation (PDO), are therefore not considered contributors of climate change due to their shorter durations (several years).

Some of the literature uses the term climate change synonymously with global warming; however, there is a distinction between the two terms. Climate change refers to a shift in climatic conditions that is attributable to any type of source (anthropogenic or natural) and can occur in any direction (warming or cooling). Global warming tends to refer strictly to heating patterns that are attributable to man-made causes and is linked to the content level of carbon dioxide and other greenhouse gases in the earth's atmosphere.

It is important to recognize that climate can change towards a cooling trend or a warming trend, and each shift can take place and alter the existing climate in different ways. Climate is primarily determined by the amount of radiation absorbed or reflected by the earth's surface and atmosphere. This in turn is determined by the presence of certain types of particles in the earth's atmosphere that enhance solar absorption or reflection (e.g. carbon dioxide or volcanic ash), the albedo on the earth's surface (albedo determines the fraction of radiation absorbed or reflected at the surface), and physical characteristics of the earth that hinder or promote radiation retention (e.g. orbital patterns and geographic locations of oceans and landmasses). Therefore, it becomes clear that the different feedbacks and relationships between climatic parameters can be complex and difficult to predict. However, the study of climate change has advanced to a stage that modeling the state of the climate, along with examining historical records of climate, has become a customary exercise for climate scientists.

A.1.1 Sources of Climate Change

<u>Solar Radiation and the Energy Balance</u>

The energy balance, the equilibrium of incoming and outgoing radiation in earth's atmosphere, is driven by the magnitude of solar output from the sun. The level of radiation absorbed by the earth dictates the type of climate it will experience (warmer vs. cooler). Variation in solar energy produced by the sun may change over time. The frequency and number of sunspots, as well as magnetic storms that occur on the sun, have shown to increase the emission of energy from the sun. The occurrence of sunspots tends to follow a quasi-periodic cycle; where the maximum number and size of the sunspots coincide with the length of the cycle. The two most commonly found cycles in solar observations are 11-year and 22-year cycles. Even though these short-term periods may not fall under a significant portion of time to represent climate change, historical records have shown that a 70-year period in the past (between 1645 to 1715) called the Maunder minimum exhibited a significant lack of sunspots that resulted in a net decrease of half a degree Celsius when compared to the long-term average. In addition, approximately four billion years ago, the sun produced 30 percent less solar power than it does today, validating the possibility of solar variation as a source of climate change.

Earth's Orbital Patterns

Changes in climate have also been attributed to variations in the earth's orbit, which affect the distribution of incoming sunlight along seasonal and geographic lines. According to the Milankovitch theory (named after astronomer Milutin Milankovitch), the combined effect of variations to three different orbital cycles can lead to changes in the amount of solar radiation received by the earth's surface. These three Milankovitch cycles are directly associated with the shape of the earth's orbit around the sun (eccentricity), the axial tilt of the earth's axis (obliquity), and the earth's 'wobble' as it rotates along its axis (precession).

The earth's eccentricity is altered over time as the earth continues to orbit around the sun. This orbit tends to alternate from a circular shape to an elliptical shape and back every 100,000 years. Adjustments to the earth's eccentricity due to this cycle translate to differences in incoming solar energy due to the earth's proximity to the sun during its orbit. At periods of low eccentricity (more circular orbit), the earth's closest approach to the sun during orbit (called the perihelion) receives approximately seven percent more radiation than the earth's furthest approach to the sun during orbit (called the aphelion). Conversely, at periods of high eccentricity (more elliptical orbit), the earth's atmosphere during a perihelion stage receives approximately 20 percent more radiation than at an aphelion stage. Furthermore, extreme eccentricity causes a subsequent change in the length of the seasons since more of the duration of the earth's orbit occurs near the aphelion than the perihelion.

The earth's obliquity, or angle of axial tilt, also undergoes a cycle every 41,000 years. In that period, the angle of tilt shifts from 22 degrees to 24.5 degrees and back. When the axial tilt is larger, there is increased solar irradiation during the summer and less during the winter. The net result of this effect is larger seasonal variability due to warmer summers and colder winters. However, when the axial tilt is decreased, there is less seasonal variation as summer receives less irradiation while winters receive more, causing summers to be cool and winters to be mild.

The earth's precession refers to the gyroscopic motion, or 'wobble', the earth makes as it rotates around its axis (similar to a spinning top toy). This axial precession induces different seasonal variability between the northern and southern hemispheres. During this cycle (which lasts between 23,000 and 25,000 years), the hemisphere that is closer to the sun due to the precession will receive increased solar radiation and as such will have greater variability in its seasons (e.g. hotter summer and colder winter). In contrast the other hemisphere will have more temperate seasons (e.g. warmer winters and cooler summers).

Ocean Circulation and Heat Redistribution

Oceans play a large role in regulating the earth's climate; they store heat during the summer and release heat during the winter, contributing to milder winters and more temperate summers. Since more of the earth is covered by oceans rather than land (about 70 percent), a significant portion of the solar radiation reaching earth is absorbed by its oceans. Furthermore, the oceans also circulate and transport this absorbed heat around the earth before it is released into the atmosphere. Ocean heat transport is possible through two types of circulation patterns: wind-driven surface currents and the density-driven thermohaline circulation.

Wind-driven currents that transport absorbed solar heat at the water surface only move a limited volume of water (about 10 percent of the earth's oceanic water), and consequently a smaller portion of the absorbed heat. Thermohaline circulation is propelled by deep water currents and affects the majority of the earth's ocean water (about 90 percent of the ocean). Deep waters develop where the air temperature is cold and the salt content of the water is high. The combination of these two effects is denser water, since dense water tends to be colder and possesses a higher salinity. As water moves towards the poles, and becomes more saline and cold, the water's density increases and it sinks into deep ocean basins. Dense water that is pushed away from the poles eventually moves into latitudes that allow for the gradual warming of the water and its subsequent rise to the ocean surface, where the circulation cycle repeats.

This process of conversion of warm shallow currents (wind-driven) and cold and salty deep currents (density-driven) and vice-versa is akin to an ocean circulation conveyer belt, which is the nickname given to the thermohaline circulation it represents. Changes to the thermohaline circulation can contribute to large-scale changes to the climate due to the large volumes of ocean water and stored heat it entails.

Chemical Composition of the Atmosphere

The chemical composition of the atmosphere and the presence of different types of particles and/or gases in the atmosphere can impact climate in different ways depending on the effect these atmospheric particles have with respect to incoming solar radiation; some may inhibit the absorption of solar radiation and instigate a cooling effect, while others may promote solar absorption and induce a warming effect. Additionally, the warming and cooling effects that these particles may cause can differ between the atmosphere and the earth's surface.

Sulfate Aerosols

Examples of particles that reflect and scatter incoming sunlight include soil dust and sulfate aerosols. Sulfate aerosols are produced from the combustion of fossil fuels that contain sulfur. When released into the atmosphere these sulfate aerosols only last a few days and as such do not spread far from their point of origin. Therefore, most sulfate aerosol concentrations in the atmosphere can be found near high sulfate pollution production zones (primarily in the northern hemisphere). Additionally, sulfate aerosols assist in cloud formation because sulfate particles act as cloud condensation nuclei (the atmospheric material upon which clouds form). In addition to reducing the amount of sunlight reaching the earth's surface, clouds may also produce droplets that help to scatter incoming radiation. The net effect of this scattering and reflecting of sunlight by sulfate aerosols is the cooling of surface temperatures.

Volcanic Eruptions

Other particles in the atmosphere have the opposite effect of absorbing incoming sunlight; prime examples of this are smoky soot and volcanic dust or ash. Volcanic eruptions release ash and dust into the atmosphere which can have a profound impact on climate, particularly if the eruption is heavily laden with sulfur gases. The combination of volcanic eruption material and water vapor in the atmosphere produces a dense layer of haze which can last for several years. This haze is then able to absorb incoming solar radiation as well as reflect some of it back. This causes the surrounding air to be warmed, but surface temperatures become cooler since a diminished amount of sunlight reaches the earth's surface.

Greenhouse Gases and Global Warming

The presence of greenhouse gases in the atmosphere also helps to absorb incoming radiation but produces a different result than that of volcanic ash. Greenhouse gases include (in order of their contribution to the greenhouse effect of warming) water vapor, carbon dioxide, methane, and ozone. Greenhouse gases have the effect of absorbing incoming solar radiation and emitting some of that absorbed radiation as infrared energy to the earth's surface. Therefore, the increased presence of greenhouse gases warms both atmospheric and surface temperatures. The rise of greenhouse gases in the earth's atmosphere have been linked with global warming due to human-induced anthropogenic activities such as the increased burning of fossil fuels and deforestation (which reduces the number of plants that can convert carbon dioxide on the earth into oxygen).

Depletion of the Ozone Layer

The depletion of the ozone layer has in the past been mistakenly linked with global warming. The loss of ozone is due to increased levels of chlorofluorocarbons (CFCs) in the atmosphere, which are produced from cooling units such as air conditioners, the release of aerosol spray propellants, and other chemical processes.

Plate Tectonics

The slow (at a rate of millions of years) and constant shifting of the earth's tectonic plates have a long-term impact on the earth's topography by helping to shape the configuration of continents and oceans. These changes in the earth's sea to landmass makeup can alter the existing mechanism of heat transport, especially the thermohaline circulation pattern. Additionally, the ocean's capacity to regulate surface temperatures becomes impacted if plate tectonics cause an increase in the earth's landmass and a decrease in ocean water volume. Geologic evidence during the presence of the supercontinent Pangaea 300 million years ago illustrate that the climate behaved much differently than how it does today, with the prevalence of large-scale monsoon circulation patterns and higher temperature variations.

Clouds and Surface Albedo

In addition to these major sources of climate change, the presence of other factors plays a role in how a climate takes shape. The formation of clouds can influence the climate significantly as the presence of low clouds may alter the energy balance of the earth. Clouds act like atmospheric buffers that can reflect a large portion of incoming solar radiation. Thus, the abundance of low clouds supports a cooling effect. Conversely, the lack of clouds can contribute to a warming effect, as more solar radiation is able to reach the surface of the earth.

Albedo, or reflectivity, then plays a role in determining how much incoming solar radiation that reaches the earth's surface is absorbed or reflected. Different types of land cover/surfaces (water, snow, grass, etc.) have different albedo values distinguishing its reflectivity with respect to solar radiation; e.g. snow has a significantly higher albedo than bare soil.

A.1.2 Indicators of Climate Change

The primary indicator of climate change is temperature measurements. However, current instrumental temperature measurements only go as far back as the 19th century. To look at historical records before that period for a longer duration of years (centuries to millenniums), scientists need to look at secondary and indirect indicators of climate change (referred to as climate proxies) that enable them to reconstruct a climate image of conditions in the past.

Another useful indicator of climate change is the change in global sea level. Much like temperature measurements, current records using tide gauge measurements only go back so far (19th century), with satellite data only being recently used. Longer historical records of sea level changes can be determined by dating geological objects in the ocean such as coral reefs and coast sediments using carbon and uranium-thorium dating methods.

Linked to changes in temperature and sea level are changes in precipitation and vegetation. Precipitation can be determined using networks of precipitation gauges that are supplemented by satellite observations. However for historical records that predate current precipitation gauges, scientists need to look at other methods such as tree ring analysis or the sampling of ice cores.

Besides inferences on climate based on types of vegetation that grow and thrive in warmer vs. cooler climates, the rate of change of climate has some consequence on the state of vegetation. Climate change that is more radical, faster, or larger can cause stress to plants and vegetation loss to the extent of desertification. Evidence of this occurring in the past is provided through the Carboniferous Rainforest Collapse that took place 300 million years ago. During this event, rapid climate change caused much of the expansive tropical rainforests that covered Europe and the Americas to decline into pockets of forests that led to the extinction of much plant- and animal-life.

Dendroclimatology, or tree ring analysis, is one of the most reliable and extensive pieces of climate data available that stretches back for thousands of years. By taking core samples from trees that have been in existence for a remarkably long time, tree ring scientist can determine the local climate of different time periods. These scientists are able to do this by looking at the growth pattern of tree rings. Wetter climates are generally indicated by wide tree rings while drier climates can be inferred from narrow tree rings.

The drilling of ice cores in long-preserved ice sheets (such as in Antarctica) can provide even more quantitative evidence of climate change. Through the use of isotope analysis, an ice core sample can provide information on temperature, sea level, precipitation, and atmospheric composition of the time periods that the ice core represents. Depending on the length of the ice core, some samples can trace back to 800,000 years. Of particular interest when it comes to ice core analysis is the ability to establish the changes to the level of carbon dioxide in the atmosphere in time periods before the large increase in recent decades. This information helps to provide a comparison point for evaluating the impact carbon dioxide in the atmosphere may have in global warming.

Several other indicators are also linked to the condition of ice. The decline in the ice of the Arctic sea is a strong indicator of a warming phase of climate change. In comparison to the Antarctic sea ice, which melts and reforms completely with little to no loss, very little of the ice lost from the Arctic sea reforms. Recent observations indicate a declining Arctic sea ice rate of 12 percent per decade (based on comparison to a 20-year average from 1980 to 2000).

Glaciers' sensitivity to temperature makes them reliable indicators of climate change. In warming periods brought about by higher temperatures and lower precipitation, glaciers will shrink in size and retreat. Conversely during cooling periods where temperatures remain low and precipitation is present, glaciers may grow and advance. As such, establishing when a glacier advances or retreats also establishes whether the climate is changing or not, especially when compared to some long-term mean of record to quantify the magnitude of the change. In addition, glaciers produce moraines during their advance and retreat that provide organic material and minerals that can be dated to correlate the time periods when a glacier advanced or retreated, thus attaching a climate setting to an actual period of time.

Additionally, other evidence of climate change can be established using less rigorous and more scientifically subjective methods. This includes examining archeology to determine the adverse effects of climate change on prior populations and peoples, the examination of animal remains (e.g. beetles) and species productivity (e.g. fishes) that are linked to different climatic patterns, and the analysis of pollen (called palynology) and the changes to their type and size that may correspond to a changing climate.

A.2 Climate Change Projections

A.2.1 Methods of Projecting Climate Change Effects on Hydrology

Projecting climate change is an area of active research across the world. Currently, evaluation of climate change effects on hydrology requires several steps, as depicted in Figure A-1. In summary, climate variables (e.g., precipitation and temperature) are simulated on a coarse global scale by general circulation models, also referred to as global climate models (GCMs). Typically, different GCMs are run, with multiple initial conditions under a range of future emission scenarios, by different national and international modeling groups. For each of these simulated potential futures, coarse global climate results are “downscaled” to a finer resolution to facilitate the hydrologic assessment. The hydrologic assessment typically includes three steps: 1) examining simulated precipitation and temperature at the land surface, 2) projecting associated runoff and 3) simulating streamflow in the built and natural environment (reservoirs, diversions, etc.). This section summarizes methods used for all steps, from global climate models to projections of streamflow.

Precipitation and temperature (climate) are projected on a global scale using GCMs, which simulate physical processes in and between the ocean, atmosphere, land, and the cryosphere (ice-covered Earth surface). There are numerous GCMs that were created for different purposes. All GCMs require input of projected greenhouse gas emissions. As future greenhouse gas emissions are unknown, multiple emissions scenarios are typically considered, ranging from status quo (continued increasing emissions) to drastic reduction in emissions. GCM projections have coarse resolution, at about 100 to 200 km.

Due to the existence of numerous GCMs and potential emissions scenarios, the World Climate Research Programme established the Coupled Model Intercomparison Project (CMIP) to standardize climate projections for evaluations. CMIP results in a group of projections that use a consistent set of emissions scenarios across multiple GCMs. CMIP has been used to support the Intergovernmental Panel on Climate Change (IPCC) assessments. The fourth IPCC assessment used CMIP phase 3 (CMIP3) projections, while the fifth assessment used CMIP phase 5 projections (CMIP5).

For more regional or local analysis, GCM data are downscaled to increase their resolution. Downscaling can be performed using multiple methods, and result in spatial resolution on the order of 1/8 degree (about 12 km x 12 km) to 1/16 degree (about 6 km x 6 km). Additionally, global models often have systematic "biases" due to coarse resolution and other model limitations. "Bias-correction" is performed to reduce the differences between observed and simulated data[12].

