CAP
CENTRAL ARIZONA PROJECT

2022

BIOLOGY

ANNUAL REPORT

Central Arizona Water Conservation District
Water Transmission Division

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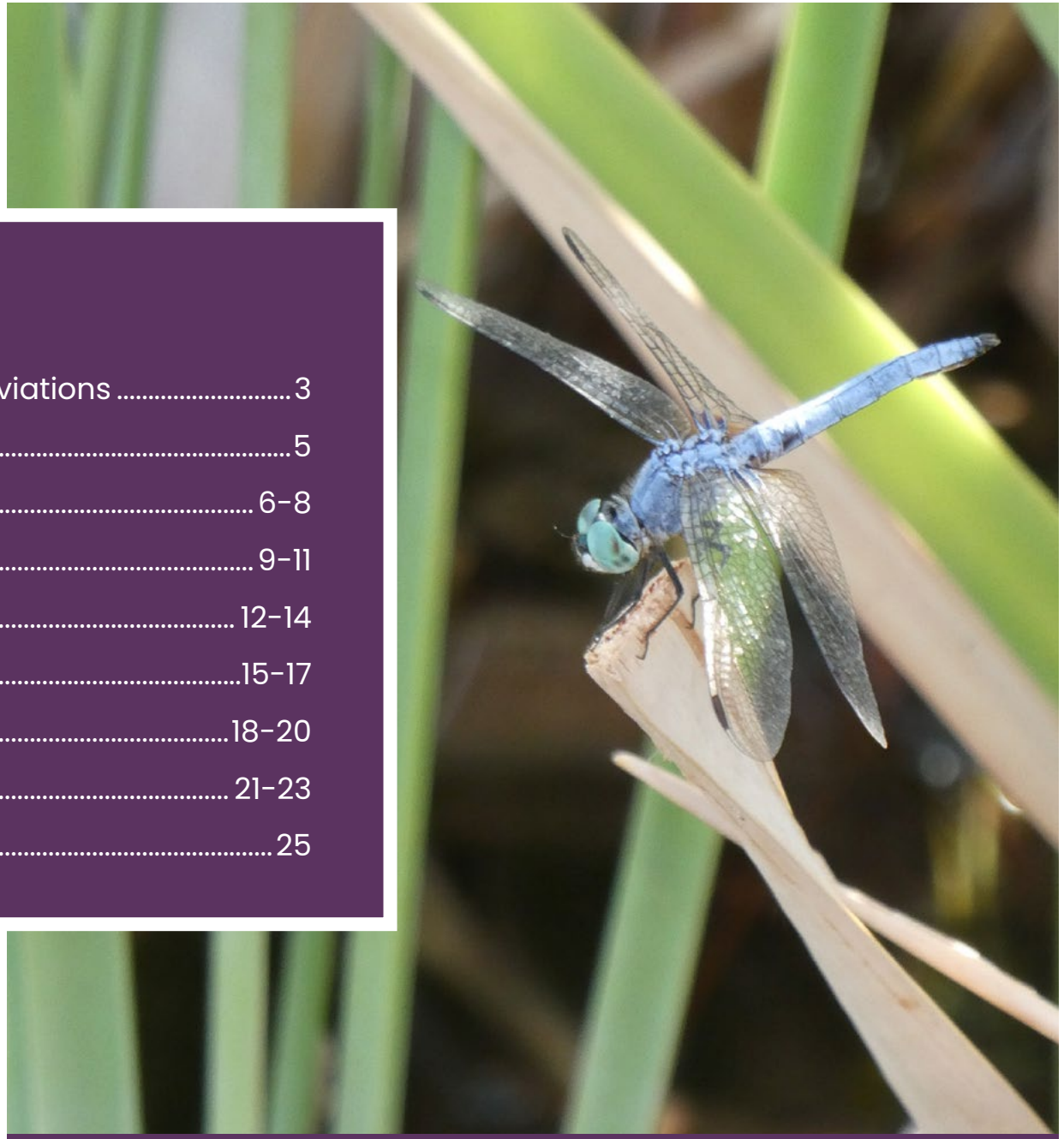
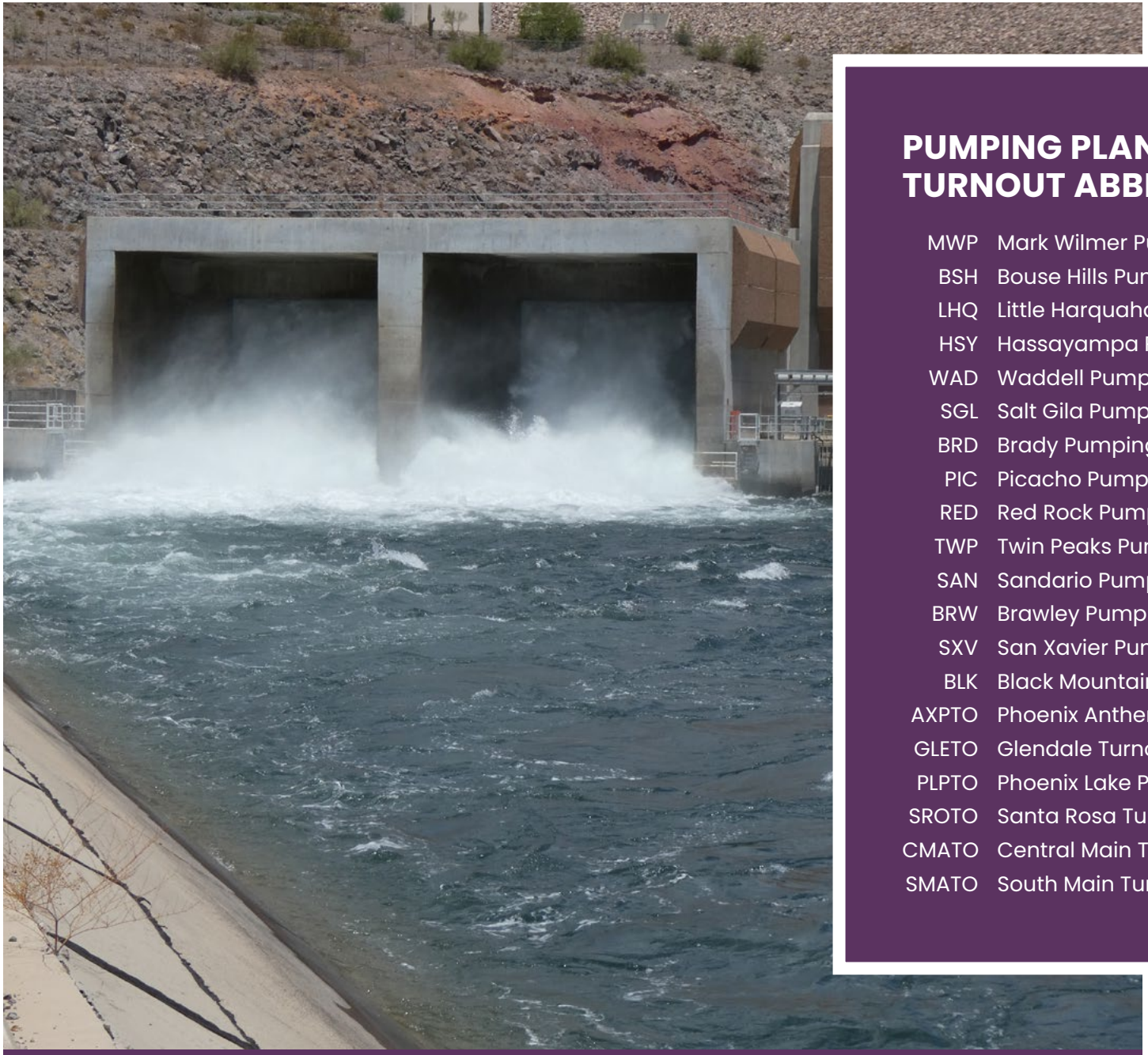


