CENTRAL ARIZONA PROJECT

CLIMATE ADAPTATION PLAN | 2018

EXECUTIVE SUMMARY

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1. Introduction

The Central Arizona Project (CAP) provides a 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 CAP's financial security. 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 to develop a plan to increase CAP's resiliency.

2. Primary Climate Change Concerns for CAP

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 the basin's water users. Reliability of Colorado River water supply is strongly influenced by hydrologic conditions in the Upper Colorado River Basin. As such, annual Colorado River flow is dependent on winter precipitation, snowpack accumulation, and spring runoff that occurs in the Upper Basin.

Drier and hotter conditions associated with 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. This reduction in snowpack can impact spring runoff, when snow accumulation shifts to snow melt. The volume of snowmelt generated from spring runoff 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 the Colorado River Basin's system storage. 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. If the Lower Basin is under shortage conditions due to Lake Mead storage falling below 1075 feet elevation, Arizona suffers a reduction to its 2.8 MAF annual allocation of Colorado River.

Furthermore, CAP is a junior Colorado River priority holder in Arizona, and due to the nature of its Colorado River entitlement 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. 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 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 toward 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 Arizona's Colorado River water users, 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 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 vulnerability due to increased warming, extreme temperatures also generate health risks and dangers to CAP's workforce, especially to CAP employees who work in the field and are exposed to these conditions on a daily basis.

Finally, a potential cost component driven by increased temperatures relates to power costs during peak temperature periods. As the largest consumer of energy in Arizona, 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 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 dust storms, heavy thunderstorms, flash flooding, and high winds with some periodic regularity. All of these extreme events can stress CAP's existing infrastructure, shortening the lifespan of physical assets and increasing the risk of system failures. 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 who primarily work out in the field.

3. Scenario Planning 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 divert and deliver Colorado River water, a scenario planning approach was developed, that considers a range of future conditions. Considering a range of future conditions allows CAP to be prepared for a variety of circumstances, mitigating uncertainty.

The scenario planning process used for this study was centered on workshops attended by CAP subject matter experts. A summary of the process is described as follows:

- **Develop focal questions and assemble the CAP team**. Prior to the workshops, the focal questions were developed, and CAP experts were selected to participate in the workshops. To select the CAP 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 operations and goals. Functions may include specific departments, pairs of departments, or entire groups. Experts were selected from CAP's functions, identified as having the greatest sensitivity to climate change impacts and potential adaptation efforts.
- **Develop drivers and scenarios**. The CAP 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" 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 CAP team identified potential implications across all CAP climate-sensitive functions. Implications are the potential effects of climate change on CAP.
- **Develop adaptation strategies**. For each scenario, the CAP team identified potential specific actions that could be taken to adapt to each implication of climate change.
- **Develop robust solutions**. The CAP team selected preferred adaptation strategies that could be implemented and organized them into several strategy portfolios.

Key to development of this adaptation plan was active participation of the CAP team, representing CAP's climate-sensitive functions. All drivers, implications, strategies, and robust solutions were developed by the CAP team, in a collaborative fashion. In all workshops, the CAP 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

4. Drivers and Scenarios

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 study, CAP focused 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 CAP's employee 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 CAP team then "bracketed" the key drivers with a qualitative range of potential future conditions.

Scenarios represent possible futures and are described by a defined "state" (high bracket or low bracket) 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 1). 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.

Table 1: Key Drivers and 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

Key Driver	Scenario 1	Scenario 2	Scenario 3
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

5. Climate Change Implications

Implications are the potential effects of the climate change scenarios on CAP. Implications may be challenges, opportunities, or both. A total of 61 unique climate change implications were identified by the CAP team. A summary of each scenario, based on both key 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 among lower basin states, as well as increased water conservation.