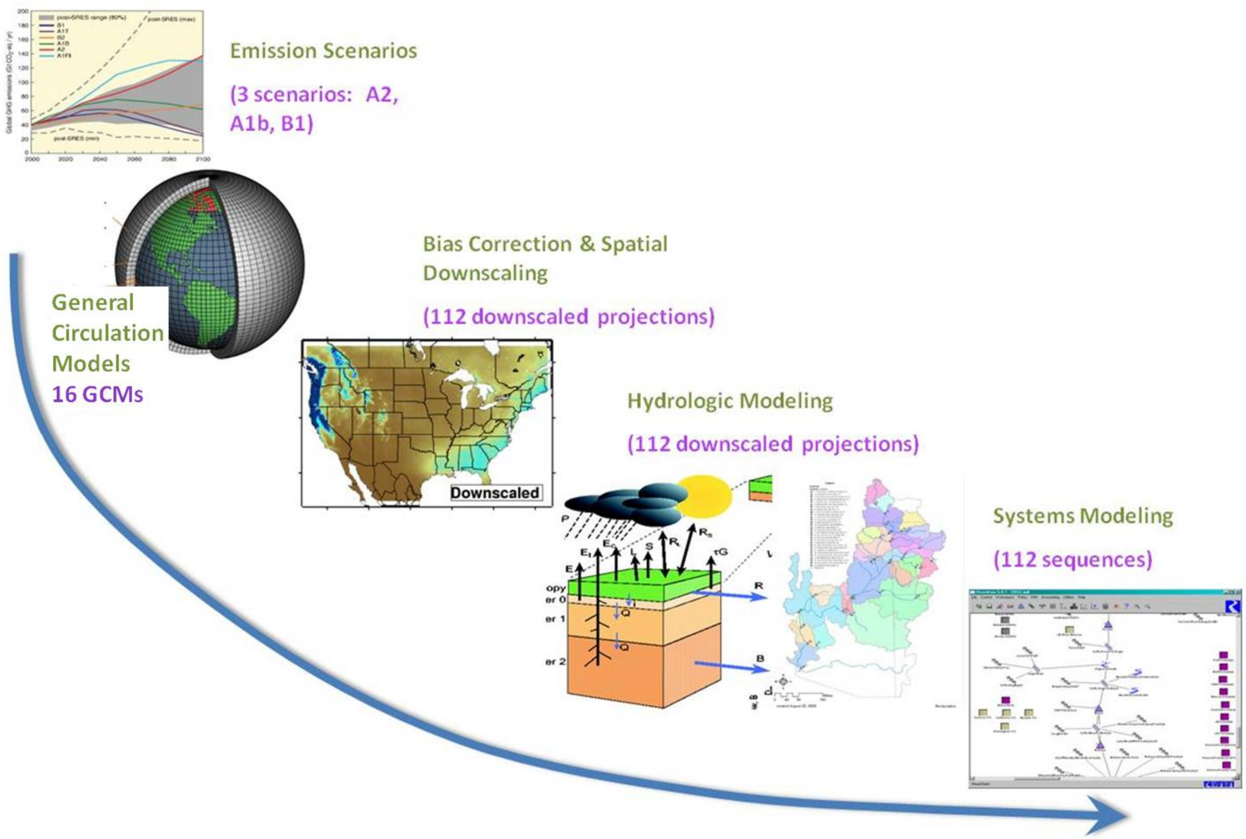

Figure A-1: Methodological approach for assessment of hydrology with climate change
From Reclamation (2012), Figure B-36.

Downscaled climate projections are then used as input to hydrologic models that estimate runoff. Based on temperature, land cover, and soil characteristics, these models simulate what happens to the precipitation and temperature at the land surface, and result in estimates of runoff and baseflow

[12] There are multiple techniques for downscaling and bias correction, and this is an area of active research. Downscaling can be performed statistically, dynamically using physically-based equations, or a combination of the two. Statistical downscaling is more common because it is less computationally intensive. Some statistical techniques that are typically used for downscaling and bias correction are "Bias-Corrected Spatial Downscaling" and "Localized Constructed Analogs." Bias-Corrected Spatial Downscaling results in spatial resolution within the U.S. of 1/8-degree; Localized Constructed Analogs results in spatial resolution of 1/16-degree.

(percolation beyond plants' roots). The most commonly used land surface model is the Variable Infiltration Capacity (VIC) model, developed by the University of Washington.

Runoff and baseflow are then input to a streamflow routing model to generate projections of natural streamflow (without human influences such as reservoirs, diversions, etc.). At this step, bias-correction may be performed again, based on observed historical streamflow. The United States Bureau of Reclamation (Reclamation), as part of the Westwide Climate Risk Assessment (WWCRA), has developed CMIP3 and CMIP5 projections of natural streamflow for the eight major Reclamation Basins, covering the majority of the western United States, using both CMIP3 (Reclamation, 2011) and CMIP5 (Reclamation, 2016)[13].

Once natural streamflow projections are developed, the impacts of potential changes can be evaluated using models that consider operations. Reclamation, as part of the WWCRA, has performed impact assessments for four basins to date: Upper Rio Grande, Sacramento/San Joaquin, Columbia River, and Missouri River.

A.2.2 Colorado River Basin Projections

The most comprehensive evaluation of climate change effects in the Colorado River Basin is Reclamation's Colorado River Basin Study, released in 2012 (Reclamation, 2012). Climate change effects were evaluated based on 112 CMIP3 climate model projections, downscaled and bias corrected using the Bias-Corrected Spatial Downscaling (BCSD) approach. Results suggest that average temperature across the Colorado River Basin is projected to increase by 1.3 ºC, 2.4 ºC, and 3.3 ºC in years 2025, 2055, and 2080 (Figure A-2), with greater changes in the Upper Colorado River Basin than in the Lower Colorado River Basin (Figure A-3). Precipitation, on an annual basis, is generally projected to change by less than five percent, with increasing variability (Figure A-2). Projections are consistent with historical observed data, in which there is a noticeable increase in observed temperature in the Colorado River Basin since about 1980 (Figure A-2).

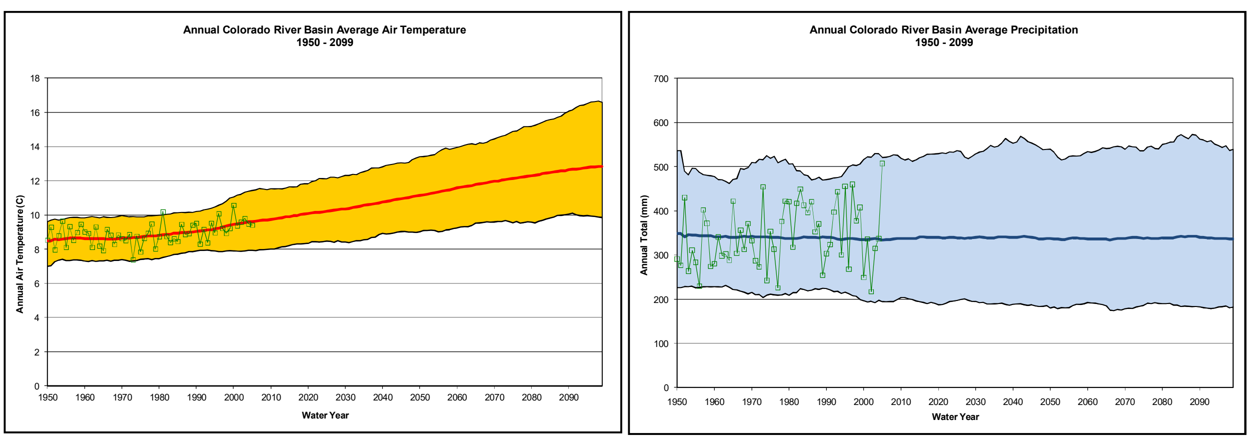

Figure A-2: Historical and projected annual average temperature (left) and total precipitation (right)

From Reclamation (2012), Figure B-37. Historical is line series with markers. Smoothed as 10-year mean. Shading represents a range of projections and the solid line represents the median of projections.

[13] Reclamation, in their hydroclimate projections, used Bias-Corrected Spatial Downscaling for both CMIP3 (Reclamation, 2011) and CMIP5 (Reclamation, 2016). There are 112 climate model projections in the CMIP3 Bias-Corrected Spatial Downscaled dataset, based on 16 GCM and three emissions scenarios (high, medium, and low), with most GCMs run with more than one initial condition. There are 231 projections in the CMIP5 Bias-Corrected Spatial Downscaled dataset, based on 36 GCMs and four emissions scenarios (high, medium by year 2040, medium by year 2080, and low), and multiple initial conditions. Reclamation used 97 out of the 231 Bias-Corrected Spatial Downscaled CMIP5 projections for their hydroclimate projections (using a single set of initial conditions for each GCM-emission scenario combination). These data, along with projections using other downscaling techniques, are available at https://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html.

Hydrology was evaluated in the Colorado River Basin Study (Reclamation, 2012). Results suggest that evapotranspiration will increase, and runoff will decrease (Figure A-4). The result is a decrease in annual average water availability from the Colorado River. Mean annual flows from 2011 to 2060 are projected to be 13.7 million acre-feet (MAF), or about a six percent reduction from the period 1950-1999 (14.6 MAF) or a nine percent reduction from the period 1906 to 2007 (15.0 MAF) (Figure A-5). However, the median projection is 12.7 MAF, or 1.0 MAF less than the mean. In most projections, there is also a shift towards runoff occurring earlier in the spring, primarily due to earlier snow melt (Reclamation, 2012). The Colorado River Basin Study projected a supply and demand imbalance in year 2060 ranging from 0 to 6.8 MAF, with a median of 3.2 MAF (Reclamation, 2012)[14].

Since the Colorado River Basin Study in 2012, which was based on CMIP3 results, Reclamation has developed hydroclimate projections using CMIP5. Comparison of the results suggest that CMIP5 projects similar temperature increases as CMIP3 and greater precipitation than CMIP3. The median CMIP5 BCSD streamflows result show greater projected water availability from the Colorado River (almost no change from historical average) than CMIP3 projected streamflows (see Figure A-6, "annual runoff"). There is a wider range in the CMIP5 projected changes of streamflows. However, Reclamation (2014) notes that "even though CMIP5 is newer, it has not been determined to be a better or more reliable source of climate projections compared to existing CMIP3 projections." Furthermore, the IPCC suggests that the datasets are complementary.

[14] Note that this projection included paleo and paleo reconstructed supply projections.

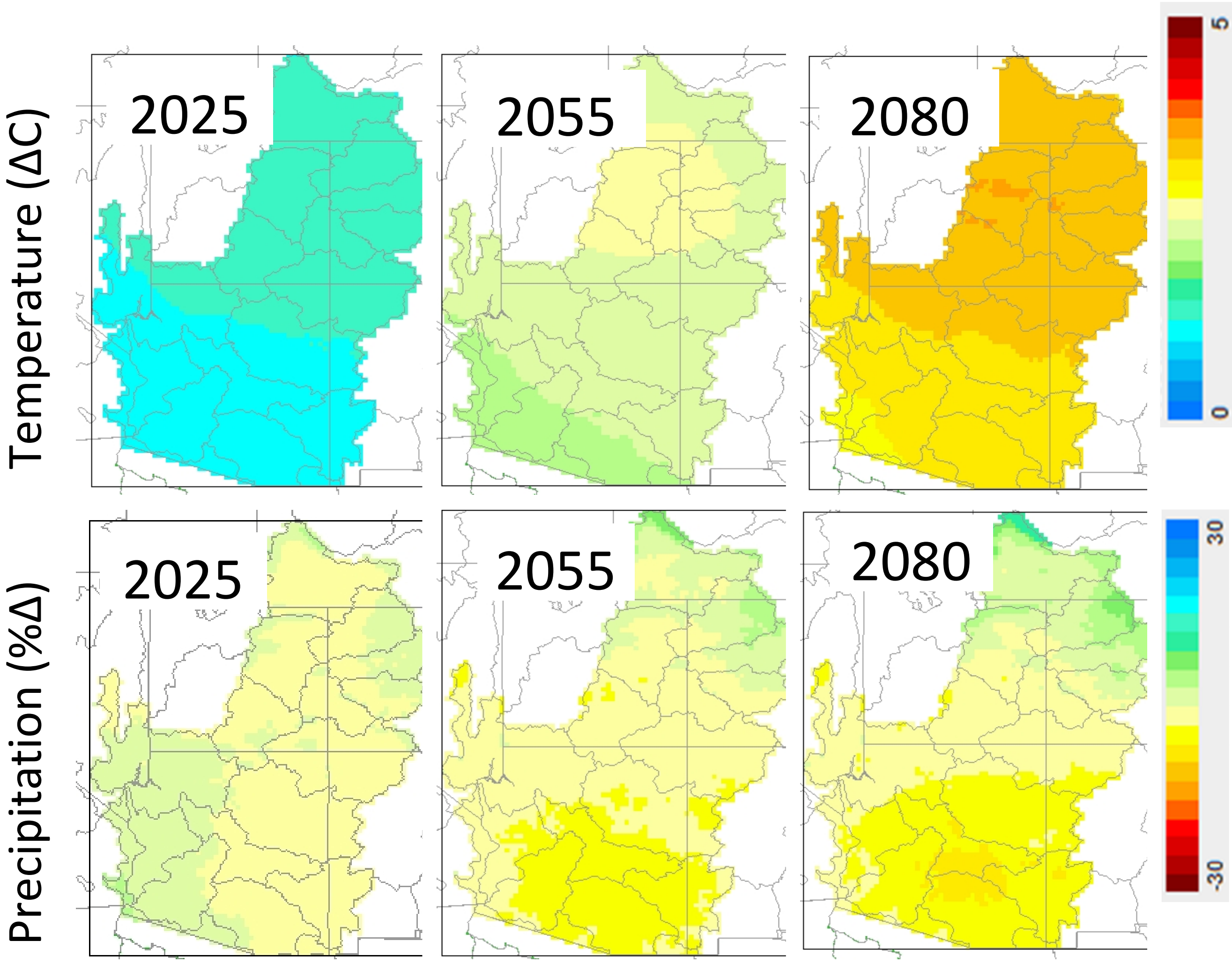

Figure A-3: Mean projected change in annual temperature and precipitation
From Reclamation (2012), Figure B-38. 2025 (2011-2040) versus 1985 (1971-2000), 2055 (2041-2070) versus (1971-2000), and 2080 (2066-2095) versus (1971-2000)

Water availability in the Colorado River Basin remains an area of ongoing active research (e.g., Vano et al. 2014; Carrillo et al. 2017; Ficklin et al. 2016). A recent paper by Udall and Overpeck (2017) argues that temperatures strongly contribute to reduced flows, as evidenced by recent “hot drought” conditions in the Colorado River Basin. Because GCM-projected temperatures consistently show higher projected temperatures whereas precipitation projections vary and are less certain, the resultant conclusion is that available water in the Colorado River may be less than what Reclamation is currently forecasting. McCabe (2017) also suggests that warming, not just precipitation, is a significant factor in reducing flows.