DRAGONFLY AT LAKE HAVASU



BYPASS AT WADDELL PUMP/GENERATING PLANT (WAD)

PUMPING PLANT AND TURNOUT ABBREVIATIONS

MWP	Mark Wilmer Pumping Plant
BSH	Bouse Hills Pumping Plant
LHQ	Little Harquahala Pumping Plant
HSY	Hassayampa Pumping Plant
WAD	Waddell Pump/Generating Plant
SGL	Salt Gila Pumping Plant
BRD	Brady Pumping Plant
PIC	Picacho Pumping Plant
RED	Red Rock Pumping Plant
TWP	Twin Peaks Pumping Plant
SAN	Sandario Pumping Plant
BRW	Brawley Pumping Plant
SXV	San Xavier Pumping Plant
BLK	Black Mountain Pumping Plant
AXPTO	Phoenix Anthem Turnout
GLETO	Glendale Turnout
PLPTO	Phoenix Lake Pleasant Turnout
SROTO	Santa Rosa Turnout
CMATO	Central Main Turnout
SMATO	South Main Turnout

GRASS CARP IN POOL 34

CAP BIOLOGY PROGRAM

The CAP Biology Program was created in 2011 to address the variety of biological issues that can affect CAP's 40,000 acres of property, the 336-mile aqueduct, and CAP's ability to deliver water. The program focuses on a comprehensive monitoring program to provide responsible management recommendations based on sound techniques and robust data.

The year 2022 marked a return to "near-normal" as many of the challenges faced during the past two years with COVID-19 became a forgettable memory. Although most CAP field employees returned to a relatively normal work schedule, many others were adapting to a hybrid schedule that allowed employees to work from home when practical. Regardless of the circumstances, CAP continued its mission to reliably deliver water to the residents of Arizona.

The decades-long drought continued in 2022, and the threat of a water supply shortage became a reality. Water volume in the canal stayed relatively consistent, but water flow decreased substantially. And with the decreased flows, the organisms in and out of the canal responded by changing their patterns and behaviors, and the Biology Program began to prepare for an uncertain future.

The long-term monitoring program implemented by the Biology Program in 2011 was designed to capture these environmentally-driven changes and measure the responses of the various organisms that utilize the CAP. Now more than ever, the continued monitoring program will help us to make data-driven management decisions as we navigate shortage conditions that will likely be more common in the coming years.

The following annual report is a summary of the work completed in 2022, including approaches and significant findings, as well as strategies for monitoring and research in 2023. Each section also includes a brief introduction to the issue being addressed, which is carried over from previous annual reports.

MOUNTAIN LION USING A CAP WILDLIFE CROSSING NEAR PIC
Trail Camera Photo provided by Thomas Bommarito, Bureau of Reclamation (Reclamation)

QUAGGA MUSSELS AND CLAMS IN MUD VALVE AT BSH

QUAGGA MUSSELS

BACKGROUND

The Western invasion of quagga mussels was first discovered in Lake Mead on the Colorado River in January 2007. Soon thereafter, the mussels were found throughout the Lower Colorado River from Lake Mead to Yuma, including CAP's water source, Lake Havasu. In early 2008, microscopic young quagga mussels (veligers) were observed in plankton samples in the CAP aqueduct and its storage reservoir, Lake Pleasant. When CAP began intensively monitoring the mussels in 2009, large numbers of veligers were found throughout the system, but few adult mussels were found.

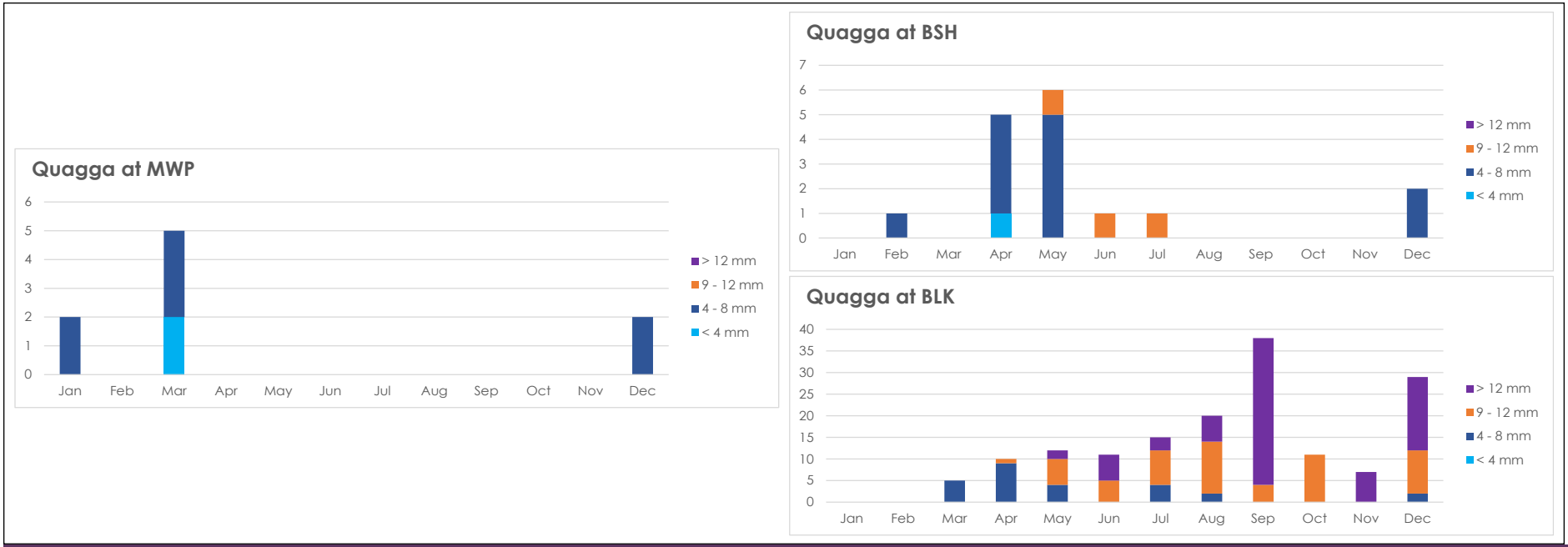
Although it was originally hypothesized that various factors would restrict mussel invasion in the aqueduct, adult settlement has occurred throughout the system. In most cases, infestations do not impact water deliveries or maintenance of the system. However, there are some instances when more critical systems are affected. CAP's typical response is to increase maintenance frequency (e.g. cleaning of filtration systems, strainers, and cooling systems) to ensure reliability. However, more severe infestation issues in recent years have created the need for alternative approaches, including the use of foul-release coatings and chemical treatment.

