CAP
CENTRAL ARIZONA PROJECT

2019 BIOLOGY ANNUAL REPORT

Central Arizona Water Conservation District
Water Transmission
by Scott Bryan, Senior Biologist

CAP BIOLOGY PROGRAM

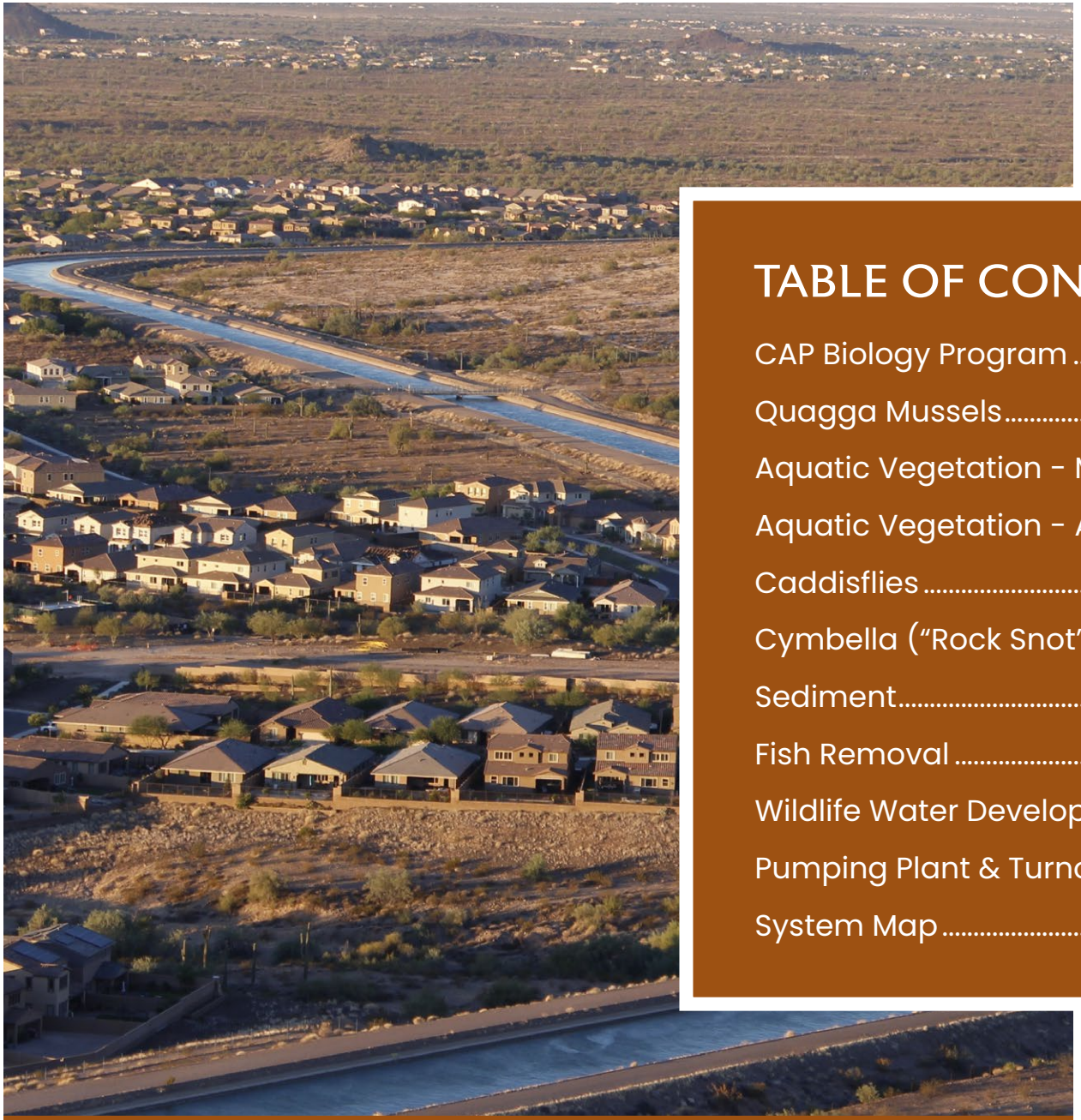
With 336 miles of aqueduct and more than 40,000 acres of property to manage, CAP faces a variety of biological challenges on a regular basis. The CAP Senior Biologist is responsible for addressing the multitude of biological issues that can affect CAP property, the aqueduct, and our ability to deliver water. Some of the issues facing CAP include:

- Quagga Mussels
- Aquatic Weeds
- Caddisflies
- Water Quality
- Fisheries Management
- Other Invasive Species
- Colorado River/Bill Williams River
- Multi-Species Conservation Program

These issues are addressed with comprehensive monitoring programs and focused research studies. In addition, the Senior Biologist works collaboratively with various local, state, and federal entities and represents CAP in the scientific community. Ultimately, it is the responsibility of the Senior Biologist to provide economically responsible management recommendations based on sound techniques and robust data.

The following annual report is a summary of the work completed in 2019, including a description of monitoring and research planned for 2020 that is based on the historical data and lessons learned from sampling efforts in previous years. The full annual report is available upon request.