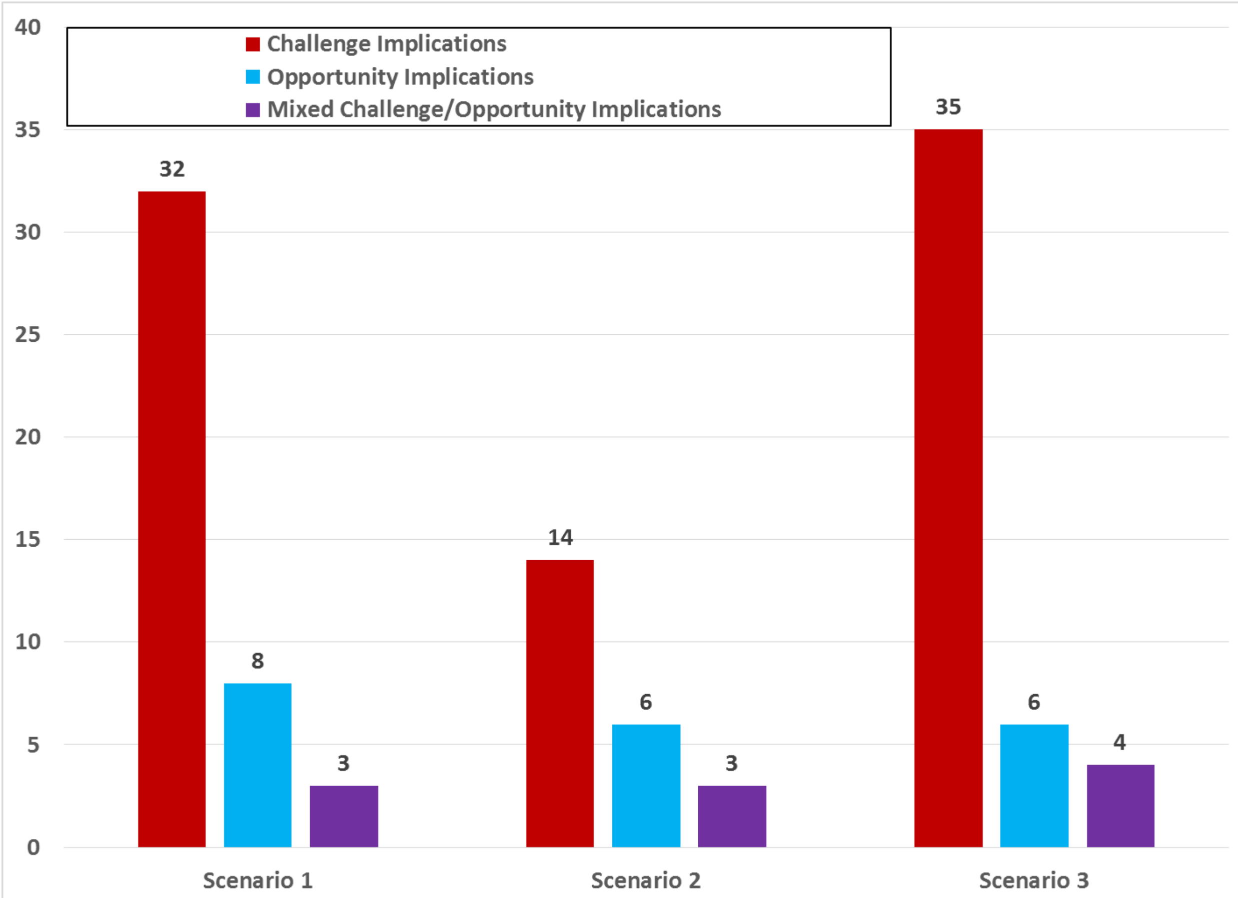

Figure 1: Number of implications per scenario

The relative influence of key drivers on scenario implications was estimated based on the number of challenges or opportunities associated with each key driver state. Colorado River supply (frequent shortages) and demand changes (full contract demand) are the two most influential key drivers in terms of challenges, and technology (higher capacity of utilization) is the most influential key driver in terms of opportunities. Two key driver states did not primarily influence any of the climate change implications generated by the CAP team: strong economic growth and historical precipitation.

Per Figure 1, Scenarios 1 and 3 are the most challenging to CAP in terms of the 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 or 3.