APPROACH

Quagga mussel infestations and impacts are monitored with monthly bio-box checks and annual trash rack inspections, and plant and aqueduct personnel report irregular findings related to quagga mussels as conditions dictate. Additionally, the chemical injection system installed at MWP to treat the cooling water system was evaluated using a videoscope in January and December 2022.

FINDINGS

In typical years, quagga mussel infestation is greatest in the bio-box at MWP with sporadic infestation at other locations. Numbers are usually in the thousands at MWP; however in 2022, only nine quagga were observed during the entire year. Reasons for the low infestation rate are unknown, but a lack of



MONTHLY QUAGGA INFESTATION AT MWP, BSH, AND BLK IN 2022.

quagga attachment on structures in the forebay of the pumping plant was also noted. Trash rack inspections at MWP in July showed some quagga attachment, but relatively light compared to previous years. Water temperatures at MWP have been higher in recent years, especially in 2021 when a daily maximum of more than 93 degrees (F) was measured. The higher temperatures may be having an impact on the quagga population in Lake Havasu. Additionally, lower river flows may also be impacting the quagga population.

Within the remainder of the pumping plants, quagga were only observed in bio-boxes at BSH and BLK, with relatively low numbers at each of the two plants. Based on the size distribution of quagga at BLK, it appears that there may have been at least two, and probably three, reproductive events in the southern portion of the canal. However, since no other pumping plants experienced quagga infestations, the reproduction may have occurred just upstream of BLK, possibly in the Lower Raw Water Impoundment (LRWI). At BSH, in addition to quagga observed in bio-boxes, plant personnel also indicated that there was a large amount of quagga and clam shell debris in the unit mud valves that needed to be cleaned. However, there were no issues with pumping plant strainers or filtration.

Colonial hydroid (Cordylophora) was observed on trash racks at all pumping plants, while quagga were only observed at MWP, SGL, BRD, and BRW. Infestations of quagga were light at all plants except MWP, where there was a moderate infestation. Hydroid growth on trashracks was light to moderate at all plants. There were no levels of infestation that required attention.

The chemical treatment system at MWP became operational in September 2021. Videoscope evaluations were conducted in January and December 2022 to determine the effectiveness of the treatment, as well as make any adjustments to the treatment rate. Overall, the treatment appears to be working as intended.

Unit 2 was power washed prior to initiation of the treatment, and 14 months later, there was no sign of quagga or hydroids in the cooling water system. Similarly, Units 4 and 5 were cleaned in July 2022, and after 5 months there was no quagga or hydroid infestation. Units, 1, 3 and 6 have not been cleaned in several years and there is significant buildup of quagga and other organic debris. The treatment appears to have killed the quagga and stopped further infestation, but the coolers need to be cleaned out to maximize their efficiency.

STRATEGIES FOR 2023

In 2023, water supply shortage (lower flows) may affect the distribution and abundance of quagga mussels in the CAP System. We will continue to monitor quagga infestation and growth rates in bio-boxes and attachment to trash racks. We will also continue to count on maintenance personnel to alert us of any issues and address those problems as they arise. The chemical injection system has proven to prevent/deter attachment of quagga and hydroid in the cooling water systems at MWP. However, it does not cause existing organisms to slough off, and remaining organics still have the potential to clog cooling tubes and overheat the units. Therefore, units that have not been power washed need to be cleaned to realize the full effect of the treatment. Although chemical usage was relatively low in 2022, the current application rate (0.75 ppm) may be reduced in some of the units to evaluate the effectiveness of a lower rate (0.5 ppm). Videoscope evaluations will be conducted in December 2023 to assess the condition of each of the cooling units.

CHEMICAL INJECTION SYSTEM AT MWP

UNIT 2 COOLER AT MWP AFTER 14 MONTHS OF TREATMENT. COOLERS WERE CLEANED PRIOR TO INITIATION OF TREATMENT.

AQUATIC VEGETATION – MWP

BACKGROUND

Aquatic vegetation growth in Lake Havasu has increased significantly since the discovery of quagga mussels in 2008. The direct relationship between quagga mussels and vegetation growth has not been proven; however, it is widely speculated that quagga have increased water clarity and nutrient loading in the reservoir, which in turn has led to an increase in weed growth. When the vegetation dies and floats to the surface during summer and early fall, the impacts are felt by CAP. Weeds become entrained in the flow of the intake channel, either as individual plants that have been dislodged or as floating mats of dead material, and threaten the reliability of the pump systems and ultimately, CAP's ability to transport water.

To prevent weed mats from approaching and impacting the pumping plant, CAP began collecting and disposing of the mats in 2010 using a combination of a weed harvesting boat and a long-reach excavator. In 2016, CAP installed a trash rake system at MWP to help ensure the reliability of the system and reduce/eliminate the need for the weed harvesting boat. However, due to the frequent breakdowns and the uncertainty in the reliability of the trash rake system, it was largely abandoned in 2018. CAP now primarily relies on the weed harvesting boat and herbicide treatments to minimize the risk posed by the weed mats.

The distribution and density of aquatic vegetation within the CAP intake channel has been mapped using sonar since 2012. The mapping helps weed harvesting crews to target problematic areas and identify areas in need of treatment (herbicide). Mapping also provides a long-term "picture" of how vegetation growth has changed over time and helps CAP to understand what changes might occur as a result of river shortage conditions.

AQUATIC WEED GROWTH WITHIN THE MWP INTAKE CHANNEL IN JUNE 2022

FLOATING WEED MATS WITHIN THE MWP INTAKE CHANNEL HAVE THE POTENTIAL TO OBSTRUCT FLOW AND THREATEN CAP'S ABILITY TO DELIVER WATER.