COYOTE AT CAP HEADQUARTERS
Photo by Scott Bryan



POOL 17 OF THE CAP
Photo by Scott Bryan

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QUAGGA MUSSELS IN GLENDALE TURNOUT
Photo by Jim Geisbush

QUAGGA MUSSELS

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 regularly with monthly bio-box checks and annual trash rack inspections. Additionally, plant and aqueduct personnel report irregular findings related to quagga mussels as conditions dictate. In 2019, CAP Maintenance personnel completed preventative and corrective maintenance in several turnouts. As part of the evaluation of the turnouts, infestations of quagga mussels were photographed and reported.

FINDINGS

Quagga mussels continue to persist throughout the CAP system, but problems associated with the invasive species are relatively minimal. The exception is the cooling water system at MWP, where quagga and colonial hydroid settlement have caused increased cooling water temperatures at each of the motor units. This causes the motors to overheat and trip, requiring disassembly, power washing of the coolers, reassembling, and a restart. A chemical injection system has been designed and will be installed in 2020 to help prevent future settlement of invasives in this critical system.

Additionally, increased quagga occurrence in the bio-box and domestic water filters at BSH is cause for increased monitoring at the pumping plant. Quagga had not been found in the BSH bio-box prior to 2018, so persistence during the past two years may indicate that the population is beginning to take hold and has the potential to impact critical systems.

Turnouts continue to be infested with quagga mussels and other organisms (colonial hydroid, freshwater sponge, Asian clams, etc.). These organisms effect the flowmeters located within the barrels of the turnouts, so they need to be periodically dewatered and cleaned.

STRATEGIES FOR 2020

In 2020, CAP will continue to monitor quagga mussels throughout the system, with special attention paid to the expansion of mussel infestation at BSH. We will also work on practical solutions for preventing mussel attachment in turnouts so that flowmeters can operate unimpeded. Finally, Standard Operating Procedures (SOP's) for the maintenance of the newly installed chemical injection system at MWP will be developed as it begins operation in mid-2020.

Quagga mussels, freshwater sponge, and colonial hydroid found in GLETO in 2019. All three are considered invasive species and they create issues in turnouts by fouling flow meters and impacting flows.

Infestations in the cooling water system at MWP requires periodic power washing to ensure that motors do not overheat.

In 2020, all cooling units at MWP will be treated with copper sulfate to prevent quagga attachment.

QUAGGA MUSSELS, COLONIAL HYDROIDS AND SEDIMENT IN COOLING UNITS AT MWP
Photo by Scott Bryan

AQUATIC VEGETATION - MWP

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.

In 2010, CAP began collecting weed mats using a weed harvesting boat and long-reach excavator to prevent the mats from approaching and impacting MWP. In spring 2016, CAP installed a trash rake system at MWP to help ensure the reliability of the pumping plant and reduce/eliminate the need for the weed harvesting boat. However, even with a robust design, the rake system had difficulties in handling even moderately sized mats. Due to the frequent breakdowns and the uncertainty in the reliability of the trash rake system, it was largely abandoned in 2018. In 2019, CAP collected vegetation mats with a newly purchased weed harvesting boat and implemented a pilot herbicide treatment in a small portion of the intake channel.

VEGETATION GROWTH IN MWP INTAKE CHANNEL
Photo by Scott Bryan

APPROACH

Aquatic vegetation growth was monitored from April through September within the 65-acre CAP intake channel using downscan sonar (Lowrance HDS-9) and the BioBase® mapping service. In May 2019, a pilot study was conducted using an herbicide commercially known as Cascade® (salt of endothall). The treatment was applied to a 5-acre area within the MWP intake channel. The effectiveness of the treatment was measured through vegetation mapping and random sampling. During the "weed season" (July through September), CAP weed collection crews actively collected floating vegetation mats using the weed harvesting boat and recorded the volume of material removed. Lastly, a weather station was installed to determine if certain weather events could be correlated with the movement of weed mats.

FINDINGS

The pilot weed treatment was determined to successfully control the vegetation that was present at the time of application; nearly 99% of the vegetation (pondweed spp.) was eliminated within three weeks of the treatment. However, five weeks after treatment, vegetation began to grow within the study area. This new growth was determined to be a different species (naiad spp.) which was not present at the time of the initial treatment. The full report of findings and recommendations is available upon request.

Just 352 cubic yards of weed material was collected in 2019, which is less than 30% of the 10-year annual average and the second lowest total since 2011. This is partly due to the successful weed treatment, but since weed mat movement is largely attributed to wind events, the lack of significant monsoon storms in summer months likely also played a role.

STRATEGIES FOR 2020

In 2020, CAP will expand the Cascade® treatment to the entire 65-acre intake channel with two treatments: one in May to control pondweed species, and one in July to control naiad species. Vegetation coverage and plant height will be mapped bi-weekly to evaluate the effectiveness of the treatments and monitor overall vegetation growth. CAP weed collection crews will continue to harvest weed mats as necessary. CAP's weather station will be downloaded monthly to correlate weather/wind events with the movement of vegetation mats.

Floating weed mats are collected by a weed harvesting boat to ensure that the mats do not impact the MWP pumping plant.