Different CAP functions had 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 CAP functions, while *Protective Services* and *Information Technology* are the two least sensitive CAP functions. Figure 2 illustrates the number and types of implications affecting each CAP function.

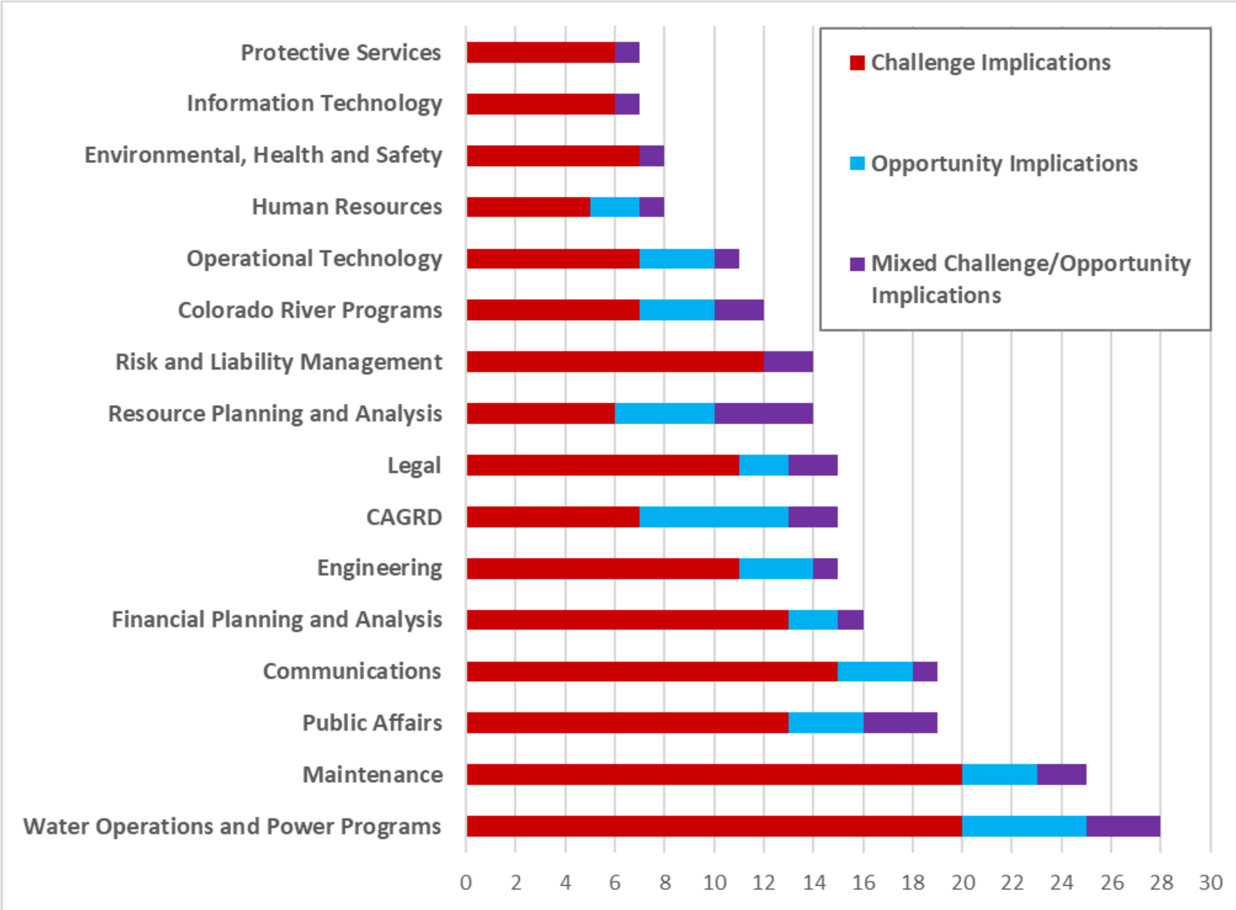

Figure 2: The number and types of implications affecting each CAP function

6. Climate Change Adaptation Strategies

One hundred and thirty one adaptation strategies were developed by the CAP 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).