VEGETATION TREATMENT IN JUNE 2022. A DYE (RHODAMINE) WAS USED TO EVALUATE HERBICIDE COVERAGE AND DISTRIBUTION.

APPROACH

Aquatic vegetation growth was monitored from April through September within the 65-acre CAP intake channel using downscan sonar and StructureScan (Lowrance HDS Live 9). Data was uploaded to BioBase® to create bathymetric maps and vegetation heat maps. In June, a combination of a liquid (Cascade®) and granular (Aquathol Super K®) endothall-based herbicides were applied to approximately 15 surface acres within the CAP intake channel. The effectiveness of the treatment was measured through vegetation mapping and random sampling. During the "weed season" (July through September), CAP weed harvesting crews actively collected floating vegetation mats using the weed harvesting boat. Aerial drone surveys were completed in July and August to evaluate growth of vegetation in both the CAP intake channel and the Bill Williams National Wildlife Refuge (BWNWR).

FINDINGS

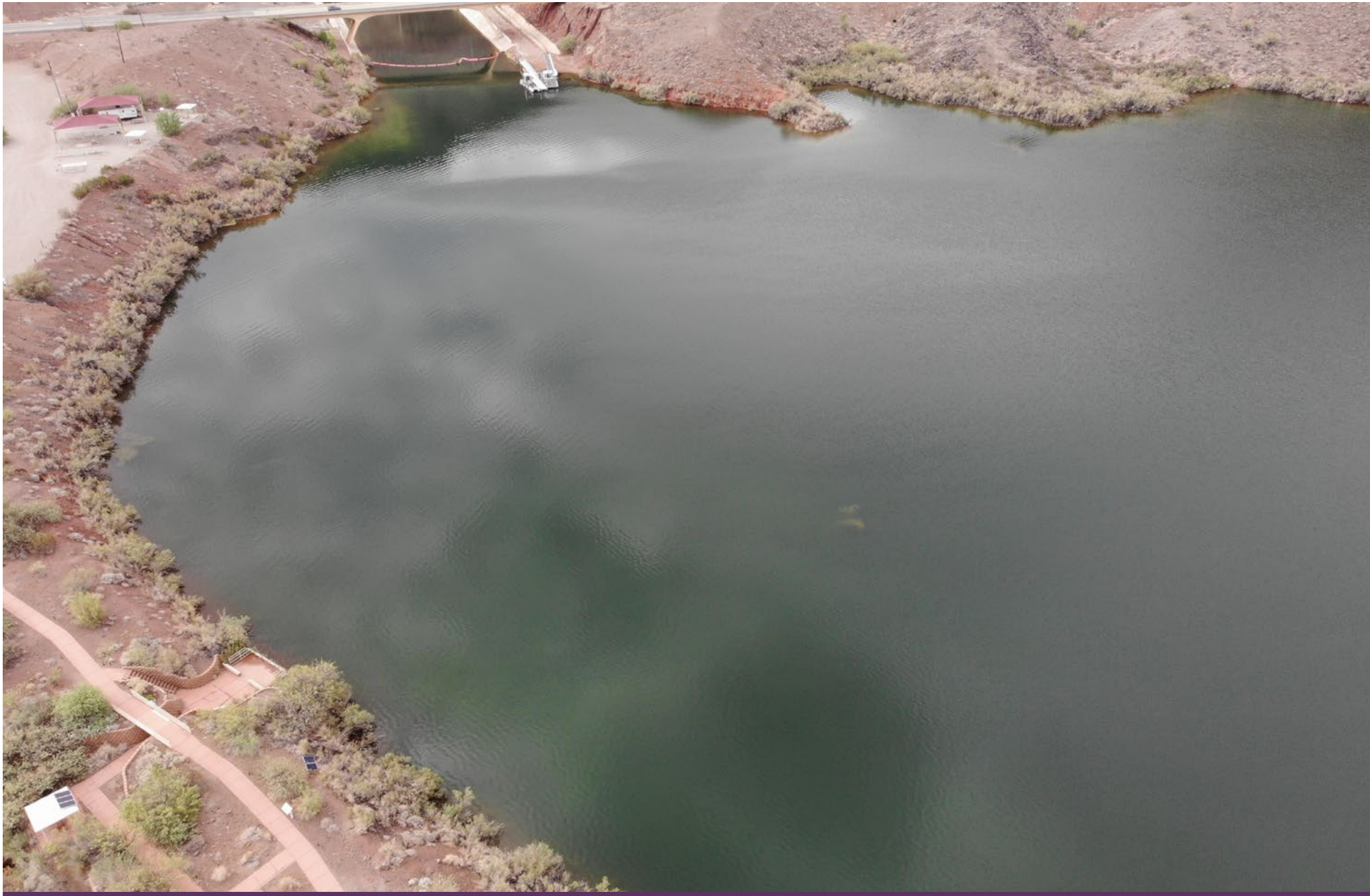
Mapping of vegetation within the intake channel showed that vegetation growth continued to increase in density and distribution compared to previous years. Conversely, vegetation growth in the adjacent BWNWR appeared to have less vegetation growth than typical, and may be the result of high turbidity events after frequent summer monsoons.

The weed treatment in 2022 was determined to be somewhat successful. Vegetation growth in the 5-acre area treated with Aquathol was completely eliminated, but areas treated with Cascade (~10 acres) only saw a modest reduction. This reduced effectiveness was attributed to extremely heavy vegetation growth (herbicide did not reach the entire plant) and application hoses that did not reach deep enough. The full report is available upon request.

Even though the treatment was not as effective as desired, only 129 cubic yards of weed material was collected in 2022 by the weed harvesting boat. In the past, heavy weed growth and active monsoon patterns would typically result in a busy weed season for harvesting crews. However, the average cubic yards collected since CAP began using endothall products is just 17% of weed collection during non-treatment years. This is clear indication that the weed treatments are reducing the effort needed for weed harvesting.

STRATEGIES FOR 2023

In 2023, CAP will replicate the weed treatment from 2022, except it will be completed earlier in the season, when weed growth isn't as dense, and application hoses will be extended to reach the entire depth. Vegetation coverage and plant height will be mapped bi-weekly to evaluate the effectiveness of the treatments and monitor overall vegetation growth.



DRONE PHOTOS IN AUGUST 2022 SHOW THAT A MAJORITY OF THE VEGETATION WAS ELIMINATED WITH THE HERBICIDE TREATMENT.
Photo by Michael Rogers

FILAMENTOUS ALGAE GROWTH IN THE WAD FOREBAY DURING AUGUST 2022.