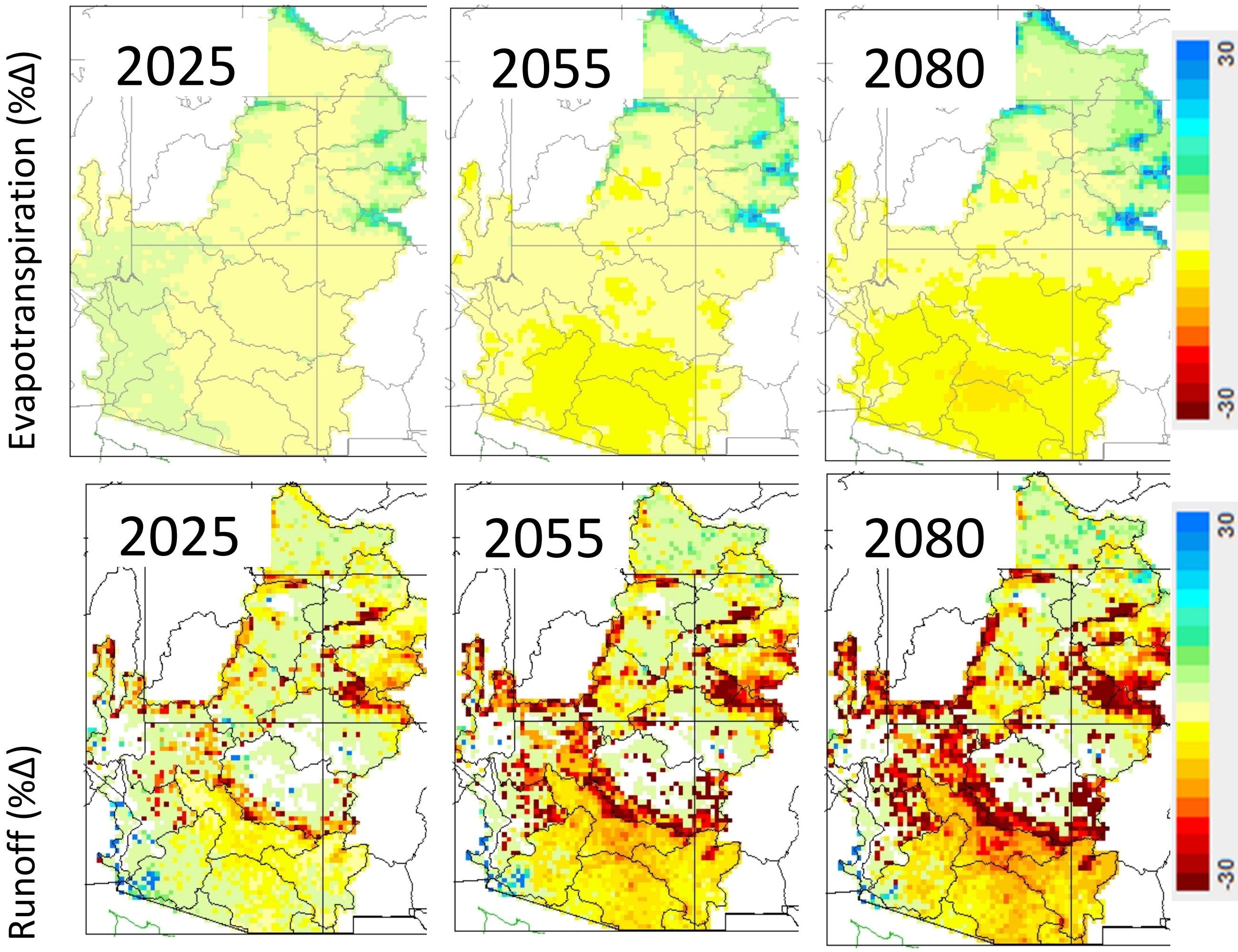

Figure A-4: Mean projected percent change in annual ET and median projected percent change in runoff
From Reclamation (2012), Figure B-40. 2025 (2011-2040) versus 1985 (1971-2000), 2055 (2041-2070) versus (1971-2000), and 2080 (2066-2095) versus (1971-2000)

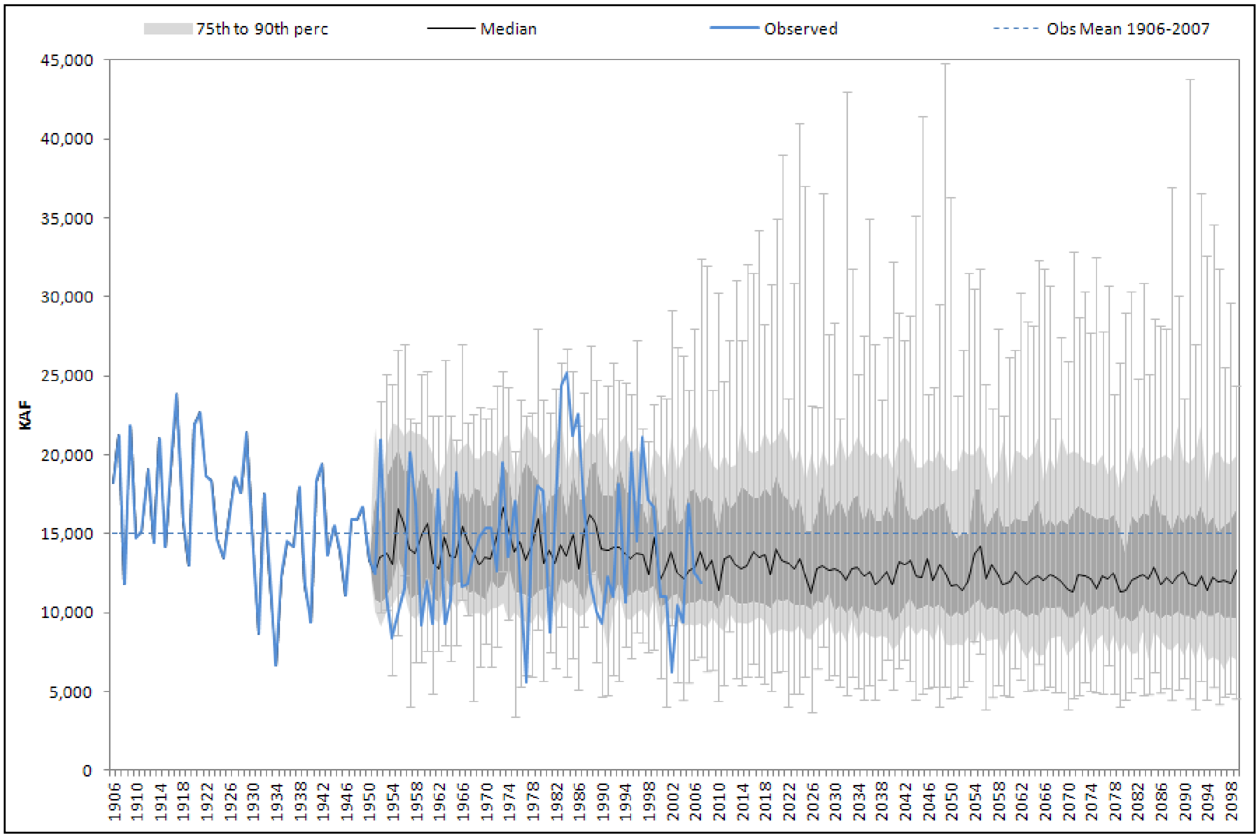

Figure A-5: Colorado River at Lees Ferry, Arizona natural flow statistics for the downscaled GCM projected scenario as compared to observed flow

From Reclamation (2012) Figure B-46. Median (line), 25th – 75th percentile band (dark shading), 10th – 90th percentile band (light shading), max/min (whiskers), and 1906-2007 observed (blue line)

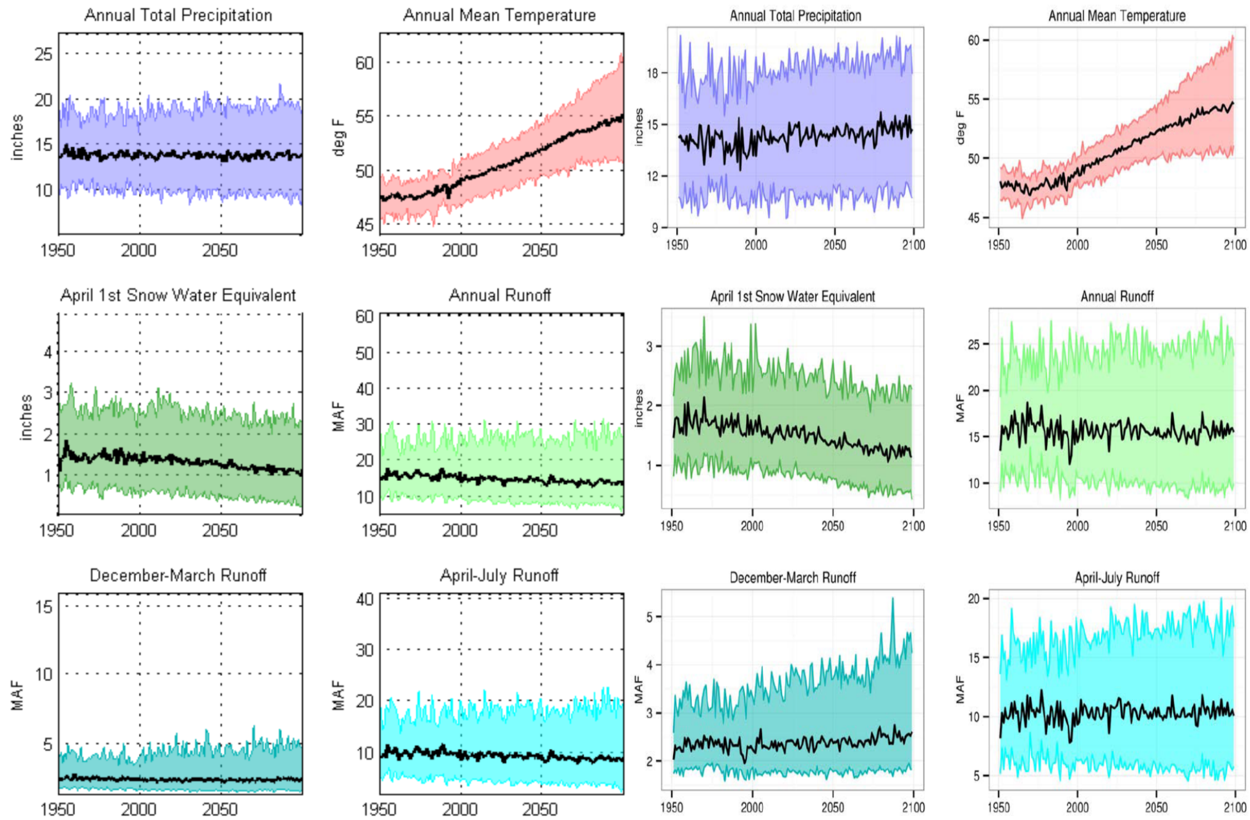

Figure A-6: Colorado River Basin hydroclimate indicators, CMIP3 versus CMIP5

Left two columns: CMIP3 (Reclamation, 2011, Figure 22); Right two columns: CMIP5 (Reclamation, 2016, Figure 1).

A.2.3 CAP Service Area Projections

This section summarizes historical and projected climate in the CAP service area. Effects of climate change in Arizona and the Southwest have been summarized in the National Climate Assessment and by the Climate Assessment of the Southwest (CLIMAS) as well as by Reclamation and others.

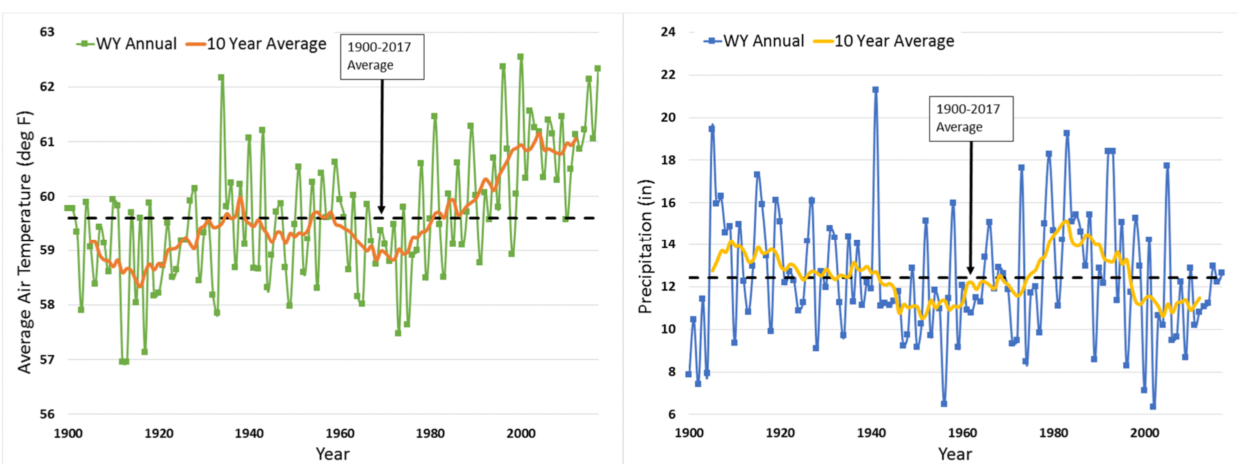

Figure A-7: Historical observed temperature and precipitation, CAP service area

Data from DRI (2018). Average temperature and precipitation across Maricopa and Pinal Counties (Arizona Climate Division 6)

Historical observed climate data suggest rising temperatures in the CAP service area since about 1980 (Figure A-7). Climate projections consistently show continued increasing annual average temperatures

(Figure A-8 presents projections for Phoenix; Figure A-3 shows spatial variability of projections across Arizona), with a median increase of about five degrees F by late century. Additionally, projected maximum temperatures are projected to increase by about five degrees F (Figure A-9).

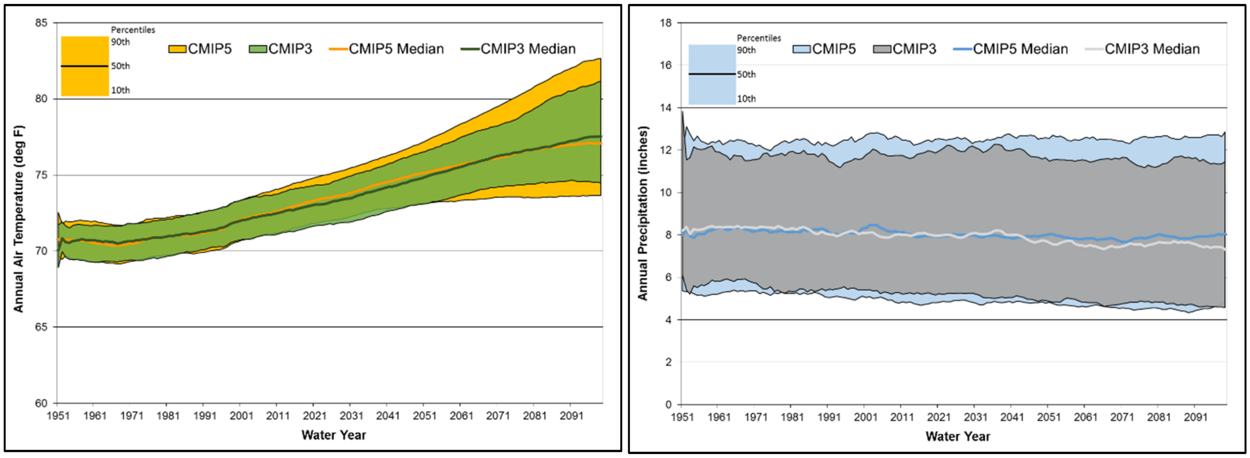

Figure A-8: Projected temperature and precipitation, Phoenix

Shading represents the 10th to 90th percentile range of projections and the solid line represents a median of projections. CMIP3 and CMIP5 data from https://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html.[15]

Historical observed precipitation is variable, with below average precipitation since about 2000 (Figure A-7). Future precipitation trends in Arizona are less certain than temperature trends; projections show a high degree of precipitation variability with no increasing or decreasing trend (Figure A-8). The National Climate Assessment projects increasing intensity of storms across the southwest (Melillo, et al., 2014). Intensity of storms can be approximated by evaluating projected maximum daily precipitation. Figure A-10 shows that median maximum daily precipitation is expected to increase by four, eight, and seven percent in the early, mid, and late future periods. More than half the projections suggest an increase in the 1-day annual maximum precipitation value in the Phoenix area, although there is no apparent projected increasing trend in this flood metric through time in the 21st century.

15 231-projection CMIP5 and 112-projection CMIP3 ensembles were used in the analyses to characterize future changes. CMIP5 GCMs were run using four relative concentration pathways (RCPs) that represent future greenhouse gas concentrations (RCP2.6, 4.5, 6.0, and 8.5). The older climate projections in the CMIP3 ensemble use Special Report on Emissions Scenarios (SRES) scenarios to represent future emissions scenarios (SRESB1, SRESA1B, SRESA2). The last three CMIP5 RCPs listed are roughly analogous to the CMIP3 SRES scenarios, but CMIP3 has no RCP2.6 equivalent. This could potentially affect results by the exclusion of lower temperature projections in the CMIP3 ensemble.