In addition to the suite of adaptation strategies, the CAP 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 there may be implications so dire or extreme that it may be more palatable for CAP to not invest resources to adapt to them.

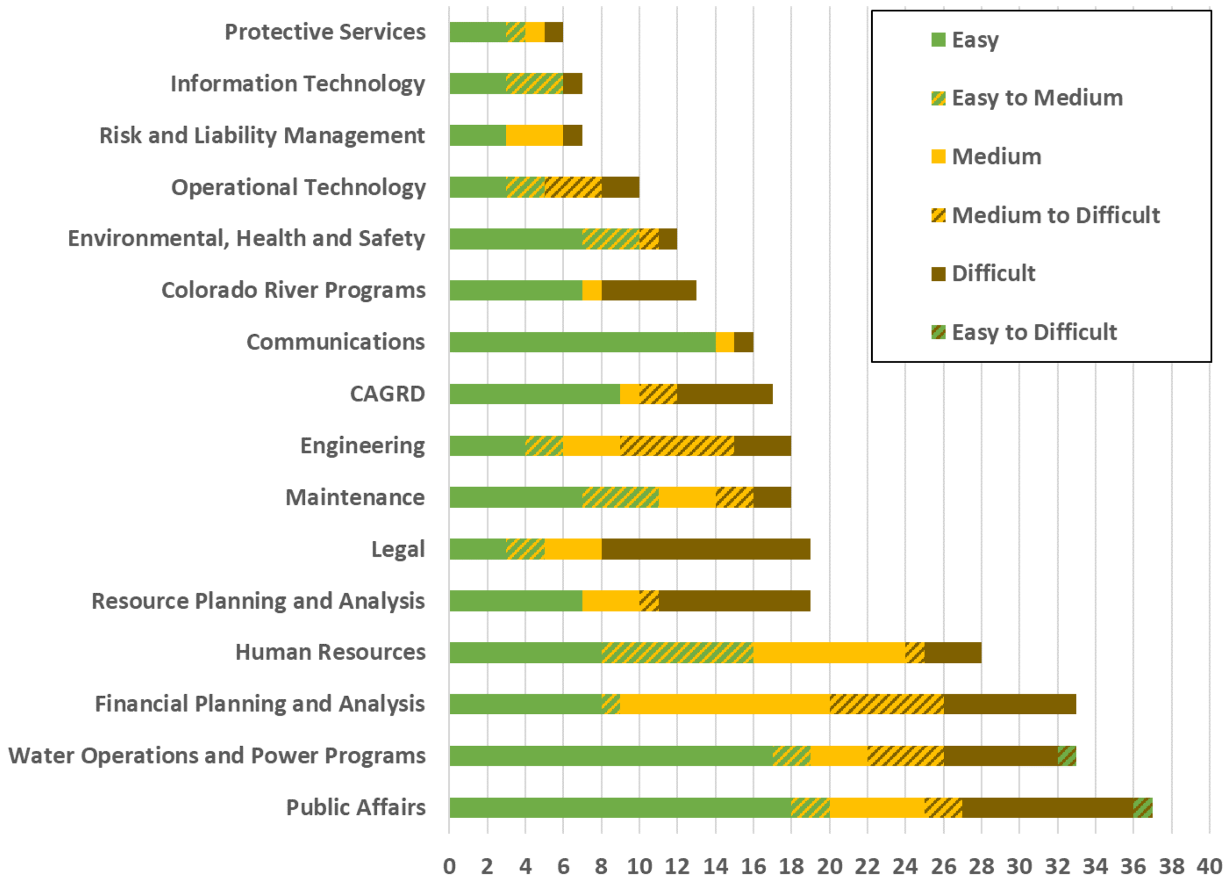

Figure 3: The number and types of strategies involving each CAP function

A function's ability to respond to climate change can be approximated by the number of strategies that involve that function (Figure 3). *Public Affairs* is the most responsive function, while *Protective Services* is the least responsive function. Most strategies (more than 70 percent) involve one or two functions; only two strategies involve more than five functions (Figure 4). 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 the formation of multi-function teams (two to three functions) to implement strategies. For example, there are 14 strategies associated with both *Legal* and *Public Affairs*, suggesting these two functions could work closely together in climate adaptation. Another potential multi-function team could include *Resource Planning and Analysis*, *Colorado River Programs*, and *CAGRD*; each of these pair combinations has at least eight shared strategies.