AQUATIC VEGETATION - AQUEDUCT

BACKGROUND

Weed growth within the aqueduct has historically been somewhat sporadic, but can be substantial. At times, filamentous algae will bloom in various sections of the canal, while rooted aquatic vegetation growth is generally restricted to slower moving areas. Pool Bouse has traditionally been a problem area for rooted vegetation, and Waddell Canal appears to go through cycles of filamentous algae problems. Chemicals have not typically been utilized in the canal to suppress vegetative growth. Instead, grass carp are stocked as a biological control.

TRIPLOID (STERILE) GRASS CARP ARE STOCKED INTO THE CAP FISH HOLDING TANKS UNTIL SMALLER BATCHES CAN BE DISTRIBUTED THROUGHOUT THE CANAL.

VEGETATION FRAGMENTS BROKE LOOSE FROM WAD FOREBAY AND WERE FLOATING IN THE WADDELL CANAL IN SEPTEMBER 2022.

ALGAE GROWTH CAN BE THICK AT TIMES IN THE WADDELL CANAL

APPROACH

Visual inspections are conducted periodically by aqueduct crews and any potential issues are reported to CAP's biologist. Additionally, CAP stakeholders often provide information to CAP during times when vegetation is impacting turnouts. In 2022, a time-lapse camera was placed along the Waddell Canal to document when growth of filamentous algae started and when it would break loose from the liner. The camera was downloaded each month. Control of aquatic vegetation in the aqueduct is achieved utilizing triploid (sterile) grass carp; however, filamentous algae is not a preferred food item for grass carp, so control is sporadic.

FINDINGS

The only rooted aquatic vegetation growth observed in the canal in 2022 was a familiar "island" of weeds growing in WAD forebay. These weeds broke off in September and fragments were seen floating in Waddell Canal. It is also interesting to note that vegetation was growing behind trash racks at WAD, as observed during annual inspections. It is apparent that the stocked grass carp are not staying in the forebay, so vegetation is not being controlled. If possible, additional fish may be stocked in summer to control this growth.

Filamentous algae was once again evident throughout Waddell Canal during summer months. Although it was dense at times, it did not cause problems downstream. Time-lapse photos show that the algae "bloom" occurred in late June and persisted until mid-September. Cymbella (rock snot) also grew during this same period, and appeared to out-compete the algae at times, but did not become problematic in 2022. The Arizona Center for Algae Technology and Innovation (AzCATI) at Arizona State University (ASU) is continuing their study of algae and *Cymbella* issues in the CAP System, which will conclude at the end of 2023.

Grass carp were stocked throughout the canal in early March to maintain population levels for effective control of aquatic vegetation. The grass carp have provided effective control since 1996, and stocking will continue as a primary control mechanism.

STRATEGIES FOR 2023

Aqueduct crews will visually monitor the system for growth of rooted aquatic vegetation, filamentous algae, and *Cymbella*. CAP's biologist will continue to work with ASU to identify factors contributing to algae growth and proliferation, as well as potential solutions. Grass carp stocking will continue and will target specific reaches of the canal where populations are less than optimal.

TRIPLOID GRASS CARP ARE IMPORTED FROM ARKANSAS TO HELP CONTROL VEGETATION WITHIN THE CANAL

CADDISFLIES

BACKGROUND

In 2004, a nuisance insect was reported to CAP by Phoenix and Scottsdale residents. The insects were identified as Smicridea, a common genus of caddisfly that is indigenous to the Colorado River. Although 2004 was the first record of complaint by nearby residents, caddisflies were found in relatively high numbers in the CAP as early as 1993. It is likely that caddisfly swarms have been common since the canal was constructed, but were largely undetected because neighborhoods were not yet constructed near the canal. The emergence of large numbers of adult caddisflies causes a nuisance because they tend to swarm around people, making outdoor dining and entertaining uncomfortable during periods of high activity.

Based on recommendations from an RNT Consultants report, CAP has stocked channel catfish in the canal since 2011 to help control the caddisfly population. Although the fish stocking does not eliminate the nuisance caddisflies, it does provide some level of relief for residents living adjacent to the canal.

CHANNEL CATFISH STOCKED INTO POOL 20 IN MARCH 2022

APPROACH

Channel catfish are stocked annually during early March. In 2022, approximately 6,350 catfish were stocked into Pools 20-24. These fish averaged 8-12 inches and weighed approximately one-half pound each.

Names and addresses of residents calling with concerns about the caddisflies are recorded to determine where the caddisflies create a significant nuisance. An online form was also created for residents to notify CAP of concerns and can be found on the CAP website.

Additionally, CAP's biologist communicates regularly with a variety of local and nationwide specialists to share ideas about potential control efforts.

FINDINGS

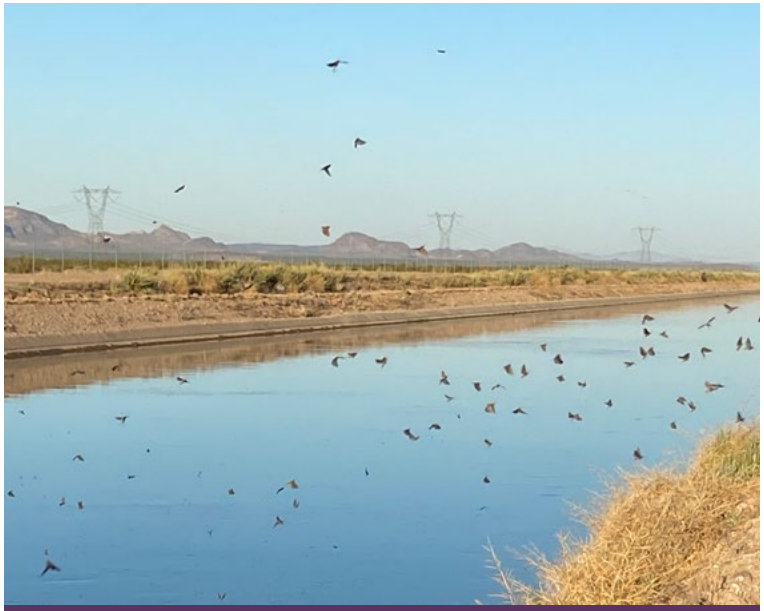
Similar to 2021, CAP only received one notification from the public in 2022. Field crews reported seeing similar "swarms" to previous years, so populations likely did not decrease significantly.

Catfish stockings in 2022 were spread out among the pools where CAP has historically seen the biggest impacts from the nuisance caddisflies (Pools 20-24). The stocking numbers were based on the estimated number of fish in each pool, and future stockings will be aimed at maintaining those population levels.

The Pest Abatement Department in Bullhead City continued to experiment with targeted reduced flows at Davis Dam to "strand" and dessicate caddisfly larvae. There has been limited evidence of success with this approach, but due to operational constraints, is an unlikely strategy in the CAP. Both CAP and SRP have attempted a similar approach in the past with no positive impact.