A pilot weed treatment in May resulted in nearly 100% elimination of weeds in a 5-acre test plot.

AQUATIC VEGETATION GROWTH IN THE LOWER PORTION OF LAKE HAVASU IN 2019
Photo by Michael Rogers

ALGAE GROWTH IN POOL 15 IN APRIL 2019
Photo by Scott Bryan

AQUATIC VEGETATION - AQUEDUCT

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 to control aquatic vegetation in the CAP Aqueduct.

Grass carp stocked in Pool Bouse.

Filamentous algae growth in WAD Canal in August 2019.

Hester-Dendy samplers were used to collect diatom specimens in 2019.

APPROACH

Visual inspections are conducted periodically by Aqueduct crews and any potential issues are reported to the Senior Biologist. Additionally, areas with potential problems are identified during monthly helicopter flights and reported. Control of aquatic vegetation in the aqueduct is achieved utilizing triploid (sterile) grass carp.

FINDINGS

Relatively heavy precipitation throughout Arizona during spring 2019 resulted in increased runoff, and subsequently, nutrient spikes in the canal. This created ideal conditions for the growth of filamentous algae in the canal between HSY and WAD during March 2019. The algae persisted for much of the summer and was especially heavy in WAD Canal during August. Despite the heavy algal growth, water deliveries were not impacted. During late August, a light bloom of Cymbella (diatom) was observed in Pool 19. Although there was some floating debris, neither the algae nor the Cymbella appeared to create issues for CAP customers.

Grass carp were stocked throughout the system in February to maintain population levels for effective control of aquatic vegetation. As a result, there was no growth of rooted aquatic vegetation observed in the aqueduct.

STRATEGIES FOR 2020

Aqueduct crews will continue to visually monitor the system for growth of rooted aquatic vegetation, filamentous algae, and Cymbella. In addition, periodic helicopter flights will be used to identify problem areas. Grass carp stocking will continue and will target specific reaches of the canal where populations are less than optimal.

FLOATING ALGAL DEBRIS IN WAD CANAL IN APRIL 2019
Photo by Scott Bryan

CADDISFLIES

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 people did not live 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 the canal since 2011 with channel catfish 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.

CADDISFLIES EMERGE FROM THE CAP IN POOL BOUSE
Photo by Scott Bryan

APPROACH

Channel catfish are stocked annually during late February/early March. In 2019, approximately 4,475 catfish were stocked into Pools 21 and 22 . These fish averaged 8-12" and weighed approximately 0.50 pound each.

Names and addresses of residents calling with concerns about the caddisflies are recorded to determine where the caddisflies are creating a significant nuisance.

FINDINGS

Based on the number of phone calls received from concerned neighbors, nuisance caddisflies were especially troublesome in 2019. There were 34 total phone calls, with over half (18) coming from residents adjacent to Pool 20. Calls from residents in Pools 21-24 came primarily in July and August, while calls in Pool 20 were primarily in September and October. These were the first reports from residents near Pool 20 since CAP began to record names and addresses of callers. One reason for the increase in calls in Pool 20 is that these are relatively new neighborhoods, so nuisance caddisflies were not noticed in the past. In addition, the filamentous algae bloom in Pool Waddell and Pool 19 during spring 2019, may have created an ideal situation to produce a large caddisfly population. Finally, catfish have never been stocked into Pool 20 because it has not been identified as a problem area, so there were no control mechanisms in place.

STRATEGIES FOR 2020

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 (~0.5 lb) in Pools 21-24, and will add Pool 20 as a stocking location. CAP Communications employees will notify the public about stocking events.

CAP continues to work closely with specialists around the country, including Bullhead City, in an effort to find relief for residents adjacent to the canal. An online submission form will be available in 2020 that will allow residents to provide CAP with valuable information for determining where caddisflies are causing the biggest nuisance.

Caddislfies were found in the CAP as early as 1993, and were identified as Smicridea in 2004.

Channel catfish are stocked annually to help control nuisance caddisfly populations.

CADDISFLIES SWARM DURING EARLY MORNING HOURS IN POOL 19
Photo by Scott Bryan

MATS OF CYMBELLA SPP. FORM IN LATE SUMMER IN THE CAP
Photo by Scott Bryan

CYMBELLA ("ROCK SNOT")

Since the time of their discovery in the CAP (1997), stalk-forming diatoms have occasionally become a nuisance for both CAP and its customers. Cymbella can cause issues when it is attached to the concrete liner and when mats become detached 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 Operations 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 customers can also be impacted, as clogged intakes, filters, strainers, and pumps reduce their ability to effectively deliver water to end users.

Based on the timing of issues related to Cymbella, it appears that the proliferation of the diatom blooms and subsequent floating mats may be related to the frequency and intensity of water releases from source reservoirs (both Lake Havasu and Lake Pleasant) and the associated nutrient levels.

APPROACH

Diatoms were sampled bi-weekly from May through September at three locations within the CAP canal. Locations were chosen based on problem areas identified in the past and their proximity to Lake Pleasant: 1) Waddell Canal, 2) Pool 19 (Glendale), and 3) Pool 26 (Mesa). Sample locations within each pool were randomly chosen near access ladders.