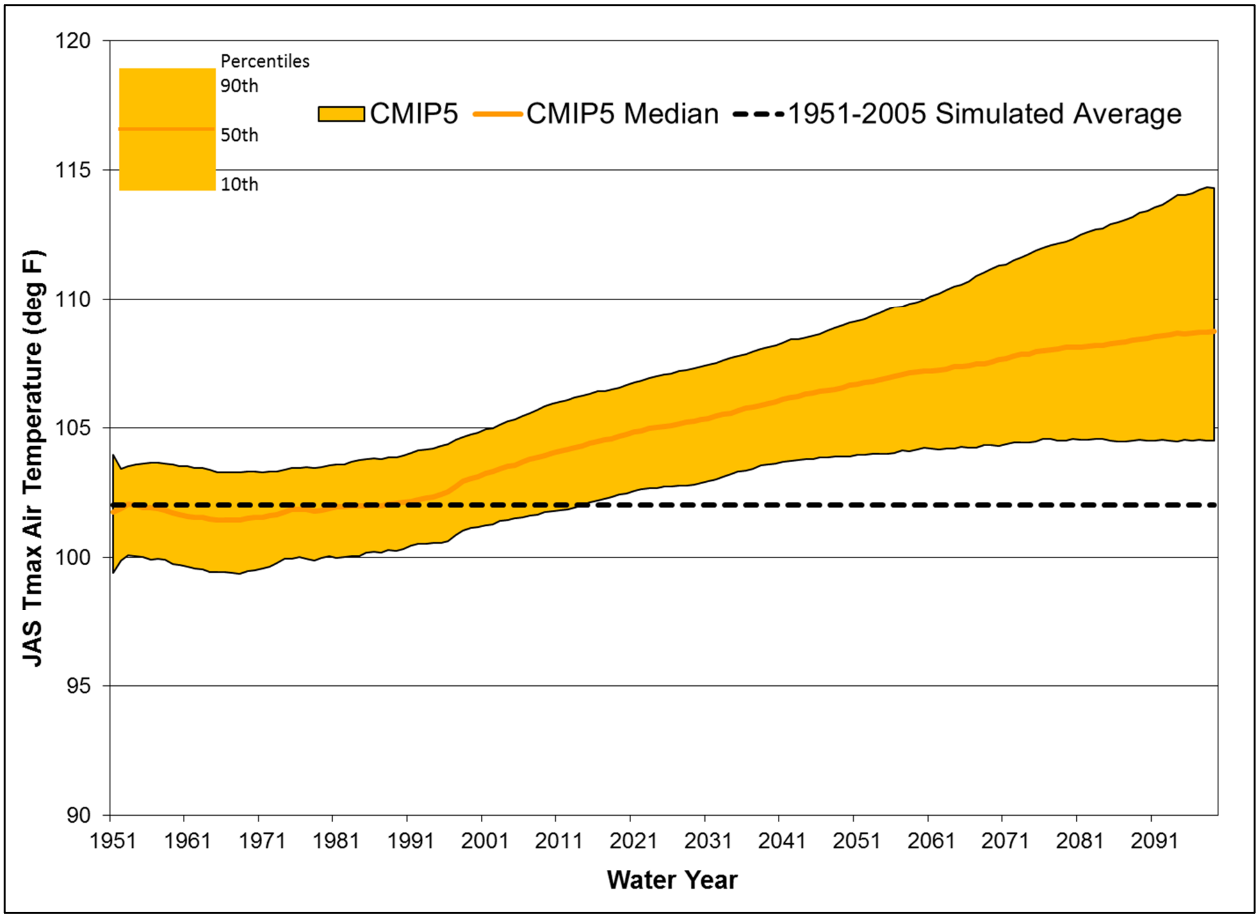

Figure A-9: Projected maximum temperature for the Phoenix area
data from https://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html

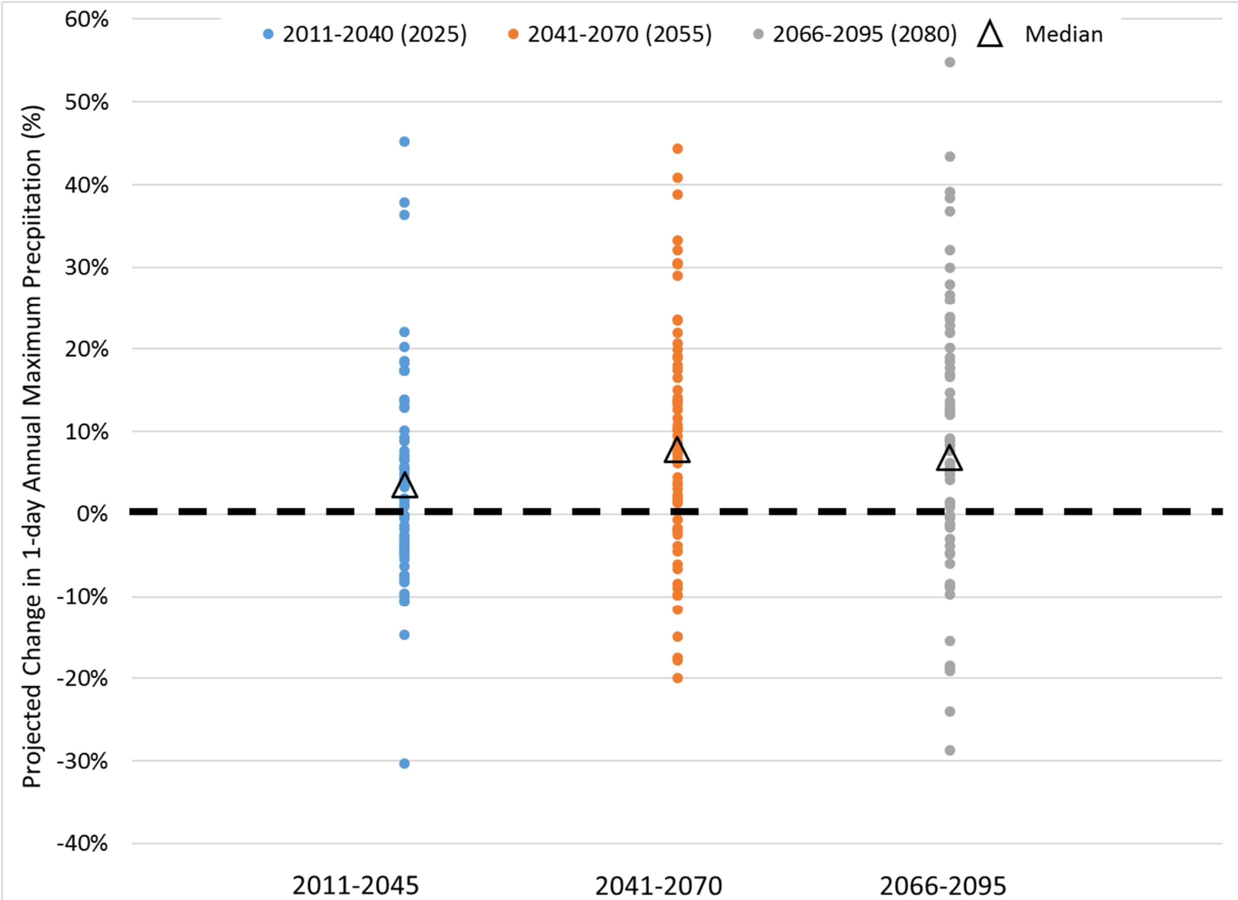

Figure A-10: Projected change in 1-day annual maximum precipitation for the Phoenix area
CMIP5 Localized Constructed Analogs data from

A.3 Climate Change References

This section summarizes references for assessments of climate change and potential impacts on hydrology. It starts with global references, working towards local references.

Globally, the International Panel on Climate Change (IPCC) publishes regular global climate assessments. From IPCC, "The IPCC is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation." The IPCC has produced five assessments to date, and is currently in its Sixth Assessment cycle. Assessments, along with other reports and information about the IPCC, can be found at http://www.ipcc.ch/.

Specific to water resources, Reclamation, as manager of the Colorado River and other major western rivers, has done extensive projections of water supply with climate change as part of the WaterSMART initiative and meeting authorizations of the Secure Water Act. Reclamation's work, referenced in the main body of this document, can be accessed from https://www.usbr.gov/watersmart/wcra/.

Within the United States, the U.S. Global Change Research Program (USGCRP) is mandated to publish an assessment of global change in the United States every four years. From USGCRP, "The USGCRP was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act (GCRA) of 1990 to 'assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change" (USGCRP, 2018). The USGCRP published their third national assessment in 2014 (https://nca2014.globalchange.gov/) and in 2017 completed Volume 1 of the Fourth National Climate Assessment (https://science2017.globalchange.gov/). USGCRP notes that "Assessments integrate findings of the USGCRP with the results of research and observations from across the U.S. and around the world, including reports from the U.S. National Research Council." The reports document "climate change related impacts and responses for various sectors and regions, with the goal of better informing public and private decision-making at all levels" (Melillo, et al., 2014).

The National Climate Assessment has a chapter devoted to climate change in the Southwest, including most of the Colorado River Basin and all of Arizona and CAP's service area. More locally, the Climate Assessment for the Southwest (CLIMAS), housed at the University of Arizona, works "to improve the ability of the region's [Arizona and New Mexico] social and ecological systems to respond to and thrive in a variable and changing climate" (CLIMAS, 2018). CLIMAS is part of the National Oceanic and Atmospheric Administration's (NOAA's) Regional Integrated Sciences and Assessments (RISA) program. Numerous studies and reports on local effects of climate change can be found at the CLIMAS website (http://www.climas.arizona.edu/).

Additionally, numerous researchers publish their own assessments of climate change and potential impacts on water supply, both regionally and locally. Similarly, numerous agencies, including water agencies, either build upon work done by Reclamation or others or develop their own research and publications related to potential effects of climate change on water supply. CAP has been involved in multiple studies and work efforts, as summarized in Section 1.2.

A.4 References

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Appendix B: Linkages Between All Drivers and Key Drivers

Drivers Identified in Workshop	Key Driver(s)
Water temperature	
Biological changes	Temperature, CO River supply
Water quality change with temperature: contaminants, turbidity	Temperature, CO River supply
Economic	
Cost of water / water rates / rates communication	CO River supply, demand, economic health
Economic health	Economic health
CAP budget / financial resource availability and competition	CO River supply, economic health, demand
Human resource availability and competition	Economic health, temperature
Water supply	
Colorado river supplies/hydrology: change in volume and variability; shortages	CO River supply, regulatory/legal/policy, temperature
Competition w/ other agencies	Interagency coordination, regulatory/legal/policy
Supply availability for CAGRD and increased competition	CO River supply, demand
Other existing water source availability, e.g. SRP, effluent	Temperature, demand
New water source availability, e.g. desal, effluent	Demand, technology, economic health
Change in natural groundwater recharge	Temperature
Environment	
Air quality	Temperature, regulatory/legal/policy, technology
Change in (more) endangered species / MSCP (multi-species conservation program) / endangered species habitat	Temperature, CO River supply, regulatory/legal/policy
Invasive species, e.g. tamarisk	Temperature, CO River supply
Public health: pollution affecting public health affecting migration	Temperature, regulatory/legal/policy, technology, population
Public health: waterborne diseases	Temperature, regulatory/legal/policy, technology, population
Social / political / regulatory	
Environmental regulation	Regulatory/legal/policy
Law of the river / allocations	Regulatory/legal/policy
Law of the river / water quality agreements	Regulatory/legal/policy
Mexico minute	Regulatory/legal/policy
Changes to air quality regulations	Regulatory/legal/policy
Internal prioritization and policy	Regulatory/legal/policy
Other agencies' adaptation plans	All key drivers

Drivers Identified in Workshop	Key Driver(s)
Legislative uncertainty: policy, attitudes shifting, social pressure	Regulatory/legal/policy, interagency coordination
Interagency coordination	Interagency coordination
Political/public support for adaptation	Regulatory/legal/policy, interagency coordination
Other legal/regulatory constraints	Regulatory/legal/policy
Federal climate policy	Regulatory/legal/policy
Political response: collaborative or competitive?	Regulatory/legal/policy, interagency coordination
Demographic and Water demand	
Population changes - local, regional, national, global	Population, economic health
Lifestyle	Regulatory/legal/policy, economic health
Types of contractors: ag/muni	Demand, population, CO River supply
Ag water use: location and demand volume/seasonality	Temperature, CO River supply
Where, how, and when water is used / timing/seasonality of demands and deliveries	Temperature, demand
Growth and spatial variability thereof	Population
Cultural shifts in landscaping (lawns/desert vegetation)	Economic health
Urban development vs suburban/sprawl	Population, regulatory/legal/policy
Land use changes	Regulatory/legal/policy, population, economic health
Human behavior / "walking dead"	Temperature, economic health
Perceived impacts, e.g. "AZ is hot and has no water"	Temperature, regulatory/legal/policy
Tribal demands	Temperature, demand, economic health
Change in demand for different types of water	Demand
Water quality	
Biological / algae	Temperature, CO River supply
Physical - due to higher temp and/or change in supply	Temperature, CO River supply
Climate	
Extreme weather / natural disasters / unpredictability and intensity of weather	Local precipitation (more extreme)
More severe flooding	Local precipitation (more extreme)
Temperature	Temperature
Precipitation - volume, timing, intensity (how and when it rains), drought	Local precipitation (more extreme)
Evaporation	Temperature
Seasonality shifts: snowmelt, demand	Temperature
Local climate	Temperature
Basin climate	Temperature
National climate	Temperature
Power	

Drivers Identified in Workshop	Key Driver(s)
Power demand	Temperature, population, technology
Variability of available power and cost	Temperature, technology (e.g., batteries), regulatory/legal/policy, economic health
Power supply	Regulatory/legal/policy, technology (e.g. renewables), economic health
Power costs / power market changes / other energy supplies / resource competition	Regulatory/legal/policy, technology (e.g. renewables), economic health
Increased solar generation	Regulatory/legal/policy, technology (e.g. renewables), economic health
Technology	
Water use efficiency	Regulatory/legal/policy, technology
Supply side / operations	Technology

Appendix C: Summary of Implications and Strategies by Function

This appendix summarizes analysis of implications and strategies by function. CAP's organizational functions that were part of the team (as described in section 2.2) were individually assessed to determine their vulnerabilities and their ability to adapt to risk (by analyzing the implications that affect them and the adaptation strategies they are a part of). The 16 CAP organizational functions that were addressed in this adaptation planning effort were:

- Central Arizona Groundwater Replenishment District (CAGRD)
- Colorado River Programs
- Communications
- Engineering
- Environmental, Health and Safety
- Financial Planning and Analysis
- Human Resources
- Information Technology
- Legal Services
- Maintenance
- Operational Technology
- Protective Services
- Public Affairs
- Resource Planning and Analysis
- Risk and Liability Management
- Water Operations and Power Programs

C.1 Financial Planning and Analysis

Financial Planning and Analysis is fairly sensitive to climate change, with 16 implications (above average for functions), and is very responsive to climate change, with 33 strategies (tied for second most of any function). Implications and strategies associated with *Financial Planning and Analysis* are presented in Table C-1 and Table C-2 and are summarized below.

Table C-1: Implications that affect Financial Planning and Analysis

Challenge Implications	Opportunity Implications	Mixed Implications
#1. Increased cost to customers – supply driven. **#2.** Increased cost to customers – power driven. **#3.** Increased cost to customers – demand driven. **#4.** Reduced ability of customers to pay rates. **#5.** Rate instability. **#6.** Decreased tax base. **#7.** Financial reserves drawn down. **#8.** Pressure to defer capital projects and technological advances. **#10.** Limited or no excess water for CAGRD. **#12.** Difficulty projecting long-range rates. **#31.** New facilities needed: wells, potential treatment. **#32.** Reduced power production. **#34.** Air quality regulations affect how and when power can be used.	**#19.** Increased tax base. **#20.** Increased power supplies/reduced power cost.	**#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

The implications affecting *Financial Planning and Analysis* reflect issues associated with changes in sources of revenue generation (rates, taxation, and power generation/use) and their associated impacts (e.g. deferring projects, triggering recovery, and depleting financial reserves). Rising costs and water rates and the inability of CAP customers to pay them is largely connected to the economic health of the region and the availability of Colorado River water supply. The generation of revenue from CAP's taxation authority is based on population growth. Several other implications are also linked to these fluctuations in revenue generation. Relying more heavily on CAP's financial reserves to compensate for reduced revenue from CAP customers is a likely outcome. In addition, reduced revenue leads to a reduced operating budget, which causes deferment of projects and activities (implication #8). The availability of Colorado River supply also affects the ability to generate revenue from the CAGRD (e.g. implication #10), power production (e.g. implication # 32), and the need for direct recovery of groundwater credits (e.g. implication #31).