STRATEGIES FOR 2023

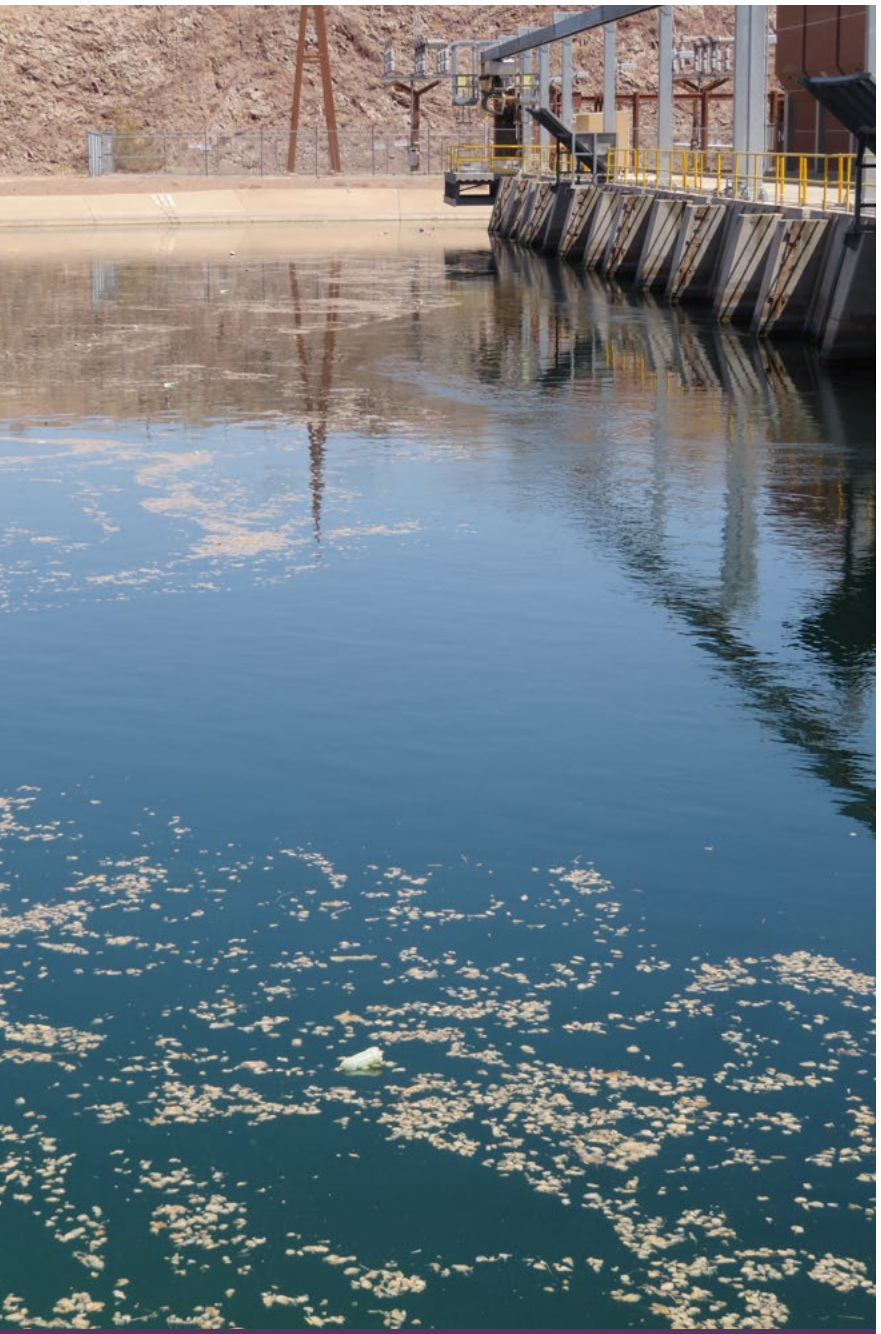
The catfish continue to provide a level of control, which appears to be improved with the stocking of smaller fish. CAP will continue to stock small catfish (one-half pound) in Pools 20-24. CAP will continue to work closely with specialists around the country, including Bullhead City and SRP, in an effort to find relief for residents adjacent to the canal.



CADDISFLIES AT SALOME ROAD IN APRIL

ADULT CADDISFLY

CHANNEL CATFISH ARE PERIODICALLY SAMPLED TO EVALUATE DIET AND DETERMINE IF THEY ARE CONSUMING CADDISFLIES.



FLOATING CYMBELLA AT THE LHQ FOREBAY IN JUNE 2022

CYMBELLA ("ROCK SNOT")

BACKGROUND

Since the time of their discovery in the CAP (1997), stalk-forming diatoms have occasionally become a nuisance for both CAP and its stakeholders. Cymbella (aka rock snot) can cause issues when mats detach from the canal liner and are floating on the water surface. When attached to the liner, the long stalks create excessive friction and reduce the flow of water. This impacts the ability of CAP's Water Operations team to deliver the requested volume of water to downstream water users. When floating on the surface, the mats of organic material may be drawn into pumping plants. Critical filters, strainers, and pumps have the potential to become clogged, which in turn affects the ability to properly cool motor components and provide service water throughout the plant. CAP water users can also be impacted, as clogged intakes, filters, strainers, and pumps reduce their ability to effectively deliver water to end users.

APPROACH

Although diatoms are one of the most prolific groups of algae in the world, relatively little is known about the factors that contribute to their growth and life cycle. CAP has partnered with the Arizona Center for Algae Technology and Innovation (AzCATI) at ASU to further study the Cymbella found in canal and determine potential methods of control.

CAP field crews were asked to report any instances of rock snot observed in the canal.

FINDINGS

In June 2022, a significant rock snot bloom was noted on the shorelines of Lake Havasu. Although this may have been a different species of diatom than is typically encountered in the canal, the bloom left little doubt that Lake Havasu is likely the primary source of rock snot in the canal (as opposed to Lake Pleasant).

Within the canal, the western portion of the canal was again affected by a bloom, as small amounts of rock snot were observed on the surface of Pool Bouse as early as April. Although there was floating material on the surface at various western

locations from April through July, it was less severe than the previous two years and did not appear to have a significant impact downstream of HSY. However, at LHQ and HSY, plant personnel were consistently called-in during early summer to clean filtomats and strainers. There were no impacts reported by stakeholders or pumping plant operators downstream of HSY.

In addition to the bloom in the western canal, there was also a small bloom in the Waddell Canal in August. This bloom did not appear to impact downstream municipal customers.