Hester-Dendy 9-plate samplers were attached to a chain at three depths (2.5', 8', and 16.5') and allowed to rest on the concrete liner of the canal. The samplers were retrieved every two weeks. Upon retrieval, the top, middle, and bottom plates were scraped into a dissecting tray and preserved in Lugol's solution. Samples were then sent to a laboratory for identification, enumeration, and biovolume estimates.

FINDINGS

The laboratory identified microorganisms from 30 distinct Genus in samples collected from May through September 2019. Nineteen of which are classified as diatoms, eight as green algae, two as cyanobacteria, and one as protist. Cymbella were found at all three locations in each sample throughout the sampling period.

Cymbella population density followed a cyclical pattern at all three sampling locations in 2019, with peaks in late May, early July, and late August. Peaks in density were typically inversely correlated with cell size (i.e. higher population density when cells were smaller).

STRATEGIES FOR 2020

In general, 2019 sampling provided good baseline information about Cymbella and other microorganisms in the CAP. Because there was not a heavy bloom in 2019, it is more difficult to make conclusions based on the data collected. Regardless, the data provides framework for future Cymbella research in the canal.

CAP will continue to monitor growth of Cymbella through periodic visual observations in areas where the nuisance diatom has been a problem in the past. CAP will also rely on customer reports of issues caused by floating mats of "rock snot" as it occurs.

When Cymbella detaches from the canal liner, it forms dense mats that accumulate and can impact water flow, as well as clog filters, strainers and other critical infrastructure.

Cymbella cell with stalk under the microscope. Photo by Walker Ecological Services

CAP initiated a baseline study in 2019 to determine population dynamics of Cymbella in the canal.

CYMBELLA CAN GROW ON THE CANAL LINER AND CREATE ISSUES FOR CAP AND ITS CUSTOMERS
Photo by Scott Bryan

SEDIMENT

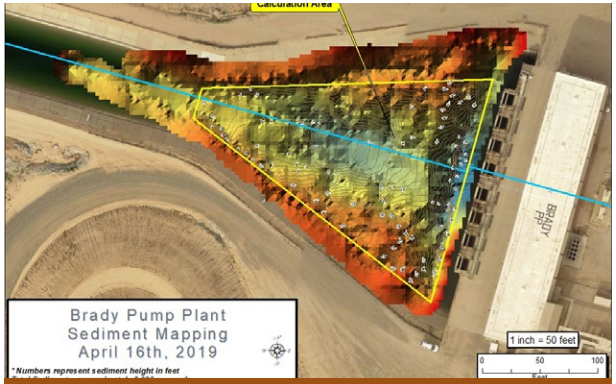
During the design phase of the CAP, it was recognized that sediment deposition could be problematic. Engineers looked into the inclusion of structures like sediment traps and de-silting plants, but ultimately determined that they were ineffective. Instead, forebays were designed to collect sediment near 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 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 Operations 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 PLUMES MOVING THROUGH THE CANAL
Photo by Scott Bryan

Sediment at SMATO in November 2019.

Sediment in SGL Forebay in November 2019.



Bathymetric maps are generated each spring to determine volume of sediment in each forebay.

APPROACH

As part of CAP's process to better understand patterns of sediment loading within the aqueduct, bathymetric mapping is conducted in each forebay and major turnout on an annual basis (since 2013). 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).

In March 2019, sediment removal using clamshell equipment was necessary at SROTO, CMATO, and SMATO to ensure that there was no disruption in water deliveries to customers. In addition, CAP took advantage of the complete dewater of SGL Forebay and SMATO in November 2019 to remove sediments using heavy equipment and clamshells.

FINDINGS

Sediment mapping in April shows that sediment volumes continued to vary greatly among pumping plants. As in previous years, SGL, BRD, and PIC have sediment volumes that are over 30% of the forebay capacity, and SAN is over 28%. BRW and SXV continued to have the lowest sediment volumes in 2019.

At SGL, CAP crews removed an estimated volume of 24,700 cubic yards of material (as determined through mapping) in just over 12 days. However, at large turnouts, the reach of the excavator/clamshell restricted the amount of sediment that could be removed (only 10-52% removed). Mapping following these removal efforts at turnouts indicates that sediment deposition was back to pre-removal levels within 9 months.

STRATEGIES FOR 2020

Sediment deposition continues to be an issue in the CAP System. Although some forebays had decreased levels in 2019, mapping shows that sediment volumes have an overall increasing trend. At SGL, sediment deposition increased to a point where over 40% of the forebay capacity was filled with material. Large turnouts continue to build significant sediment deposits and "mounds" regularly appear above water levels. Each forebay will be mapped again in spring 2020 and sediment loading will be compared to previous year's data. Sediment removal will be initiated when practical.

HEAVY EQUIPMENT IS USED TO HELP TO REMOVE SEDIMENT IN SGL FOREBAY DURING THE 2019 FALL OUTAGE
Photo by Scott Bryan

FISH REMOVED FROM SALT RIVER SIPHON IN NOVEMBER 2019
Photo by Scott Bryan

FISH REMOVAL

Central Arizona Project siphons are periodically dewatered to facilitate inspection and repair of the underground pipes. Each siphon needs to be completely drained to adequately assess its condition and make repairs, so fish removal becomes necessary. If fish are not removed, odors and off-gassing of the fish becomes intolerable for inspectors.