Only one implication exclusively affects *Financial Planning and Analysis*, implication #12 (Difficulty projecting long-range rates), which is primarily an activity associated with this function. *Financial Planning* *and Analysis* also shares the highest number of implications (eight) with *Public Affairs* and *Communications*. These shared implications are also associated with changes to rates and taxation and the ability of CAP customers to pay. And while these impacts to sources of CAP revenue directly implicate *Financial Planning and Analysis*, communication of these changes to CAP stakeholders, customers, and the public requires and affects *Public Affairs* and *Communications*.

Table C-2: Strategies that involve Financial Planning and Analysis

Easy Strategies	Medium Strategies	Difficult Strategies
#19. Reprioritize non-critical capital improvement projects to future budget. **#24.** Create technology replacement fund. **#42.** Increased budget. **#44.** Decrease rates and communicate rate decrease. **#77.** Increase open market power purchases. **#84.** Enforce existing contract condition that limits monthly supply to 11 percent of annual supply. **#85.** Decrease rates due to increased operational and/or maintenance efficiency. **#99.** Prioritize work activities.	**#2.** Early rate increases to decrease rate shock. **#5.** Look at refinance options. **#6.** Alternative (non-project) water supply in canal, to help share costs over more customers. **#17.** Rate Tier restructuring. **#18.** Subcontractor finance program: review payment timing. **#21.** Issue bond. **#34.** Explore alternate rate projection model. **#35.** Publish adaptive rate structure, use ranges. **#40.** Buy long-term storage credits. **#70.** Create recharge storage fee that applies to every customer. **#115.** Increase rates for MSCP costs, permits.	**#3.** Decrease level of service. **#8.** Increase tax authority/increase tax percentage. **#14.** Pre-emptively increase financial reserves. **#15.** Explore other sources of revenue for CAGRD. **#20.** Additional service charge. **#25.** Incentives for stakeholders' own projects in service area. **#36.** Infrastructure investment: groundwater facilities.

Easy to Medium Strategies	Medium to Difficult Strategies	Easy to Difficult Strategies
#72. New capital projects.	**#1.** Rate stabilization fund using taxes. **#10.** Energy rate stabilization fund. **#22.** Increase rates to build reserves. **#33.** Increased developer fees for CAGRD, e.g., enrollment and activation. **#54.** Infrastructure improvements to mitigate water quality issues due to weather effects. **#56.** Pursue infrastructure improvements to minimize specific sedimentation impacts to operations.	**N/A**

Most of the strategies that involve *Financial Planning and Analysis* (see Table C-2) address the revenue generating issues that are reflected in the implications from Table C-1. Eight strategies that involve *Financial Planning and Analysis* do not address any of the implications that affect *Financial Planning and Analysis*. Furthermore, one implication, "Air quality regulations affect how and when power can be used" (implication #34), is not addressed by any of the strategies that involve *Financial Planning and Analysis*. Implication #34 is addressed by three other strategies (strategies #39, 80, and 81) that include several other functions.

Eleven strategies exclusively involve *Financial Planning and Analysis*, making them primarily the responsibility of *Financial Planning and Analysis* to implement. Out of the 11 strategies that exclusively involve *Financial Planning and Analysis* and the eight strategies that involve *Financial Planning and Analysis* but do not address *Financial Planning and Analysis* implications, there are only two strategies that exclusively involve *Financial Planning and Analysis* that address only non-*Financial Planning and Analysis* implications. These two strategies that exclusively rely on *Financial Planning and Analysis* (strategies #70 and #85) target implications for the benefit of *Maintenance*, *Water Operations and Power Programs*, *Engineering*, and *Operational Technology*. Of the strategies that involve *Financial Planning and Analysis* and other CAP functions, the highest number of strategies (eight) is shared with *Engineering.*

C.2 Maintenance

Maintenance is very sensitive to climate change, with 25 implications (second most of all functions), and is fairly responsive to climate change, with 18 strategies (about average for functions). Implications and strategies associated with *Maintenance* are presented in Table C-3 and Table C-4 and are summarized below.

Table C-3: Implications that affect Maintenance

Challenge Implications	Opportunity Implications	Mixed Implications
#8. Pressure to defer capital projects and technological advances.	**#38.** Increased operational efficiency.	**#36.** Change in seasonal demand curve.
#21. Biological: increased algae, aquatic vegetation, terrestrial weeds, invasive species.	**#39.** Increased maintenance efficiency.	**#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.
#22. Degraded water quality – weather driven.	**#40.** Increased operational and maintenance flexibility.	
#23. Degraded water quality – supply driven.		
#24. Increased sedimentation issues.		
#25. Increased O&M on equipment (pumps, etc.) and facilities.		
#26. Land subsidence near canal.		
#27. Potential damage to CAP infrastructure and facilities, from weather.		
#29. Decreased operational head.		
#30. Increased O&M for recharge.		
#31. New facilities needed: wells, potential treatment.		
#33. Interruptions in power service (transmission).		
#41. Increased health and safety issues – temperature driven.		
#42. Increased health and safety issues – accidents.		
#47. More attempts at illegal diversions on canal.		
#48. Increased encroachment on CAP lands.		
#49. Increased theft of copper/vandalism		
#51. Challenges meeting environmental requirements.		

#52. Increased permitting time/cost. **#53.** Continuous adjusting to regulatory environment.		

Challenge implications that affect *Maintenance* constitute physical challenges to performing maintenance on the CAP canal, impacts to CAP infrastructure, and/or risks to maintenance staff working on the canal. Predominant drivers to these challenges include warmer/hotter temperatures and increased extreme precipitation events. Physical challenges to canal maintenance include increased biological control, water sedimentation issues, and degraded water quality. Impacts to infrastructure include land subsidence near the canal and weather damage to infrastructure and facilities, both increasing the frequency of maintenance on CAP equipment. Risks to maintenance staff include health issues from increased exposure due to climate and weather, and safety issues from illegal diversions, vandalism/theft, and encroachment.

Opportunity implications for *Maintenance* revolve around increased efficiency in the areas of maintenance and water operations. All of the implications that affect *Maintenance* also affect other functions; there are no implications exclusive to *Maintenance*. Not surprisingly, due to the mutual function emphasis on the CAP canal, *Maintenance* shares the largest number of implications with *Water Operations and Power Programs* (18).

Table C-4: Strategies that involve Maintenance

Easy Strategies	Medium Strategies	Difficult Strategies
#46. Operational flexibility to facilitate maintenance. **#52.** Add more real-time water quality monitors and sampling on canal. **#83.** Change maintenance schedule to reduce costs. **#91.** Staff subject to exposure; take days off when conditions are dangerous. **#99.** Prioritize work activities. **#116.** Increase collaboration with other agencies to facilitate permitting and environmental compliance. **#117.** Increase planning timelines / timeframe for permitting.	**#55**. Develop plan for water quality issues due to severe weather incidents. **#58.** Changing staffing resource distribution, functions, responsibilities, possibly mothball equipment. **#60.** Increase engineering and maintenance resources to address subsidence issue.	**#3.** Decrease level of service. **#90.** Automate resources/equipment.

Easy to Medium Strategies	Medium to Difficult Strategies	Easy to Difficult Strategies
#47. Increase environmental O&M: invasive species, weed removal, sedimentation, etc. **#59.** Increase facilities/infrastructure maintenance. **#74.** Outsource O&M and IT needs. **#75.** Increase O&M and IT staff.	**#45.** Apply new technology/projects, e.g. UV treatment. **#118.** Increase staff to support permitting.	**N/A**

All strategies that involve *Maintenance* address implications that affect *Maintenance.* However, several (seven) *Maintenance*-related implications are not addressed by strategies that involve *Maintenance*. These seven implications include safety issues and aspects of maintenance and operations that only other CAP functions can primarily address. Examples of safety issues include increased accidents due to extreme weather events (mainly addressed by *Human Resources*, and *Risk and Liability Management*-centric strategies) and issues related to illegal canal diversions and encroachment on CAP lands (which would require strategies that are spearheaded by *Protective Services*). Implications that affect *Maintenance* but require other CAP functions to address include “Interruptions in power service (transmission)” (implication #33) and “Increased operational efficiency” (implication #38).

The implications from Table C-3 that cover the areas of physical challenges to maintenance, impacts to infrastructure, and risks to maintenance staff are addressed by adaptation strategies in Table C-4. Just as the case was for the highest number of shared implications, *Maintenance* also has the highest number of shared adaptation strategies with *Water Operations and Power Programs*. Only one adaptation strategy is exclusively implementable by *Maintenance*, since it is an activity wholly within that function’s purview: “Change maintenance schedule to reduce costs” (strategy #83). This strategy also exclusively addresses a single implication: “Change in seasonal demand curve” (implication #36). Changes in seasonal water demand from CAP customers can allow *Maintenance* to adjust their canal maintenance schedule to optimally achieve their work tasks and cut costs.

C.3 Operational Technology

Operational Technology is moderately sensitive to climate change, with 11 implications (below average for functions), and is not very responsive to climate change, with 10 strategies (fourth fewest of all functions). Implications and strategies associated with *Operational Technology* are presented in Table C-5 and Table C-6 and are summarized below.

Table C-5: Implications that affect Operational Technology

Challenge Implications	Opportunity Implications	Mixed Implications
#8. Pressure to defer capital projects and technological advances. **#25.** Increased O&M on equipment (pumps, etc.) and facilities. **#27.** Potential damage to CAP infrastructure and facilities, from weather. **#29.** Decreased operational head. **#33.** Interruptions in power service (transmission). **#34.** Air quality regulations affect how and when power can be used. **#49.** Increased theft of copper/vandalism.	**#38.** Increased operational efficiency. **#39.** Increased maintenance efficiency. **#40.** Increased operational and maintenance flexibility.	**#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

The implications affecting *Operational Technology* (summarized in Table C-5) impact the CAP canal and infrastructure that *Operational Technology* supports. Changes in operational and maintenance efficiency (e.g. implications #38 and #39), power usage and availability (implications #33 and #34), and the safety and condition of CAP equipment and facilities (e.g. implications #27 and #49) have a direct consequence to *Operational Technology* performing its duties. The implications that affect *Operational Technology* are also mostly shared with *Maintenance* (10 implications affecting *Operational Technology* are shared by *Maintenance*). The importance of maintaining the integrity of the CAP canal, through optimal maintenance and electronic system support, explains the high number of shared implications between *Maintenance* and *Operational Technology*. Because of these shared priorities, *Operational Technology* is not exclusively affected by any implication, and furthermore, none of the strategies that involve *Operational Technology* (see Table C-6) are exclusively implemented by that function.

Table C-6: Strategies that involve Operational Technology

Easy Strategies	Medium Strategies	Difficult Strategies
#24. Create technology replacement fund. **#52.** Add more real-time water quality monitors and sampling on canal. **#99.** Prioritize work activities.	**N/A**	**#3.** Decrease level of service. **#90.** Automate resources/equipment.

Easy to Medium Strategies	Medium to Difficult Strategies	Easy to Difficult Strategies
#74. Outsource O&M and IT needs. **#75.** Increase O&M and IT staff.	**#45.** Apply new technology/projects, e.g. UV treatment. **#56.** Pursue infrastructure improvements to minimize specific sedimentation impacts to operations. **#57.** Upgrade, update, or modify equipment for new issues.	**N/A**

The adaptation strategies that involve *Operational Technology* primarily benefit other functions, with a few exceptions. For example, strategies #52 ("Add more real-time water quality monitors and sampling on canal"), #45 ("Apply new technology/projects, e.g. UV treatment"), and #56 ("Pursue infrastructure improvements to minimize specific sedimentation impacts to operations") all aim to enhance system maintenance and water operations. In fact, only four of the 10 strategies that include *Operational Technology* address implications that are of significance to *Operational Technology*. And these four strategies only address four *Operational Technology* implications, leaving seven implications that are primarily addressed by other functions. Due to most *Operational Technology* strategies emphasizing improvements to canal operations, *Operational Technology* shares the highest number of strategies with *Water Operations and Power Programs* (eight).

C.4 Water Operations and Power Programs

Water Operations and Power Programs is very sensitive to climate change, with 28 implications (the most of all functions), and also very responsive to climate change, with 33 strategies (tied for second most of all functions). Implications and strategies associated with *Water Operations and Power Programs* are presented in Table C-7 and Table C-8 and are summarized below.

Table C-7: Implications that affect Water Operations and Power Programs

Challenge Implications	Opportunity Implications	Mixed Implications
#9. Reduction in deliveries to low priority users. **#15.** Limited diversions from Colorado River because Lake Mead is low. **#21.** Biological: increased algae, aquatic vegetation, terrestrial weeds, invasive species. **#22.** Degraded water quality – weather driven. **#23.** Degraded water quality – supply driven. **#24.** Increased sedimentation issues.	**#20.** Increased power supplies/reduced power cost. **#37.** Increased turn-back water/short-term demand reduction. **#38.** Increased operational efficiency. **#39.** Increased maintenance efficiency. **#40.** Increased operational and maintenance flexibility.	**#16.** Physical challenges to storing excess water due to long-term groundwater level rise. **#36.** Change in seasonal demand curve. **#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

#25. Increased O&M on equipment (pumps, etc.) and facilities. **#26.** Land subsidence near canal. **#27.** Potential damage to CAP infrastructure and facilities, from weather. **#28.** Low elevations at Lake Pleasant/Waddell Dam. **#29.** Decreased operational head. **#30.** Increased O&M for recharge. **#32.** Reduced power production. **#33.** Interruptions in power service (transmission). **#34.** Air quality regulations affect how and when power can be used. **#46.** More scrutiny placed on planning. **#47.** More attempts at illegal diversions on canal. **#50.** Increased lawsuits – contract challenges. **#52.** Increased permitting time/cost. **#53.** Continuous adjusting to regulatory environment.		

Implications to *Water Operations and Power Programs* generally fall under five different areas:

1. Diversions from the Colorado River
2. Conveyance of water in the canal
3. Power resources supporting the CAP system
4. Operations and management of the CAP system
5. Integrity and reliability of the canal

Implications that affect CAP's diversions from the Colorado River include limited diversions due to Lake Mead being low, and consequently Arizona suffering a Lower Colorado River Basin shortage; this implication assumes that CAP will take all or most of that shortage reduction (implication #15). Another implication that is connected to diversions from the Colorado River is having to continually adjust to a shifting or flexible regulatory environment (implication #53). This implication can alter when and how CAP diverts its Colorado River allocation. The conveyance of water in the CAP canal can be influenced by implications that are also of relevance to *Maintenance*. These implications include increases in algae, vegetation, invasive species, and sedimentation in the canal (implications #21 and 24), which could alter the capacity of the canal and the movement of water in it.

The availability of power resources necessary to operate and transport water through the canal is also considered in the implications for *Water Operations and Power Programs*. Power-related implications consider increases and reductions/interruptions to power (implications #20, #32, and #33), and changes to power usage schedules (implication #34). Implications that alter how the CAP system is managed through operations span many issues such as reduced demands and deliveries (implications #9 and #37), challenges to storing excess water (implication #16), reduced storage in Lake Pleasant (implication #28), changes in seasonal demand (implication #36), and increased operational and maintenance efficiency/flexibility (implications #39, #39, and #40). Finally, risks that threaten the integrity and reliability of the CAP canal include land subsidence near the canal (implication #26), damage to CAP infrastructure due to extreme weather (implication #27), and illegal diversions from the canal (implication #47).

Table C-8: Strategies that involve Water Operations and Power Programs

Easy Strategies	Medium Strategies	Difficult Strategies
#11. Bank water. **#12.** Reduce operations/lower power costs. **#37.** More intentionally created surplus (ICS) in Lake Mead. **#39.** Monitor changes to prepare for changes**.** **#43.** Operational flexibility and shift to low-cost power. **#46.** Operational flexibility to facilitate maintenance. **#52.** Add more real-time water quality monitors and sampling on canal. **#53.** Increase frequency of water quality reporting (website / customers)**.** **#65.** Operational flexibility to address low supply in CAP system. **#68.** Increase/utilize Reach 1 for storage. **#77.** Increase open market power purchases. **#80.** Operational flexibility to meet regulations. **#82.** Flexible operations to respond to changes in seasonal demand. **#84.** Enforce existing contract condition that limits monthly supply to 11 percent of annual supply. **#86.** Implement more flexible and efficient operational practices. **#91.** Staff subject to exposure; take days off when conditions are dangerous. **#99.** Prioritize work activities.	**#6.** Alternative (non-project) water supply in canal, to help share costs over more customers. **#26.** Increase collaboration with others on infrastructure. **#55**. Develop plan for water quality issues due to severe weather incidents.	**#3.** Decrease level of service. **#7.** Lobby for ability to generate power to offset power costs. **#36.** Infrastructure investment: groundwater facilities. **#67.** Redirect recharge to Lake Pleasant. **#76.** Increase power generation, capture, and storage. **#90.** Automate resources/equipment.