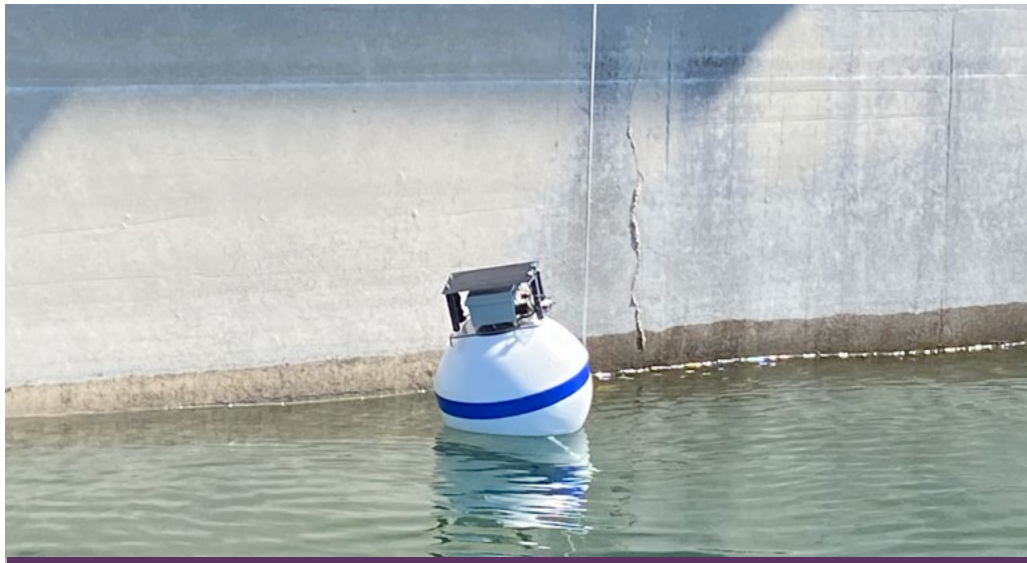
AzCATI researchers continued their work on Cymbella in 2022. A bulk of the AzCATI research focused on "ground-truthing" the algal sensors (MiProbe®) to ensure that biological activity was accurately being captured. Their work will continue until the end of 2023 and a detailed report is expected at that time.

STRATEGIES FOR 2023

Field personnel will continue to report any observed Cymbella growth and CAP's Biologist will periodically check specific areas for activity. AzCATI will also continue their research to identify the factors contributing to diatom growth and search for potential methods of control.

THE SNAIL POPULATION IN THE CAP MAY HELP TO CONTROL ROCK SNOT BLOOMS

"ROCK SNOT" WAS PREVALENT ON THE SHORELINES OF LAKE HAVASU IN 2022



AzCATI DEPLOYED SENSORS NEAR THE CAP TOWERS IN LAKE PLEASANT TO MEASURE ALGAL ACTIVITY IN THE LAKE

CYMBELLA ACCUMULATED UPSTREAM OF CHECK #3 WHEN FLOWS WERE CURTAILED IN JULY 2022. THIS MAY HAVE PREVENTED PROBLEMS WITH CLOGGED STRAINERS DOWNSTREAM AT LHQ.

SEDIMENT

BACKGROUND

During the design phase of the CAP, it was recognized that sediment deposition could be problematic. Engineers looked into the inclusion of structures like sediment traps and desilting plants, but ultimately determined that they were ineffective. Instead, forebays were designed to collect sediment near the intakes and it was suggested that regular cleaning would ensure that sediment deposition did not become a problem. However, due to costs, logistics, and the perception that sediment was not causing operational or maintenance issues, there was no formal removal process implemented. Occasionally, attempts have been made to remove sediment using a variety of methods, including clamshell dredging, highline buckets, pump dredges, "mucking" with loaders and excavators, and "vacuuming" using divers. Although each method has had various levels of success, most would consider these attempts to be ineffective and inefficient. Furthermore, there is considerable debate as to whether sediment removal is even necessary.

CAP's Water Operations team has indicated that water deliveries are rarely affected by sediment deposition. However, from a maintenance perspective, anecdotal evidence suggests that the sediment renders flow meters inoperable, clogs strainers and filters, causes premature wear to critical components (such as wear rings, impellers, and casings), degrades piping in cooling water systems, and causes wear and misalignment to trash rake systems. Nonetheless, increased maintenance and replacement of parts has not been quantified with data, so the impact of sediment deposition remains disputable.

SEDIMENT (TURBIDITY) INCREASES WHEN PUMPS AT HSY ARE ACTIVATED AFTER SUMMER OUTAGE.

APPROACH

Bathymetric mapping is conducted in each forebay and major turnout on an annual basis (since 2013) to help better understand patterns in sediment deposition. Data from the mapping is used to estimate total sediment volume in each forebay. Sediment removal is only attempted when opportunities arise, such as a forebay dewatering, or when conditions become degraded to a point where removal is necessary (e.g. flows in turnouts are restricted).

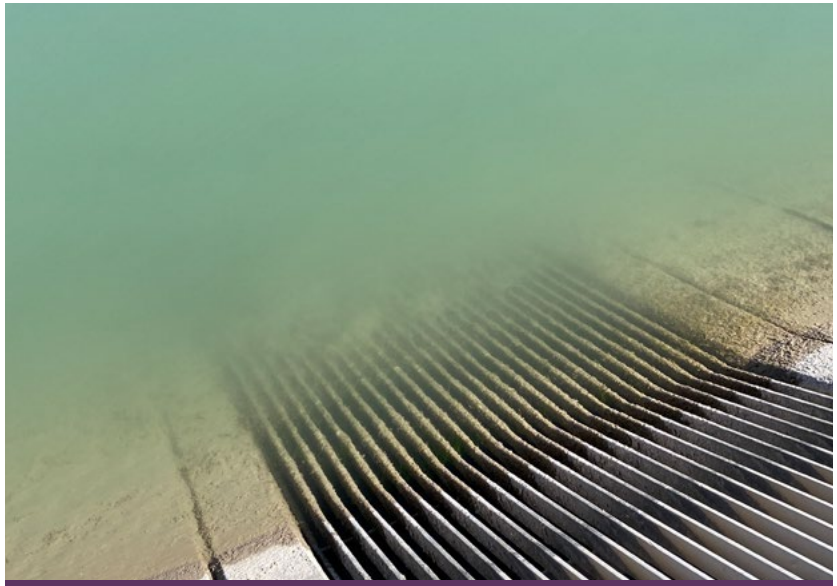
FINDINGS

Sediment mapping and analysis in April 2022 showed an increase in sediment volume at all pumping plants except for BSH, which had an 11% decrease. HSY, SGL, PIC, BRW, and SXV all had increases of more than 20% since 2021. The SGL forebay, which was completely dredged in November 2019, had a sediment volume of over 11,000 cubic yards in 2022. This represents nearly 19% of the total available forebay volume and is 32% higher than in 2021. Two of the largest turnouts (SROTO and CMATO) continued to show a high level of sediment deposition, with over 60% of the total turnout volume being occupied by sediment. The third large turnout, SMATO, was slightly lower than in previous years, as it was dredged when Pool 34 experienced a breach in 2021 after strong storms. BRD, PIC, and SAN continued to have the highest percentage of sediment deposition in forebays, ranging from 34-41% of total forebay volume.