Pumping plant forebays are rarely dewatered, but when they are, CAP will remove fish to avoid large-scale mortality. Additionally, grass carp and channel catfish are valuable assets to CAP for vegetation and insect control, so "rescuing" as many of these fish as possible is in CAP's best interest.

Grass carp removed from SGL Forebay during fish removal activities in November 2019.

APPROACH

In January 2019, Hassayampa and Jackrabbit siphons were dewatered prior to inspection. When water levels reached approximately 18", CAP's Biologist led a crew into the siphon to seine and dip net fish from the remaining water. Fish were loaded into a hoist net or barrel and transferred to a fish hauling truck, where they were later released back into the canal. A similar approach was taken at Salt River Siphon in November, although a contractor was used to remove the fish.

Prior to the SGL Forebay dewater, CAP's Biologist worked with aqueduct crews and the Bureau of Reclamation to remove fish using trammel netting and boat electrofishing. CAP Operations reduced flows for five hours each night to allow for more effective fish removal. All captured fish were transferred to a fish hauling tank and transferred downstream of the pumping plant.

FINDINGS

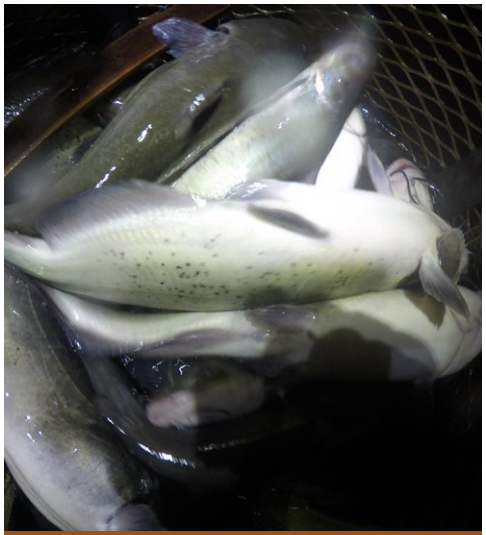
At Hassayampa and Jackrabbit siphons, 108 fish were captured and moved, all of which were channel catfish. At Salt River Siphon, an estimated 220 fish were removed, consisting of grass carp (35%), channel catfish (35%), common carp (25%), and striped bass (5%).

About 13 hours was expended removing fish from SGL Forebay. It was found that the trammel netting was ineffective in the higher flows, so a majority of the fish were captured via electrofishing. In total, 215 fish were removed from the forebay, with grass carp and common carp making up more than 75% of the catch. Striped bass, Sonora sucker, smallmouth bass, threadfin shad, channel catfish, inland silverside, and western mosquitofish were also collected. Once the forebay was completely dewatered, an additional 178 fish were left stranded. Those fish were removed during sediment removal operations.

STRATEGIES FOR 2020

There are no siphons or forebays scheduled for dewatering in 2020, so no fish removal will be necessary.

Fish captured in the siphons and SGL forebay are transferred to a fish hauling tank and transported to other sections of the canal.



Channel catfish captured at Jackrabbit siphon in January 2019.

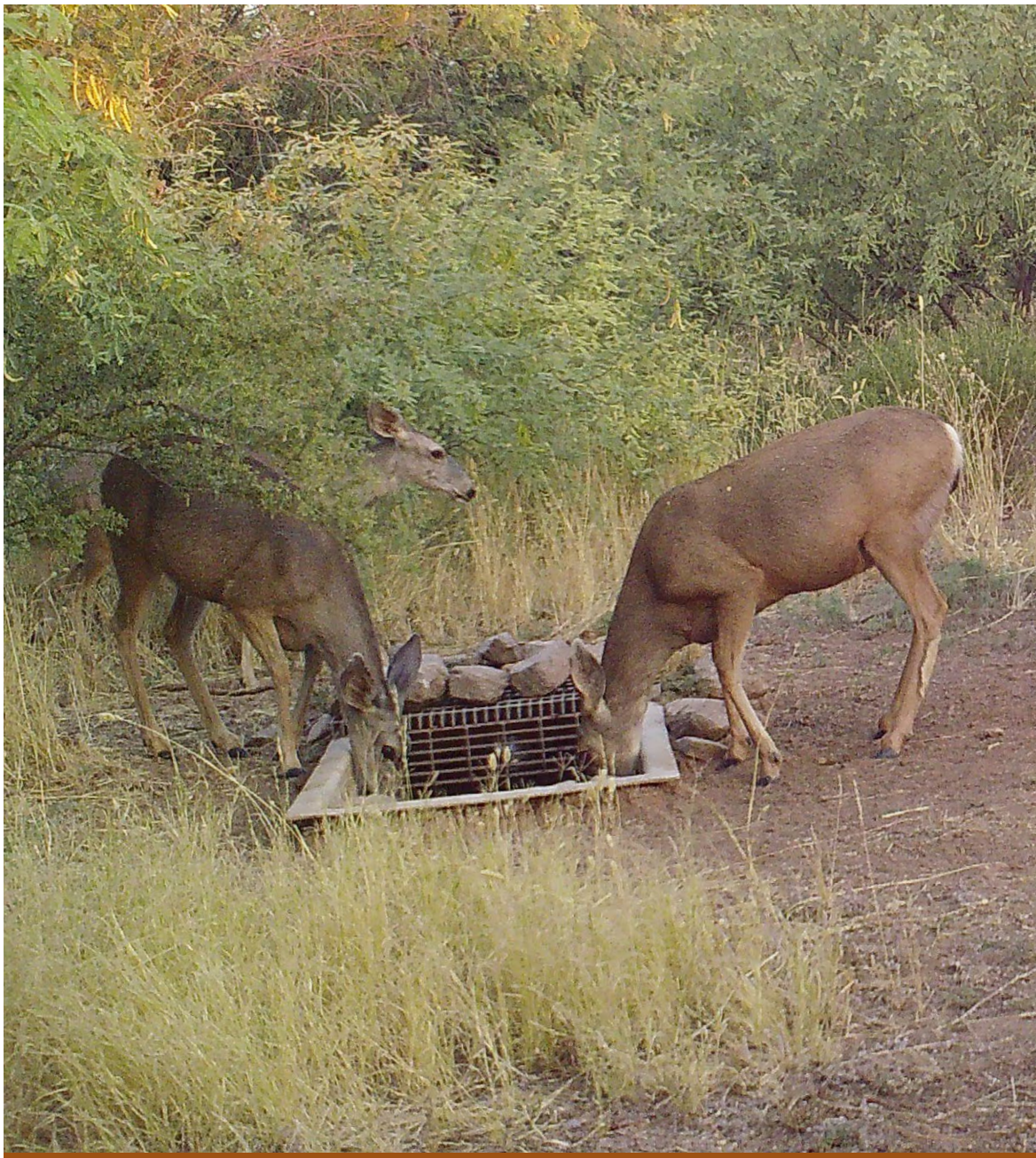
Trammel nets were used to remove fish from the SGL Forebay in November 2019.