Easy to Medium Strategies	Medium to Difficult Strategies	Easy to Difficult Strategies
#74. Outsource O&M and IT needs. **#75.** Increase O&M and IT staff.	**#56.** Pursue infrastructure improvements to minimize specific sedimentation impacts to operations. **#57.** Upgrade, update, or modify equipment for new issues. **#66.** Collaborate with others (public or private) to store more water at Lake Pleasant or meet customer demands. **#73.** Implement recovery plan.	**#78.** Interagency collaboration/partnerships for power transmission infrastructure.

Due to the close interconnection of issues that link water operations and canal maintenance, *Water Operations and Power Programs* shares the highest number of implications (18) and strategies (nine) with *Maintenance*. There are no implications that only affect *Water Operations and Power Programs*. However, seven of the implications in Table C-7 are not addressed by any of the strategies that include *Water Operations and Power Programs* in Table C-8.

With regards to strategies, *Water Operations and Power Programs* are associated with nine strategies that can only be implemented by the *Water Operations and Power Programs* function. There are also nine strategies that require *Water Operations and Power Programs*' participation to implement but these nine strategies do not address any *Water Operations and Power Programs* implications. Out of the nine strategies that are exclusive to *Water Operations and Power Programs* and the nine strategies that do not address *Water Operations and Power Programs* implications, there is only one strategy that can only be implemented by *Water Operations and Power Programs* for the benefit of other functions. This is strategy #12 ("Reduce operations/lower power costs"). Strategy #12 exclusively addresses implication #3 ("Increased cost to customers – demand driven"). Implication #3 has repercussions for *Financial Planning and Analysis* (as it correlates to revenue generation), *Public Affairs,* and *Communications* (who have to communicate the increase in cost to customers and the public).

C.5 Engineering

Engineering is fairly sensitive to climate change, with 15 implications (about average for functions), and also fairly responsive to climate change, with 18 strategies (about average for functions). Implications and strategies associated with *Engineering* are presented in Table C-9 and Table C-10 and are summarized below.

Table C-9: Implications that affect Engineering

Challenge Implications	Opportunity Implications	Mixed Implications
#8. Pressure to defer capital projects and technological advances. **#24.** Increased sedimentation issues. **#25.** Increased O&M on equipment (pumps, etc.) and facilities.	**#38.** Increased operational efficiency. **#39.** Increased maintenance efficiency. **#40.** Increased operational and maintenance flexibility.	**#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

#26. Land subsidence near canal. **#27.** Potential damage to CAP infrastructure and facilities, from weather. **#30.** Increased O&M for recharge. **#31.** New facilities needed: wells, potential treatment. **#33.** Interruptions in power service (transmission). **#48.** Increased encroachment on CAP lands. **#52.** Increased permitting time/cost. **#53.** Continuous adjusting to regulatory environment.		

Challenge implications for *Engineering* from Table C-9 generally impede that function's ability to meet its objectives of designing asset modifications, supporting construction projects, and providing construction management services for all major capital improvements by limiting or delaying access (physically and time-wise) to CAP infrastructure in need of *Engineering* support. Increased maintenance on CAP equipment and facilities (implication #25), land subsidence occurring near the CAP canal (implication #26), and increased encroachment on CAP property (implication #48) are all implications that limit access to CAP assets that may require engineering work. Examples of implications that delay the completion of engineering work include pressure to defer capital projects (implication #8), increased permitting time and costs (implication #52), and dealing with regulations that continue to change (implication #53).

Opportunity implications on the other hand provide the opposite effect, by improving *Engineering*'s access to CAP infrastructure in order to optimally complete engineering projects and activities. Increased operation and maintenance efficiency and flexibility (implications #38, #39, and #40) enhances *Engineering*'s ability to conduct capital improvement and asset modification projects. Since the emphasis of the implications that are relevant to *Engineering* is on CAP assets and infrastructure, *Engineering* shares the highest number of implications with *Maintenance*. And since implications that target issues associated with CAP infrastructure affect numerous functions, *Engineering* has no implications that do not also affect other functions.

Table C-10: Strategies that involve Engineering

Easy Strategies	Medium Strategies	Difficult Strategies
#19. Reprioritize non-critical capital improvement projects to future budget. **#99.** Prioritize work activities. **#116.** Increase collaboration with other agencies to facilitate permitting and environmental compliance. **#117.** Increase planning timelines/timeframe for permitting.	**#6.** Alternative (non-project) water supply in canal, to help share costs over more customers. **#26.** Increase collaboration with others on infrastructure. **#60.** Increase engineering and maintenance resources to address subsidence issue.	**#3.** Decrease level of service. **#36.** Infrastructure investment: groundwater facilities. **#90.** Automate resources/equipment.
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
#59. Increase facilities/infrastructure maintenance. **#72.** New capital projects.	**#54.** Infrastructure improvements to mitigate water quality issues due to weather effects. **#56.** Pursue infrastructure improvements to minimize specific sedimentation impacts to operations. **#57.** Upgrade, update, or modify equipment for new issues. **#63.** Specific infrastructure improvements to limit damage to CAP infrastructure and facilities (e.g., from subsidence and weather). **#73.** Implement recovery plan. **#118.** Increase staff to support permitting.	**N/A**

Strategies associated with *Engineering* from Table C-10 support the improvement of CAP infrastructure through capital projects; e.g. increasing collaboration on infrastructure issues (strategy #26), infrastructure improvements to mitigate effects from extreme weather, sedimentation, and subsidence (strategies #54, #56, and #63), and pursuing new capital projects (strategy #72). Since most of *Engineering*'s strategies are closely linked to CAP infrastructure (of which the CAP canal is a primary asset), *Engineering* has the most shared number of strategies with *Water Operations and Power Programs*.

Most of the strategies that involve *Engineering* address implications that are relevant to *Engineering*, with the exception of three strategies that target non-*Engineering* implications. However, there are six *Engineering* implications (implications #30, # 38, #39, #40, #48, and #53) that are not addressed by *Engineering* strategies – these implications are addressed by strategies involving other functions such as

Financial Planning and Analysis, *Water Operations and Power Programs*, and *Human Resources*. One strategy that only *Engineering* can implement is strategy #63 ("Specific infrastructure improvements to limit damage to CAP infrastructure and facilities (e.g., from subsidence and weather)). This *Engineering*-driven strategy attempts to resolve several implications: land subsidence near the canal (implication #26), potential damage to CAP infrastructure and facilities from weather (implication #27), and interruptions in power service and transmission (implication #33).

C.6 Information Technology

Information Technology is not very sensitive to climate change, with seven implications (tied for fewest of all functions), nor is it very responsive to climate change, with seven strategies (tied for second fewest of all functions). Implications and strategies associated with *Information Technology* are presented in Table C-11 and Table C-12 and are summarized below.

Table C-11: Implications that affect Information Technology

Challenge Implications	Opportunity Implications	Mixed Implications
#8. Pressure to defer capital projects and technological advances. **#25.** Increased O&M on equipment (pumps, etc.) and facilities. **#27.** Potential damage to CAP infrastructure and facilities, from weather. **#33.** Interruptions in power service (transmission). **#35.** Limited IT resources: responding to problems, fewer refreshes, technology lagging behind. **#49.** Increased theft of copper/vandalism.	**N/A**	**#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

Information Technology provides a support role that enables other CAP functions to better perform their duties. The challenge implications that afflict *Information Technology* reflect interruptions or limitations in the ability to provide that support to CAP. Cascading financial effects borne of a weak economy can lead to expected implications such as having to defer technological advances (implication #8) and utilizing limited information technology resources (implication #35). Other implications that are unexpected or sudden can be directly linked to climate change effects and are associated with impacts to CAP assets and facilities that can cause an interruption in *Information Technology* services. Examples include damage to CAP facilities due to extreme weather events (implication #27) and vandalism of CAP equipment and hardware (implication #49). This vulnerability to implications that affect CAP infrastructure and facilities is another reason why *Information Technology* has the highest shared number of implications (six) with *Maintenance* and *Operational Technology*. Similarly, due to being involved in strategies that address technological issues, *Information Technology* shares the highest number of strategies with *Operational Technology* (six). There is only one implication, limited information technology resources (implication # 35) that exclusively affects *Information Technology*.

Table C-12: Strategies that involve Information Technology

Easy Strategies	Medium Strategies	Difficult Strategies
#24. Create technology replacement fund. **#52.** Add more real-time water quality monitors and sampling on canal. **#99.** Prioritize work activities.	**N/A**	**#3.** Decrease level of service.
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
#74. Outsource O&M and IT needs. **#75.** Increase O&M and IT staff. **#108.** Use technology: drones, remote monitoring.	**N/A**	**N/A**

None of the strategies in Table C-12 are unique to *Information Technology*. Most of the strategies that involve *Information Technology* address *Information Technology* implications – with the exception of two strategies (strategies #52 and #108). However, the strategies that do address *Information Technology* implications only address three of the seven implications that *Information Technology* faces (implications #8, #35, and #55), making *Information Technology* dependent on other functions to implement strategies that target *Information Technology* implications.

C.7 Resource Planning and Analysis

Resource Planning and Analysis is moderately sensitive to climate change, with 14 implications (about average for functions), and is also fairly responsive to climate change, with 19 strategies (above average for functions). Implications and strategies associated with *Resource Planning and Analysis* are presented in Table C-13 and Table C-14 and are summarized below.

Table C-13: Implications that affect Resource Planning and Analysis

Challenge Implications	Opportunity Implications	Mixed Implications
#9. Reduction in deliveries to low priority users. **#14.** Higher priority CAP users increase water demand. **#31.** New facilities needed: wells, potential treatment. **#44.** Increased difficulty seeking legislative/regulatory solutions without partners. **#45.** Difficulty collaborating due to lack of staff, including legal staff. **#46.** More scrutiny placed on planning.	**#37.** Increased turn-back water/short-term demand reduction. **#58.** Increased non-traditional public/private partnerships. **#59.** Collaborative planning environment. **#61.** Less urgency for short-term water policy planning, affording flexibility and proactive, not reactive, response.	**#13.** Higher priority Colorado River users using full entitlement. **#16.** Physical challenges to storing excess water due to long-term groundwater level rise. **#36.** Change in seasonal demand curve. **#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

Since a large portion of *Resource Planning and Analysis*' activities are associated with the CAP service area, *Resource Planning and Analysis* implications are either associated with their ability to conduct long-range planning for the service area or associated with water deliveries to CAP customers within the CAP service area (which in turn shapes *Resource Planning and Analysis*' long-range planning activities). Implications such as difficulties in seeking solutions without collaborative partners (implications #44 and #45), enhanced partnerships and collaborative environment (implications #58 and #59), more scrutiny or less urgency placed on planning (implications #46 and #61) and the need to do the work of other agencies (implication #55) affect how *Resource Planning and Analysis* performs its work. Implications such as higher or lower water demand (implications #14 and #36), less or more water available to the service area (implications #9 and #13), and water storage issues (implications #16 and #31) affect *Resource Planning and Analysis*' work directly. No single implication or strategy (from Table C-13 and Table C-14) uniquely affects *Resource Planning and Analysis* or solely relies on *Resource Planning and Analysis* for implementation, respectively.

Table C-14: Strategies that involve Resource Planning and Analysis

Easy Strategies	Medium Strategies	Difficult Strategies
#11. Bank water. **#99.** Prioritize work activities. **#102.** Act without collaboration. **#107.** Increase transparency, documentation. **#121.** Collaborate with others to address water supply/demand imbalance. **#125.** Strategic planning with others. **#131.** More scenario planning.	**#6.** Alternative (non-project) water supply in canal, to help share costs over more customers. **#38.** Interstate and intrastate water exchange/sales. **#71.** Collaborate with agencies to recharge outside of AMA for future wheeling, if aquifer storage in AMA is full.	**#3.** Decrease level of service. **#9.** Find other supplies, e.g. desalination, weather modification, etc. (augmentation). **#27.** Firm more water supplies. **#28.** Authority to move non-CAP tribal water off river. **#29.** Look at new water collection options, e.g. stormwater in extreme events. **#30.** Try to renegotiate water rights. **#31.** Increase conservation programs. **#36.** Infrastructure investment: groundwater facilities.
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
N/A	**#73.** Implement recovery plan.	**N/A**

The strategies that involve *Resource Planning and Analysis* directly address the aforementioned implication themes with respect to the CAP service area and *Resource Planning and Analysis*' duties. These strategies, in Table C-14, comprehensively address all of the implications that affect *Resource Planning and Analysis* – with one exception. Implication #36 ("Change in seasonal demand curve") does have relevance to *Resource Planning and Analysis* as it affects how and when CAP customers utilize their water deliveries, but the majority of the strategies that address this implication are under the purview of *Water Operations and Power Programs*, and *Maintenance*.

With a larger number of strategies available than the number of implications that *Resource Planning and Analysis* faces, there are two strategies co-implemented by *Resource Planning and Analysis* that do not target *Resource Planning and Analysis* implications (strategies #3 and #6). However, these strategies provide a benefit to other CAP functions that need to adapt to the implications these strategies attempt to resolve. Shared water policy concerns and reliance on Colorado River water supplies to meet function objectives, links *Resource Planning and Analysis* with *Colorado River Programs* and *CAGRD*. This connection is also evident in the number of shared implications and strategies. *Resource Planning and Analysis* shares the highest number of implications with *CAGRD* (11) and the highest number of strategies with *Colorado River Programs* and *CAGRD* (12).

C.8 Colorado River Programs

Colorado River Programs is moderately sensitive to climate change, with 12 implications (below average for functions), and is also moderately responsive to climate change, with 13 strategies (below average for functions). Implications and strategies associated with *Colorado River Programs* are presented in Table C-15 and Table C-16 and are summarized below.

Table C-15: Implications that affect Colorado River Programs

Challenge Implications	Opportunity Implications	Mixed Implications
#14. Higher priority CAP users increase water demand. **#15.** Limited diversions from Colorado River because Lake Mead is low. **#44.** Increased difficulty seeking legislative/regulatory solutions without partners. **#45.** Difficulty collaborating due to lack of staff, including legal staff. **#46.** More scrutiny placed on planning. **#51.** Challenges meeting environmental requirements. **#53.** Continuous adjusting to regulatory environment.	**#58.** Increased non-traditional public/private partnerships. **#59.** Collaborative planning environment. **#61.** Less urgency for short-term water policy planning, affording flexibility and proactive, not reactive, response.	**#13.** Higher priority Colorado River users using full entitlement. **#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

Colorado River Programs' implications focus on scenario outcomes related to CAP's Colorado River water supply, and water policy planning issues. Implications that are directly relevant to the Colorado River supply include limited CAP diversions from the river due to a Lower Basin shortage (e.g. implication #15) or increased consumptive use from higher priority Colorado River users in Arizona (e.g. implication #13). Beyond the planning efforts that *Colorado River Programs* provides with respect to CAP's Colorado River supply, this function also helps to shape Colorado River Basin water policy in conjunction and collaboration with other water users from across the basin (as well as the Bureau of Reclamation and the Republic of Mexico). Therefore, implications that obstruct or assist in collaborative policy goals have huge consequences for *Colorado River Programs*. Examples of implications that may play a role in *Colorado River Programs*' efforts to contribute to Colorado River Basin water policy by cooperatively working with other users include difficulty collaborating due to lack of staff (implication #45), meeting environmental and regulatory requirements (implications #51 and #53), and increased non-traditional partnerships (implication #58). Other implications affect *Colorado River Programs*' ability to conduct planning efforts in general (e.g. implications #46 and #61).