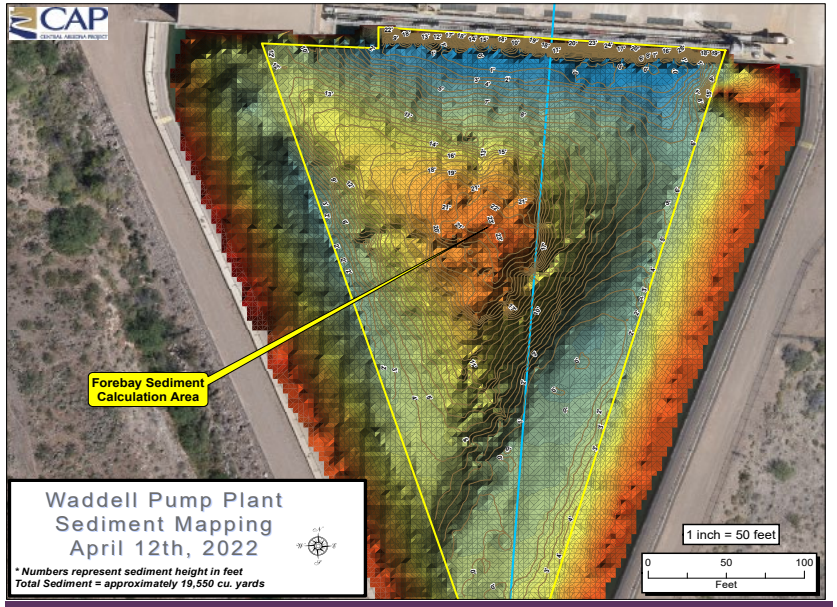
STRATEGIES FOR 2023

As flows decrease in the canal with water shortage, sediment deposition will become even more critical to monitor. Sediment mapping in the pumping plant forebays will continue so that long-term trends can be evaluated. Results of the mapping will identify where sediment removal would be beneficial.

A sediment management plan, which includes triggers for removal efforts, should be developed in 2023.



SEDIMENT TURBIDITY CAN BE EASILY OBSERVED AT TURNOUTS.

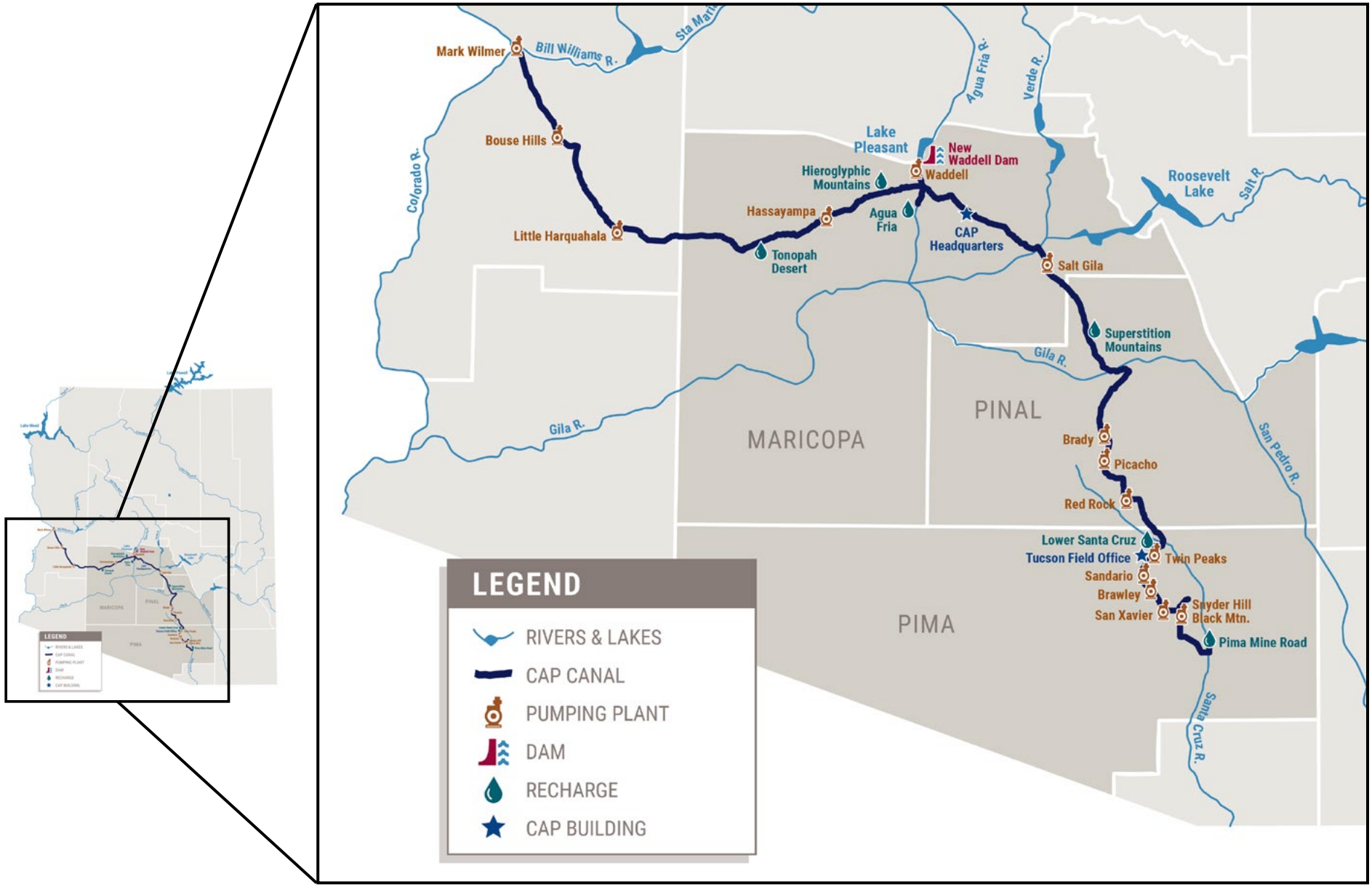


BATHYMETRIC MAPS ARE CREATED IN APRIL EACH YEAR TO DETERMINE THE AMOUNT OF SEDIMENT DEPOSITION IN EACH FOREBAY.

SEDIMENT DEPOSITION AT BRD; SHOWN HERE WITH LOW WATER LEVELS.

CAP EMPLOYEE JUSTIN CONLEY WITH A STRIPED BASS AT SGL

CAP SYSTEM MAP



2022

BIOLOGY

ANNUAL REPORT

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