FISH WERE REMOVED FROM THE SGL FOREBAY USING A BOAT-MOUNTED ELECTROFISHING UNIT IN NOVEMBER 2019
Photo by Christina Collins

WILDLIFE WATER DEVELOPMENTS

During construction of the CAP, it was recognized that the canal would create a man-made barrier to important wildlife corridors. This "barrier" would have the potential to alter migration patterns, segregate populations of wildlife, and restrict access to natural waters. An environmental impact study was completed prior to canal construction to determine these potential impacts and ensure compliance with state and federal regulations protecting fish, wildlife, and native plants. As a result of the various studies, wildlife bridges were constructed at strategic locations to maintain wildlife migration corridors, drainage structures were constructed to be "wildlife friendly," and water developments (drinkers) were created at several locations to ensure access to fresh water.

CAP is responsible for maintenance at a number of these drinkers to support wildlife populations. However it is not known how frequently the tanks are being utilized by wildlife or how often the tanks run out of water. This study was initiated to determine wildlife usage of the drinkers.



MULE DEER USING WATER DRINKER NEAR KLECK ROAD IN JUNE 2019
Photo by Scott Bryan

APPROACH

Wildlife usage was captured using Browning Strike Force Pro XD trail cameras. This camera model has dual camera lenses to capture both daytime and night photos with an 80-foot motion detection range. Night photos are taken with an infra-red flash so animals were not disturbed. Cameras were mounted in concealed locations near the water drinkers at a distance ranging no more than 50 feet. Capture delay was set at 30 seconds, so a large number of photos were not taken of the same animal on the same visit.

Cameras were downloaded every two weeks. Once downloaded, photos were grouped by animal species and the number of individuals in each photo were counted.