Table C-16: Strategies that involve Colorado River Programs

Easy Strategies	Medium Strategies	Difficult Strategies
#37. More intentionally created surplus (ICS) in Lake Mead. **#99.** Prioritize work activities. **#102.** Act without collaboration. **#107.** Increase transparency, documentation. **#121.** Collaborate with others to address water supply/demand imbalance. **#125.** Strategic planning with others. **#131.** More scenario planning.	**#38.** Interstate and intrastate water exchange/sales.	**#3.** Decrease level of service. **#9.** Find other supplies, e.g. desalination, weather modification, etc. (augmentation). **#28.** Authority to move non-CAP tribal water off river. **#30.** Try to renegotiate water rights. **#31.** Increase conservation programs.
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
N/A	**N/A**	**N/A**

The adaptation strategies which involve *Colorado River Programs* collectively address all of *Colorado River Programs*' implications, less two. The only *Colorado River Programs* implications not targeted by a *Colorado River Programs* strategy are implications #51 ("Challenges meeting environmental requirements") and #53 ("Continuous adjusting to regulatory environment"). As discussed, implication #53 can be a significant impediment in how *Colorado River Programs* works towards implementing new Colorado River policies with other Colorado River Basin partners.

Since *Colorado River Programs*' responsibilities are intrinsically conjoined to the Colorado River and the water supply that CAP diverts from the river to meet CAP's mission and vision, *Colorado River Programs* activities can be implicitly and explicitly germane to other functions within CAP. Consequently, all the implications and strategies that are relevant to *Colorado River Programs* are also relevant to at least one other CAP function – with high relevance to one function in particular. The similarities in the adaptation challenges and solutions that *Colorado River Programs* and *Resource Planning and Analysis* share can be seen between Tables C-13 and C-15 (implications), and Tables C-14 and C-16 (strategies), respectively. *Colorado River Programs* shares the highest number of implications (nine) and strategies (12) with *Resource Planning and Analysis*.

C.9 CAGRD

CAGRD is fairly sensitive to climate change, with 15 implications (about average for functions), and is moderately responsive to climate change, with 17 strategies (about average for functions). Implications and strategies associated with *CAGRD* are presented in Table C-17 and Table C-18 and are summarized below.

Table C-17: Implications that affect CAGRD

Challenge Implications	Opportunity Implications	Mixed Implications
#9. Reduction in deliveries to low priority users. **#10.** Limited or no excess water for CAGRD. **#11.** CAGRD potentially out of credits/limited ability to acquire on-river supply. **#14.** Higher priority CAP users increase water demand. **#44.** Increased difficulty seeking legislative/regulatory solutions without partners. **#45.** Difficulty collaborating due to lack of staff, including legal staff. **#46.** More scrutiny placed on planning.	**#17.** Low obligations from CAGRD. **#18.** Good supply for CAGRD. **#37.** Increased turn-back water/short-term demand reduction. **#58.** Increased non-traditional public/private partnerships. **#59.** Collaborative planning environment. **#61.** Less urgency for short-term water policy planning, affording flexibility and proactive, not reactive, response.	**#13.** Higher priority Colorado River users using full entitlement. **#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

A number of the implications affecting the *CAGRD* in Table C-17 are very specific to the *CAGRD* (implications #10, #11, #17, and #18), with three of these four *CAGRD*-specific implications only affecting the *CAGRD* (implication #10 also affects *Financial Planning and Analysis* since there is reduced revenue when CAP cannot provide excess water to CAGRD). Implications #10 and #11 are challenge implications associated with the CAGRD having a severely limited water supply due to no excess water available from CAP and CAGRD being out of credits and/or unable to acquire other Arizona on-river water supplies. Opportunity implications #17 and #18 are virtually the opposite of the *CAGRD*-specific challenge implications. Implications #17 and #18 present outcomes where CAGRD supply is more than sufficient to meet its obligations.

Another implication that provides an interesting contrast to these *CAGRD*-specific implications, is the mixed challenge/opportunity implication #13. The full entitlement use of higher priority Colorado River water users in Arizona poses a challenge in that there would be a reduction to CAP's on-river diversion and thus the reduced availability of excess CAP water for CAGRD. The potential opportunity from this implication is that there is greater opportunity for CAGRD to acquire on-river water supplies from these higher priority on-river water users. The remaining implications to the *CAGRD* deal with the general availability of Colorado River water to CAP customers (e.g. implications #9 and #14), influences on water policy planning and partnerships (e.g. implications #46, #58, and #61), and ability to collaborate (implications #44 and #45).

Table C-18: Strategies that involve CAGRD

Easy Strategies	Medium Strategies	Difficult Strategies
#11. Bank water. **#32.** Look to CAGRD to help supplement other areas. **#41.** Reduce CAGRD water supply acquisition. **#99.** Prioritize work activities. **#102.** Act without collaboration. **#107.** Increase transparency, documentation. **#121.** Collaborate with others to address water supply/demand imbalance. **#125.** Strategic planning with others. **#131.** More scenario planning.	**#40.** Buy long-term storage credits.	**#3.** Decrease level of service. **#15.** Explore other sources of revenue for CAGRD. **#27.** Firm more water supplies. **#28.** Authority to move non-CAP tribal water off river. **#36.** Infrastructure investment: groundwater facilities.
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
N/A	**#33.** Increased developer fees for CAGRD, e.g., enrollment and activation. **#73.** Implement recovery plan.	**N/A**

The combination of *CAGRD* strategies in Table C-18 address all of the *CAGRD* implications in Table C-17. Two of those strategies can only be implemented by the *CAGRD* – strategy #32 ("Look to CAGRD to help supplement other areas") and strategy #41 ("Reduce CAGRD water supply acquisition"). Since the implications and strategies that are pertinent to the *CAGRD* are linked to the CAP service area and the supply available to CAP customers, there is significant overlap between *CAGRD* and *Resource Planning and Analysis*. *CAGRD* has the highest number of shared implications (11) and strategies (12) with *Resource Planning and Analysis*.

C.10 Environmental, Health and Safety

Environmental, Health and Safety is not very sensitive to climate change, with eight implications (third fewest of all functions), and is moderately responsive to climate change, with 12 strategies (below average for functions). Implications and strategies associated with *Environmental, Health and Safety* are presented in Table C-19 and Table C-20 and are summarized below.

Table C-19: Implications that affect Environmental, Health and Safety

Challenge Implications	Opportunity Implications	Mixed Implications
#27. Potential damage to CAP infrastructure and facilities, from weather. **#34.** Air quality regulations affect how and when power can be used. **#41.** Increased health and safety issues – temperature driven. **#42.** Increased health and safety issues – accidents. **#51.** Challenges meeting environmental requirements. **#52.** Increased permitting time/cost. **#53.** Continuous adjusting to regulatory environment.	**N/A**	**#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

Challenge implications for *Environmental, Health and Safety* that fall under the environmental category include air quality regulations affecting power use (implication #34) and dealing with shifting environmental regulations (implications #51 and #53). Health and safety challenge implications have a more direct effect on CAP infrastructure and employees; e.g. increased accidents and damage to facilities due to more extreme weather events (implications #27 and #42), and health concerns due to higher temperatures in Arizona (implication #41). A large number of these implications, especially those that are most connected to health and safety, have consequences to CAP employees that regularly work in the field and are exposed to a higher potential of accidents, weather events, and heat illnesses. *Maintenance* constitutes the largest number of CAP employees that could be affected by these *Environmental, Health and Safety* challenge implications. Unsurprisingly, *Environmental, Health and Safety* also has the highest number of shared implications with *Maintenance* (seven).

Table C-20: Strategies that involve Environmental, Health and Safety

Easy Strategies	Medium Strategies	Difficult Strategies
#39. Monitor changes to prepare for changes. **#64.** Increase training, awareness, safety campaigns regarding weather issues/conditions. **#87.** Shift schedules/alternative work schedule. **#91.** Staff subject to exposure; take days off when conditions are dangerous. **#99.** Prioritize work activities.	**N/A**	**#3.** Decrease level of service.

#116. Increase collaboration with other agencies to facilitate permitting and environmental compliance. **#117.** Increase planning timelines / timeframe for permitting.		
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
#48. Increase environmental compliance staff. **#88.** Increased and mandatory use of safety equipment and personal protective equipment. **#92.** Increase incentive programs for worker safety.	**#118.** Increase staff to support permitting.	**N/A**

With the exception of one strategy (strategy #3), all of the strategies in Table C-20 address *Environmental, Health and Safety* implications in Table C-19. Likewise, all *Environmental, Health and Safety* implications can be addressed by *Environmental, Health and Safety* strategies. Most of the strategies in Table C-20 are highly relevant to *Environmental, Health and Safety* (e.g. strategies #48 and #118) but all of them require the participation of other functions to implement (similarly none of the implications in Table C-19 exclusively affect *Environmental, Health and Safety*). To address the health and safety issues in Table C-19, many of the strategies in Table C-20 are geared towards CAP employees (e.g. strategies #64, #87, #88, #91, and #92). Strategies geared towards CAP employees and how they conduct their work requires the participation of *Human Resources* to help implement. As such, *Environmental, Health and Safety* has the highest number of shared strategies with *Human Resources* (nine).

C.11 Human Resources

Human Resources is not very sensitive to climate change, with eight implications (third fewest of all functions), but is very responsive to climate change, with 28 strategies (fourth most of all functions). Implications and strategies associated with *Human Resources* are presented in Table C-21 and Table C-22 and are summarized below.

Table C-21: Implications that affect Human Resources

Challenge Implications	Opportunity Implications	Mixed Implications
#41. Increased health and safety issues – temperature driven. **#42.** Increased health and safety issues – accidents. **#43.** Employee recruitment challenges. **#45.** Difficulty collaborating due to lack of staff, including legal staff. **#53.** Continuous adjusting to regulatory environment.	**#57.** Increased staff retention. **#60.** Larger talent pool.	**#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

Human Resources implications and strategies can be generally organized under three themes: staff recruitment (implications #43 and #60), employee well-being (implications #41 and #42), and workforce management (implications #45, #53, #55, and #57). These three themes have strong correlations with several other functions; employee well-being can be linked to *Environmental, Health and Safety*, which is strongly linked to *Maintenance* and maintenance staff that are more exposed to health and safety issues by working in the field. *Risk and Liability Management* is also relevant to all three *Human Resources* themes of implications and strategies. In fact, *Human Resources* has the highest number of shared strategies with *Environmental, Health and Safety* (nine), and the highest number of shared implications with *Maintenance*, *Environmental, Health and Safety*, and *Risk and Liability Management* (four).

Three implications uniquely affect *Human Resources*: employee recruitment challenges (implication #43), increased staff retention (implication #57), and a larger talent pool (implication #60). Employee recruitment challenges is a challenge implication that is driven by low population growth. Increased staff retention and a larger talent pool are opportunity implications that are influenced by two different drivers. Increased staff retention is a byproduct of weak economic health and growth; when the economy is weak, fewer new jobs are available – causing more people to remain at their current places of employment. A larger talent pool is directly associated with high population growth; the number of well-qualified local candidates available for CAP to recruit also increases when the population of central Arizona grows.

Table C-22: Strategies that involve Human Resources

Easy Strategies	Medium Strategies	Difficult Strategies
#64. Increase training, awareness, safety campaigns regarding weather issues/conditions. **#87.** Shift schedules/alternative work schedule. **#91.** Staff subject to exposure; take days off when conditions are dangerous. **#96.** Internship to full time employment program.	**#58**. Changing staffing resource distribution, functions, responsibilities, possibly mothball equipment. **#94.** Increase internal training. **#95.** Employee recruitment incentives such as relocation incentives. **#97.** Rotational program for existing staff.	**#3.** Decrease level of service. **#13.** Workforce restructuring/reduction. **#119.** Increase staff.

#98. Advertise employee benefits. **#99.** Prioritize work activities. **#106.** Staff outreach and education (employees promote message), on CAP's behalf. **#123.** Reduced pay increases/reduced increases in benefits.	**#122.** Knowledge transfer and documentation. **#128.** Increase workforce diversity. **#129.** Analyze compensation methods and policies. **#130.** Evaluate hiring practices process.	
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
#23. Outsource general needs. **#48.** Increase environmental compliance staff. **#74.** Outsource O&M and IT needs. **#75.** Increase O&M and IT staff. **#88.** Increased and mandatory use of safety equipment and personal protective equipment. **#92.** Increase incentive programs for worker safety. **#104.** Outsource legal and legislative staff. **#114.** Increase legal and legislative staff.	**#118.** Increase staff to support permitting.	**N/A**

Similar to the *Human Resources* implications in Table C-21, strategies that involve *Human Resources* also fall under the three themes of staff recruitment (e.g. strategy #119), employee well-being (e.g. strategy #88), and workforce management (e.g. strategy #13). All of the strategies associated with *Human Resources* collectively address all of the *Human Resources* implications in Table C-21; however, there are six *Human Resources* strategies that do not target any *Human Resources* implications (strategies #13, #48, #74, #75, #106, and #118). *Human Resources* also has the highest adaptation capacity score amongst all CAP functions (see Figure 8 in Section 4.6.1) due the large number of strategies that involve *Human Resources* (28) as compared to the much smaller number of implications that affect *Human Resources* (eight).

There are 12 strategies that are solely implemented by *Human Resources*, 10 of which address *Human Resources* implications and two that address implications not pertinent to *Human Resources*. Nine of the strategies that are unique to *Human Resources* (strategies #23, #94, #95, #96, #97, #122, #128, #129, and #130) address at least one of the three implications that are also unique to *Human Resources* (implications #43, #57, and #60). The two strategies that are solely implemented by *Human Resources* but do not target

Human Resources implications (strategies #13 and #106) focus on implications resulting from reduced financial revenue generation and legal and public image issues.

C.12 Protective Services

Protective Services is both the least sensitive to climate change, with seven implications, and the least responsive to climate change, with six strategies. Implications and strategies associated with *Protective Services* are presented in Table C-23 and Table C-24 and are summarized below.

Table C-23: Implications that affect Protective Services

Challenge Implications	Opportunity Implications	Mixed Implications
#27. Potential damage to CAP infrastructure and facilities, from weather. **#41.** Increased health and safety issues – temperature driven. **#42.** Increased health and safety issues – accidents. **#47.** More attempts at illegal diversions on canal. **#48.** Increased encroachment on CAP lands. **#49.** Increased theft of copper/vandalism	**N/A**	**#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

Protective Services has the lowest number of implications (seven) and adaptation strategies (six) out of all the CAP functions discussed in this report. While having no opportunity implications, the challenge implications that affect *Protective Services* are safety issues that are relevant to other CAP functions, especially to *Maintenance* (thus none of the implications in Table C-23 are exclusively applicable to *Protective Services*). Implications like more attempts at illegal canal diversions (implication #47), increased encroachment on CAP lands (implication #48), and increased theft and vandalism (implication #49) may require *Protective Services* to play a key role to resolve but these implications also impact how CAP field staff perform their work on and along the canal. In fact, all of the *Protective Services* implications in Table C-23 are shared with *Maintenance*.

Table C-24: Strategies that involve Protective Services

Easy Strategies	Medium Strategies	Difficult Strategies
#99. Prioritize work activities. **#109.** Increase security infrastructure. **#110.** Increase patrolling/surveillance.	**#111.** Cooperation with local authorities and law enforcement agencies.	**#3.** Decrease level of service.
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
#108. Use technology: drones, remote monitoring.	**N/A**	**N/A**

Half of the strategies in Table C-24 can only be implemented by *Protective Services*: increasing CAP's security infrastructure (strategy #109), increasing patrolling and surveillance (strategy #110), and continued cooperation with local authorities and law enforcement (strategy #111). These strategies help to resolve some of the implications that would affect *Protective Services* the most; e.g. implications #47 and #49. *Protective Services* also shares the same number of strategies with all CAP functions (two), excluding *Information Technology*, which shares one more strategy (three in total) than all other CAP functions with *Protective Services*. This is because outside of strategies #3 ("Decrease level of service") and #99 ("Prioritize work activities"), which *Protective Services* shares with all other CAP functions, and the strategies that can only be implemented by *Protective Services* (strategies #109, #110, and #111), *Protective Services* shares one strategy solely with *Information Technology* (strategy #108). Strategy #108 leverages the participation of *Information Technology* to help *Protective Services* deploy drones for remote monitoring and surveillance.

All of the strategies that involve *Protective Services* address implications that affect *Protective Services*, with one exception: strategy #3 (decrease level of service). Of the seven implications that affect *Protective Services*, three implications (implications #27, #41, and #42) are not addressed by *Protective Services* strategies – these implications are addressed by strategies involving other functions such as *Environmental, Health and Safety* and *Human Resources*.