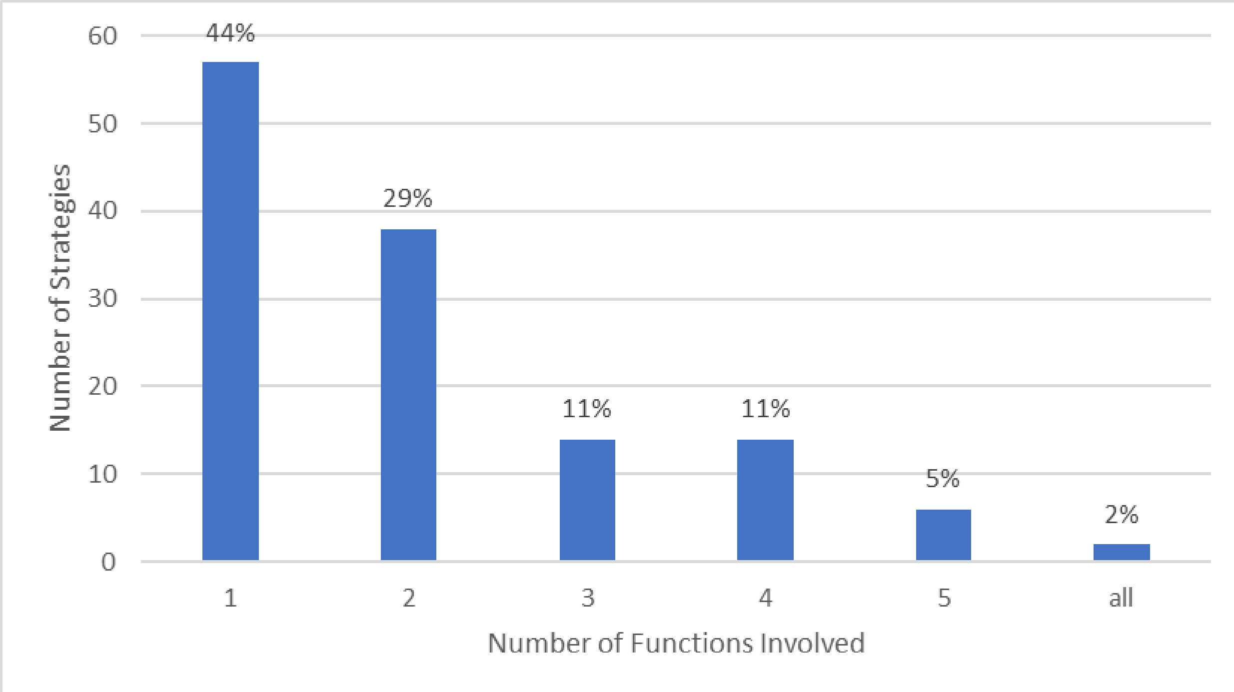

Figure 4: Adaptation strategies summarized by number of functions involved

7. Portfolios

A portfolio is defined as a collection of strategies. Portfolios are used to help understand how individual strategies perform under different conditions. The CAP team developed several portfolios that generally mitigate implications affecting all CAP climate-sensitive functions, but not all functions were involved with implementing each portfolios' strategies. The CAP team assigned one of the following categories to each portfolio 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. As such, there is no risk of overinvestment with No Regrets strategies. 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.
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.

8. Next Steps

Additional in-depth analysis of implications and strategies with respect to CAP functions is recommended to identify and prioritize the most important adaptation strategies. This analysis could be used to support an implementation plan that highlights what strategies should be implemented and how to implement them, along with a process for monitoring conditions to inform additional future action.

The following is an example list of actions that could be included in the implementation 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 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 implementation 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 timeline for revisiting and updating the analysis. Generally, the implementation 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.