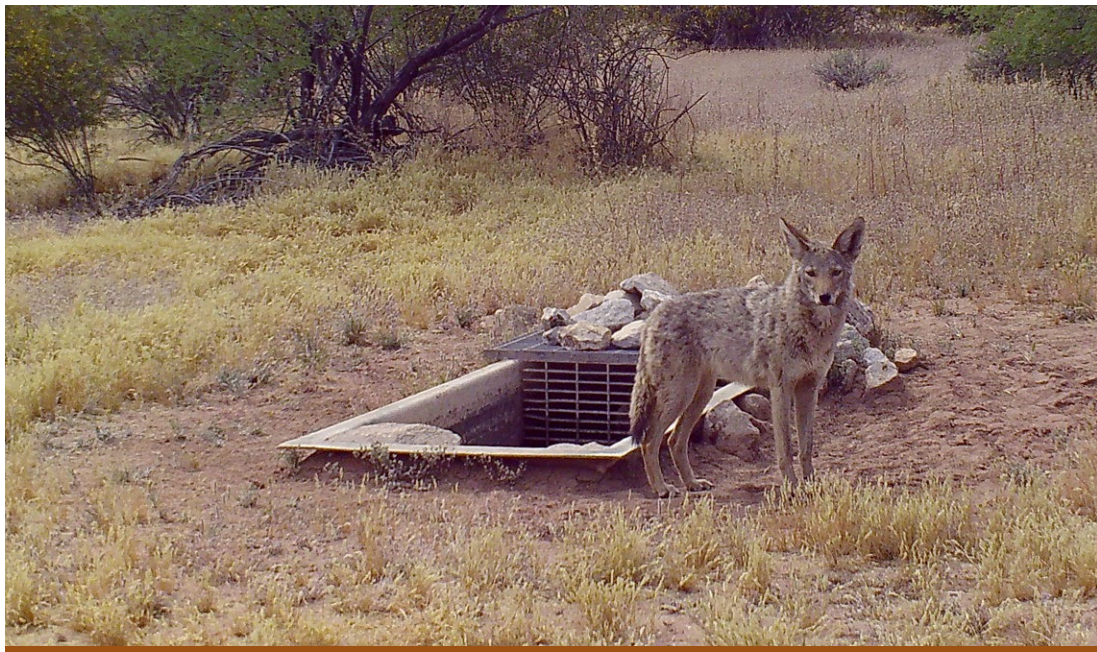
FINDINGS

During the course of the six month study, over 120,000 photos were taken. Of that, 32,087 photos captured wildlife using the drinkers with 13,260 unique visits. Mule deer, javelina (collared peccary), and coyotes were the most frequent non-bird wildlife species visiting the tanks; however, birds (especially dove, woodpeckers, and quail) were the dominant users of the tanks.

Based on the frequent wildlife visits, it is apparent that these water developments are important for a variety of wildlife species. This may be especially true in summer, as use was at its highest in the hotter months. CAP aqueduct crews should maintain these tanks on a quarterly basis to ensure that there is always proper water flow.

STRATEGIES FOR 2020

Additional tanks will be evaluated using similar methods. Recommendations will be made for maintenance schedules based on the usage of each tank.



Coyote at CAP wildlife water development near Kleck Road in April 2019.

Squadron of javelina (collared peccary) near the water drinker at Kleck Road.

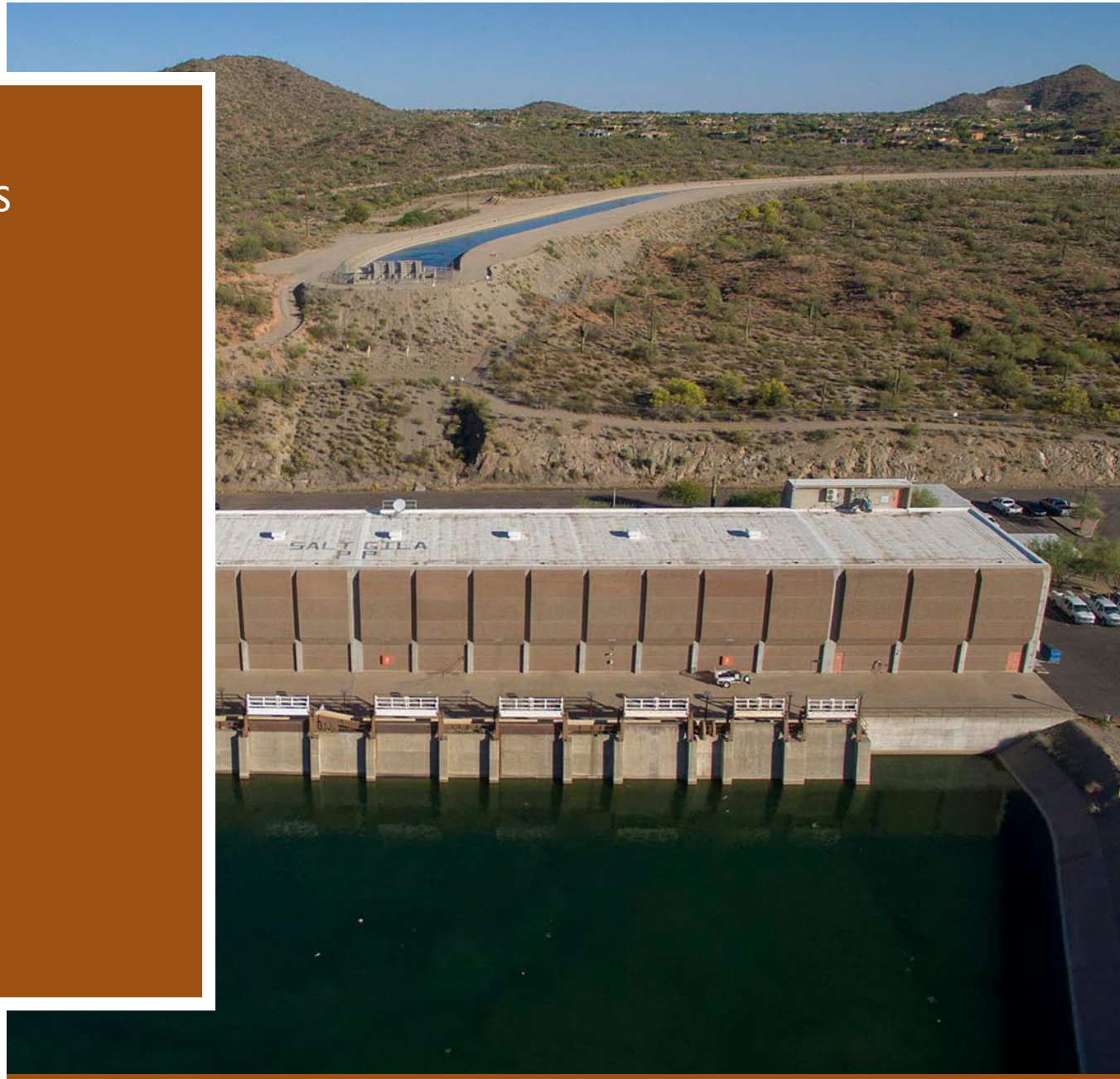
Red-tailed hawk at the wildlife water development near the Gila River.