C.13 Risk and Liability Management

Risk and Liability Management is moderately sensitive to climate change, with 14 implications (about average for functions), and not very responsive to climate change, with seven strategies (tied for second fewest of all functions). Implications and strategies associated with *Risk and Liability Management* are presented in Table C-25 and Table C-26 and are summarized below.

Table C-25: Implications that affect Risk and Liability Management

Challenge Implications	Opportunity Implications	Mixed Implications
#5. Rate instability. **#7.** Financial reserves drawn down. **#8.** Pressure to defer capital projects and technological advances. **#26.** Land subsidence near canal. **#27.** Potential damage to CAP infrastructure and facilities, from weather. **#31.** New facilities needed: wells, potential treatment. **#41.** Increased health and safety issues – temperature driven. **#42.** Increased health and safety issues – accidents. **#47.** More attempts at illegal diversions on canal.	**N/A**	**#16.** Physical challenges to storing excess water due to long-term groundwater level rise. **#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

#48. Increased encroachment on CAP lands. **#49.** Increased theft of copper/vandalism **#53.** Continuous adjusting to regulatory environment.		

Risk and Liability Management is a function that provides a service to CAP by identifying, analyzing, and controlling risk at minimal cost. The implications that affect *Risk and Liability Management* in Table C-25 also affect other CAP functions and represent implications that pose risks with corresponding financial costs. Human risks (e.g. more workplace accidents from implication #42), business operating risks (e.g. low financial reserves from implication #7), and risks associated with infrastructure (e.g. land subsidence near the canal from implication #26) all incur financial costs, either through insurance coverage or preventative programs. In terms of its relation to other CAP functions, *Risk and Liability Management* has the highest number of shared implications with *Maintenance* (11) and the highest number of shared strategies with *Water Operations and Power Programs* (four).

Table C-26: Strategies that involve Risk and Liability Management

Easy Strategies	Medium Strategies	Difficult Strategies
#39. Monitor changes to prepare for changes. **#61.** Analysis of criticality/vulnerability. **#99.** Prioritize work activities.	**#6.** Alternative (non-project) water supply in canal, to help share costs over more customers. **#89.** Increase insurance coverage. **#93.** Increase risk management.	**#3.** Decrease level of service.
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
N/A	**N/A**	**N/A**

Three of the adaptation strategies in Table C-26 fall under the complete jurisdiction of *Risk and Liability Management* to implement: strategies #61 ("Analysis of criticality/vulnerability"), #89 ("Increase insurance coverage"), and #93 ("Increase risk management"). Increasing CAP's insurance coverage(s) and increasing risk management analyses and practices helps to manage several very specific implications, such as more occurrences of copper theft and property vandalism, and increased health and safety issues due to higher temperatures and accidents resulting from extreme weather. In addition, due to *Risk and Liability Management*'s focus on analyzing risk and vulnerability regardless of whether business operating conditions are favorable or not, there are no opportunity implications for this function to capitalize on.

All of the strategies that involve *Risk and Liability Management* address implications that affect *Risk and Liability Management*. Similarly, most of the implications that affect *Risk and Liability Management* are addressed by *Risk and Liability Management* strategies. Three implications (implications #31, #47, and #48) are not addressed by *Risk and Liability Management* strategies – these implications are addressed by strategies involving other functions such as *Protective Services* and *Water Operations and Power Programs*.

C.14 Legal

Legal is fairly sensitive to climate change, with 15 implications (about average of functions), and fairly responsive to climate change, with 19 strategies (above average of functions). Implications and strategies associated with *Legal* are presented in Table C-27 and Table C-28 and are summarized below.

Table C-27: Implications that affect Legal

Challenge Implications	Opportunity Implications	Mixed Implications
#9. Reduction in deliveries to low priority users. **#26.** Land subsidence near canal. **#44.** Increased difficulty seeking legislative/regulatory solutions without partners. **#45.** Difficulty collaborating due to lack of staff, including legal staff. **#47.** More attempts at illegal diversions on canal. **#48.** Increased encroachment on CAP lands. **#49.** Increased theft of copper/vandalism. **#50.** Increased lawsuits – contract challenges. **#51.** Challenges meeting environmental requirements. **#52.** Increased permitting time/cost. **#53.** Continuous adjusting to regulatory environment.	**#58.** Increased non-traditional public/private partnerships. **#59.** Collaborative planning environment.	**#16.** Physical challenges to storing excess water due to long-term groundwater level rise. **#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

CAP's *Legal* function assists other CAP functions by providing legal support for their respective needs or by providing direct legal action on their behalf or on behalf CAP as a whole. In some cases, *Legal* provides legal support in anticipation of direct legal action. The implications that affect *Legal* in Table C-27 reflect this range of possible interaction for CAP's *Legal* function. For example, difficulty seeking regulatory solutions (implication #44) and increased lawsuits (implication #50) are implications that will require direct action from *Legal*. Having to continuously adjust to a flexible regulatory environment (implication #53) is a prime example of an implication that *Legal* can provide support on for other CAP functions.

Table C-28: Strategies that involve Legal

Easy Strategies	Medium Strategies	Difficult Strategies
#99. Prioritize work activities. **#102.** Act without collaboration. **#127.** Support collaborative policy changes.	**#17.** Rate Tier restructuring. **#18.** Subcontractor finance program: review payment timing. **#38.** Interstate and intrastate water exchange/sales.	**#3.** Decrease level of service. **#7.** Lobby for ability to generate power to offset power costs. **#8.** Increase tax authority/increase tax percentage. **#9.** Find other supplies, e.g. desalination, weather modification, etc. (augmentation). **#20.** Additional service charge. **#28.** Authority to move non-CAP tribal water off river. **#29.** Look at new water collection options, e.g. stormwater in extreme events. **#30.** Try to renegotiate water rights. **#31.** Increase conservation programs. **#62.** Pursue legislation to further minimize subsidence. **#81.** Pursue regulatory changes.
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
#104. Outsource legal and legislative staff. **#114.** Increase legal and legislative staff.	**N/A**	**N/A**

Due to *Legal*'s capacity as a function that supports other CAP functions, none of the implications and strategies in Tables C-27 and C-28, respectively, are exclusively applicable to *Legal*. *Legal* has the highest number of shared implications (nine) and strategies (14) with *Public Affairs*. Most of the implications and adaptation strategies that require *Legal* to provide legal support or action for are the same implications and strategies that *Public Affairs* need to address for and with CAP's stakeholders, legislative partners, and the public.

The majority of *Legal*'s adaptation strategies are difficult to implement. What makes these particular strategies difficult to implement is the cost component behind them and/or the legal and legislative hurdles they must overcome to be successful. Difficult and costly *Legal* strategies include finding other water supplies (strategy #9), looking at new water collection options (strategy #29), and increasing conservation programs (strategy #31). Difficult and legally/legislatively-intensive strategies include increasing CAP's taxation authority (strategy #8), trying to renegotiate water rights (strategy #30), and pursuing regulatory changes (strategy #81).

The majority of the strategies (12 out of 19) that involve *Legal* address implications that affect *Legal*. Similarly, the majority of the implications (nine out of 15) that affect *Legal* are addressed by *Legal* strategies.

C.15 Public Affairs

Public Affairs is very sensitive to climate change, with 19 implications (third most of all functions), and the most responsive to climate change of all functions, with 37 strategies. Implications and strategies associated with *Public Affairs* are presented in Table C-29 and Table C-30 and are summarized below.

Table C-29: Implications that affect Public Affairs

Challenge Implications	Opportunity Implications	Mixed Implications
#1. Increased cost to customers – supply driven. **#2.** Increased cost to customers – power driven. **#3.** Increased cost to customers – demand driven. **#4.** Reduced ability of customers to pay rates. **#5.** Rate instability. **#6.** Decreased tax base. **#9.** Reduction in deliveries to low priority users. **#44.** Increased difficulty seeking legislative/regulatory solutions without partners. **#45.** Difficulty collaborating due to lack of staff, including legal staff. **#46.** More scrutiny placed on planning. **#50.** Increased lawsuits – contract challenges. **#51.** Challenges meeting environmental requirements. **#54.** Ongoing need to manage perceptions (public image).	**#19.** Increased tax base. **#58.** Increased non-traditional public/private partnerships. **#59.** Collaborative planning environment.	**#16.** Physical challenges to storing excess water due to long-term groundwater level rise. **#55.** Cutbacks to other agencies resulting in need for CAP to do other's work. **#56.** Increased pressure on legislature to enact solutions to water supply/demand imbalance.

All but one of the implications that affect *Public Affairs* also affect other CAP functions (with Increased pressure on legislature to enact solutions, implication #56, being the exception). However, the implications in Table C-29 have legislative repercussions, and other consequences that can be of concern to CAP stakeholders. Increased costs to CAP customers (implications #1, #2, and #3), increases or decreases in the tax base (implications #6 and #19), and rate instability (implications #4 and #5) are financial implications that CAP stakeholders and customers would find very important. Difficulties in seeking legislative solutions (implication #44) and increased pressure on the legislature to enact solutions (implication #56) are examples of implications with more direct legislative relevance. Furthermore, the occurrence of these implications would necessitate CAP to inform their legislative partners, stakeholders, and the general public about them. Hence, *Public Affairs* shares the highest number of implications with *Communications* (14).

Table C-30: Strategies that involve Public Affairs

Easy Strategies	Medium Strategies	Difficult Strategies
#16. Public campaign advocating for value/importance of water.	**#26.** Increase collaboration with others on infrastructure.	**#3.** Decrease level of service.
#69. Public awareness campaign for recreational impacts (potential partnership for communications plan).	**#38.** Interstate and intrastate water exchange/sales.	**#7.** Lobby for ability to generate power to offset power costs.
#77. Increase open market power purchases.	**#71.** Collaborate with agencies to recharge outside of AMA for future wheeling, if aquifer storage in AMA is full.	**#8.** Increase tax authority / increase tax rate percentage.
#84. Enforce existing contract condition that limits monthly supply to 11 percent of annual supply.	**#101.** Increased meetings between elected officials, e.g. board members meet with legislators.	**#9.** Find other supplies, e.g. desalination, weather modification, etc. (augmentation).
#99. Prioritize work activities.	**#120.** Collaborate with difficult partners.	**#25.** Incentives for stakeholders' own projects in service area.
#100. Increase lobbying efforts.		**#30.** Try to renegotiate water rights.
#102. Act without collaboration.		**#31.** Increase conservation programs.
#103. Stakeholder workshops, collaboration, outreach.		**#62.** Pursue legislation to further minimize subsidence.
#105. Board outreach and education, on CAP's behalf.		**#81.** Pursue regulatory changes.
#107. Increase transparency, documentation.		
#112. Public awareness campaign communicating dangers of canal.		
#113. Communication with customers to work through contract issues and avoid lawsuits.		
#116. Increase collaboration with other agencies to facilitate		

permitting and environmental compliance. **#121.** Collaborate with others to address water supply/demand imbalance. **#124.** Explore long-term partnership projects. **#125.** Strategic planning with others. **#126.** Work with stakeholders on what to do with challenges. **#127.** Support collaborative policy changes.		
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
#104. Outsource legal and legislative staff. **#114.** Increase legal and legislative staff.	**#50.** Seek partnerships/federal grants **#66.** Collaborate with others (public or private) to store more water at Lake Pleasant or meet customer demands.	**#78.** Interagency collaboration/partnerships for power transmission infrastructure.

Public Affairs has the highest number of strategies (18) that are easy to implement amongst all CAP functions (see Figure 7 in Section 4.6.1). Eight strategies from Table C-30 are primarily implemented by *Public Affairs*: seek partnerships/federal grants (strategy #50), increase lobbying efforts (strategy #100), increase meetings with between elected officials (strategy #101), hold stakeholder workshops (strategy #103), encourage CAWCD Board outreach on behalf of CAP (strategy #105), collaborate with difficult partners (strategy #120), explore long-term partnership projects (strategy #124), and work with stakeholders on challenges (strategy #126). All of these eight strategies that are unique to *Public Affairs* address implications from Table C-29. In terms of common strategies with other functions, *Public Affairs* has the highest number of shared strategies with *Legal* (14).

Most of the strategies (30 out of 37) that involve *Public Affairs* address implications that affect *Public Affairs*. Likewise, all but one of the implications that affect *Public Affairs* are addressed by *Public Affairs* strategies. The one implication that affects *Public Affairs* but cannot be addressed by *Public Affairs* is an opportunity: implication #19: increased tax base.

C.16 Communications

Communications is very sensitive to climate change, with 19 implications (third most of all functions), and moderately responsive to climate change, with 16 strategies (just below the average for functions). Implications and strategies associated with *Communications* are presented in Table C-31 and Table C-32 and are summarized below.

Table C-31: Implications that affect Communications

Challenge Implications	Opportunity Implications	Mixed Implications
#1. Increased cost to customers – supply driven. **#2.** Increased cost to customers – power driven. **#3.** Increased cost to customers – demand driven. **#4.** Reduced ability of customers to pay rates. **#5.** Rate instability. **#6.** Decreased tax base. **#9.** Reduction in deliveries to low priority users. **#22.** Degraded water quality – weather driven. **#23.** Degraded water quality – supply driven. **#26.** Land subsidence near canal. **#27.** Potential damage to CAP infrastructure and facilities, from weather. **#28.** Low elevations at Lake Pleasant/Waddell Dam. **#46.** More scrutiny placed on planning. **#50.** Increased lawsuits – contract challenges. **#54.** Ongoing need to manage perceptions (public image).	**#19.** Increased tax base. **#58.** Increased non-traditional public/private partnerships. **#59.** Collaborative planning environment.	**#55.** Cutbacks to other agencies resulting in need for CAP to do other's work.

Almost all of the implications in Table C-31 are mainly pertinent to other CAP functions; e.g. issues associated with costs, rates, and the tax base (*Financial Planning and Analysis*), water delivery, storage, and quality (*Water Operations and Power Programs*), and CAP infrastructure, facilities and equipment (*Maintenance*). However, all of the major themes (revenue, water, and infrastructure) covered by these implications represent topics that CAP needs to keep external and internal constituents informed on. External constituents include CAP customers, legislative representatives, water and power agencies, and the general public. Internal constituents are chiefly the CAWCD Board of directors, CAP leadership, and CAP employees. One of the implications that is very germane to *Communications* is the ongoing need to manage perceptions and CAP's public image (implication #54).

Table C-32: Strategies that involve Communications

Easy Strategies	Medium Strategies	Difficult Strategies
#4. Communicate potential for increased rates to customers. **#16.** Public campaign advocating for value/importance of water. **#44.** Decrease rates and communicate rate decrease. **#49.** Share water quality management with customers/manage customer expectations. **#51.** Increase external/internal communications on water quality. **#53.** Increase frequency of water quality reporting (website/customers). **#64.** Increase training, awareness, safety campaigns regarding weather issues/conditions. **#69.** Public awareness campaign for recreational impacts (potential partnership for communications plan). **#79.** Messaging re: power interruptions. **#98.** Advertise employee benefits. **#99.** Prioritize work activities. **#107.** Increase transparency, documentation. **#112.** Public awareness campaign communicating dangers of canal. **#113.** Communication with customers to work through contract issues and avoid lawsuits.	**#35.** Publish adaptive rate structure, use ranges.	**#3.** Decrease level of service.
Easy to Medium Strategies	**Medium to Difficult Strategies**	**Easy to Difficult Strategies**
N/A	**N/A**	**N/A**

Almost all of *Communications'* adaptation strategies in Table C-32 are easy to implement strategies. The exceptions are strategies #3 ("Decrease level of service") and #35 ("Publish adaptive rate structure, use ranges"), which are medium and difficult to implement, respectively. Four of *Communications*' easy strategies are primarily implemented by *Communications*. Half of these strategies that are primarily implemented by *Communications* address implications that are connected to *Communications* (strategies #4 and #51), while the other half address implications that do not affect *Communications* (strategies #49 and #79). *Communications* has the highest number of shared implications (14) and strategies (seven) with *Public Affairs*.

Most of the strategies that involve *Communications* address implications that affect *Communications*, with the exception of six strategies that target non-*Communications* implications. Similarly, most of the implications that affect *Communications* are addressed by *Communications* strategies. Six implications (implications #9, #19, #26, #54, #58, and #59) are not addressed by *Communications* strategies.