BOBCAT USING WILDLIFE DRINKER NEAR THE GILA RIVER IN MAY 2019
Photo by Scott Bryan

APPENDIX

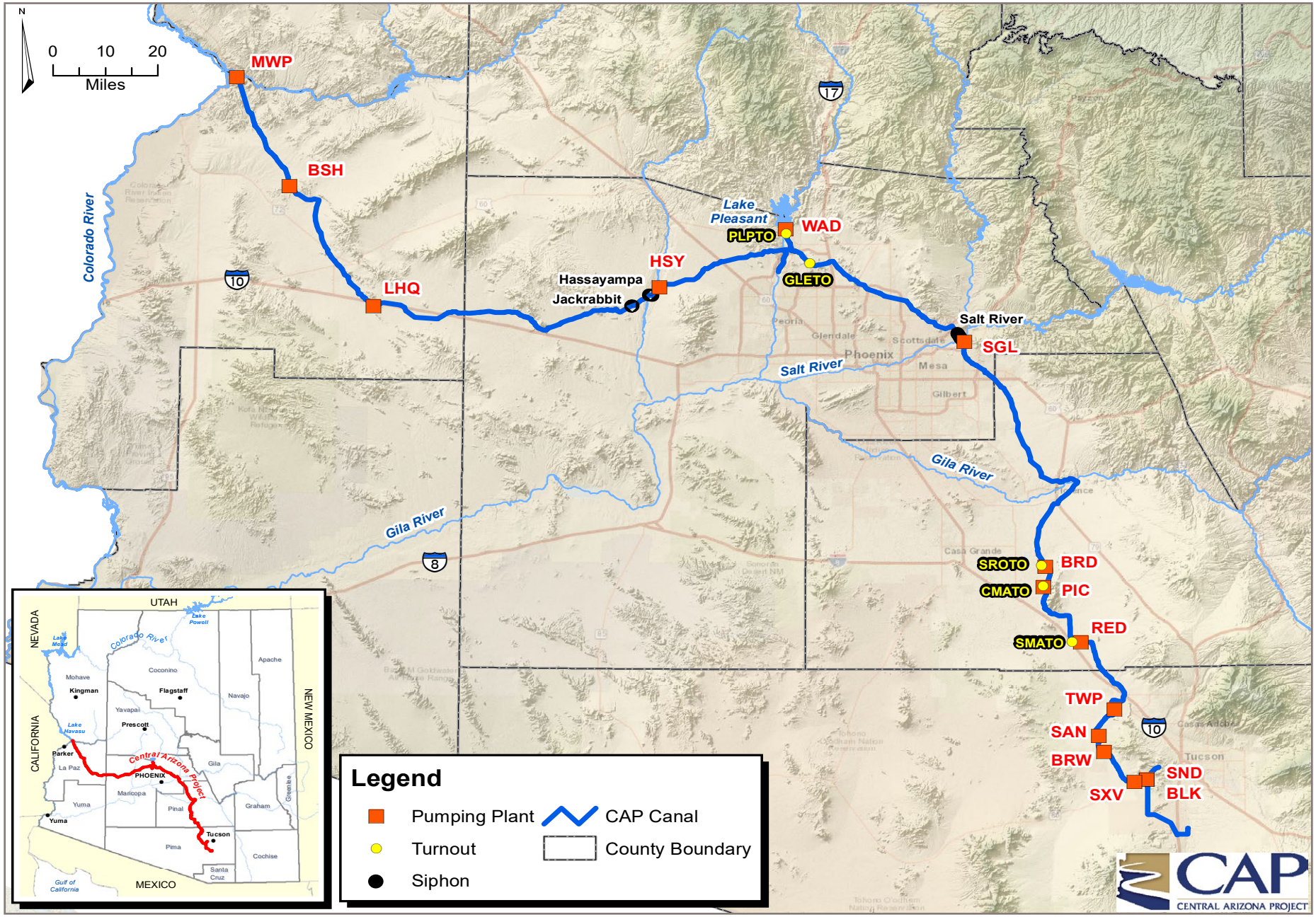
PUMPING PLANT AND TURNOUT ABBREVIATIONS

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
SNH	Snyder Hill Pumping Plant
BLK	Black Mountain Pumping Plant
GLETO	Glendale Turnout
PLPTO	Phoenix Lake Pleasant Turnout
SROTO	Santa Rosa Turnout
CMATO	Central Main Turnout
SMATO	South Main Turnout



SALT GILA PUMPING PLANT
Photo by Phil Fortnam

CAP SYSTEM MAP



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