mortality currently occurring at the plant, as well as a foundation for estimating the calculation baseline. The Rule requires that the IM Characterization Study provide:

1. Taxonomic identifications of all life stages of fish, shellfish, and protected species in the vicinity of the CWIS and susceptible to impingement;
2. A characterization of these species and life stages in terms of their abundance and their spatial and temporal distribution, sufficient to characterize the annual, seasonal and diel variations in impingement mortality; and
3. Documentation of current impingement mortality of these species and life stages.

In addition to these basic requirements, the IM Characterization Study can provide information necessary for the permit applicant to choose the appropriate Rule compliance alternative, such as applying for a site-specific determination of BTA. To justify this alternative, the results of the IM Characterization Study are needed to evaluate the benefits of implementing technology, operational, or restoration measures, in terms of the numbers or biomass of fish and shellfish potentially saved by their implementation.

The Phase II Rule allows impingement mortality to be quantified either for all taxa or through the use of Representative Species (RS) as part of the compliance assessment. RS are chosen to be surrogates for other species not selected for detailed study. RS typically are those most frequently observed in impingement and entrainment collections, or those deemed to be most important because of their economic value (e.g., commercially or recreationally exploited species), value to the ecosystem (e.g., abundant prey species), or societal value (e.g., threatened or endangered species). Since biological information necessary to complete analyses for the CDS are not available for all species, we believe it is both more practical and more technically defensible to base all analyses on RS. In this sampling plan, we provide the technical rationale for the RS likely to be used for Four Corners.

1.2 SAMPLING PLAN OBJECTIVES AND ORGANIZATION

This Impingement Mortality Sampling Plan has been prepared to meet the following objectives:

1. To identify and summarize existing data on the fish community in the vicinity of the station's CWIS;
2. To identify and summarize existing data on fish impingement mortality within the station's CWIS;
3. To evaluate the sufficiency of existing data to describe the current fish abundance and spatial and temporal distribution of fish in the vicinity of the station's CWIS, and the current rates of impingement mortality;
4. To make an initial selection of RS; and
5. To prepare a work scope for a monitoring program to quantify impingement mortality at Four Corners.

This sampling plan is organized to first present background information on the station, including the source waterbody (Section 2.1), the cooling water intake design and operation (Section 2.2), historical biological data (Section 2.3), and a discussion of the need for data for the IM Characterization Study (Section 2.4). Section 3 describes the fish community in the vicinity of the station's CWIS, using available historical data. Section 3 also briefly summarizes life history information for RS. Section 4 describes the recommended sampling scope for impingement monitoring. This program work scopes describes the recommended sampling design, sampling gear and its deployment, sample processing procedures, collection of any required ancillary information, and data analysis. Section 5 provides recommendations for a quality assurance program, which will address data quality concerns.

2. BACKGROUND INFORMATION

This section presents a summary of available information on the Four Corners Generating Station regarding its source waterbody, Morgan Lake; the design and operation of the facility; and previous biological studies at the station and in the source waterbody.

2.1 SOURCE WATERBODY

The Four Corners Generating Station is located on Morgan Lake, which is on Navajo Indian Reservation Tribal Lands in northwestern New Mexico near the town of Fruitland in San Juan County, approximately 17 miles southwest of Farmington (Figure 2-1). Morgan Lake was constructed during 1959 to 1961 to serve as a cooling water reservoir for the station and a water source for BHP's Navajo Mine. Morgan Lake was formed by constructing an earthen dam at the western end of a natural basin south of the San Juan River. Dikes with spillways were built on the south and east sides for water level control. Morgan Lake has a surface area of approximately 1,200 acres and a storage capacity of 39,000 acre-feet at a surface elevation of 5327.5 feet above mean sea level.

Morgan Lake is described further in Section 3.1, Aquatic Habitat.

2.2 INTAKE DESIGN AND OPERATION

Cooling water is withdrawn from Morgan Lake into an intake canal, which has a 120-foot long skimmer wall barrier at its mouth (Figure 2-2). The opening beneath the skimmer wall was built to be 9.5 feet high, but clearance is now about 6 feet due to siltation. Lake depth at the skimmer wall is about 50 feet. The canal serves Units 1, 2 and 3, and a branch of the canal extends around to the rear of the station where it terminates at the intake structures for Units 4 and 5.

Units 1, 2 and 3 share a 115.5-foot long intake structure that contains nine bays: two 9.75-foot wide bays each for Units 1 and 2, four 11-foot wide bays for Unit 3, and a 6.17-foot wide service water bay. The intake contains seven traveling screens, i.e., two screens per unit plus a service water screen. The Unit 1 and 2 screens are 8.5 feet wide, the Unit 3 screens are 10 feet wide, and the service water screen is 5 feet wide. The screens have ¼-inch woven wire mesh and can be rotated at either 5 fpm or 10 fpm. Typical operation includes screen rotation once per day, but the screens will rotate automatically based on the head differential. Debris and fish are washed from the front of the screens into a sluiceway that leads to the intake canal branch for Units 4 and 5.

Units 4 and 5 share an 84.5-foot long intake structure, which contains four bays (two per unit) and four 14-foot wide traveling screens. There are no trashracks. Screen mesh size is 3/8-inch, and screens are rotated automatically based on head differential. Debris and fish are washed off the screens into a common sluice that leads to a large rectangular mesh collection basket placed within a pit at the end of the sluiceway and row of screen housings. Fish and debris in the collection basket are then disposed, with no means for return to the lake.

Cooling water from all units is discharged to the lake via a canal at a location east of the facility.

2.3 HISTORICAL DATA

The limnology and biological community of Morgan Lake has been studied since the creation of the lake in the early 1960's. These studies have documented the progression of the biological community as the heated discharge was added to the lake and as various fish and other species were introduced into the community. Morgan Lake is managed as a recreational lake and fishery by the Navajo Department of Fish & Wildlife (NDF&W) and the U.S. Fish and Wildlife Service (USFWS). Fish impingement at the station has never been monitored. The following sections briefly describe previous studies on the fish community of Morgan Lake and the type of information available from these studies.

2.3.1 Impingement Studies

No formal impingement studies have been conducted at the Four Corners Generating Station, so there are no historical data on species impinged or rates of impingement. However, visual observations made on September 10, 2004 indicated that the bulk of fish currently being impinged are gizzard shad, with occasional sunfish, channel catfish, or other species.

2.3.2 Fish Community Studies

In a February 1966 report, Southern California Edison Company chronicled the information recorded on the fish, wildlife, and recreational use of Morgan Lake from its creation in 1961 through 1965 (SCE 1966). Information provided included successful and failed stocking efforts beginning in October 1961, accidental introductions of fish species to the lake, seasonal thermal stratification and dissolved oxygen concentrations, disease and parasitism documentation, effects of added thermal inputs, evidence of natural reproduction of fish species, lake productivity and trophic relationships, and water chemistry.

In 1966, Edward Schmidt began graduate research on Morgan Lake that continued until 1970 (Schmidt 1970). He kept a daily log that included information on fish, wildlife, and aquatic vegetation; weather conditions; water chemistry; seasonal temperature and dissolved oxygen (DO) profiles; diseases and parasitism; growth rates of fish; thermal tolerance testing in experimental ponds located adjacent to the discharge canal; lake productivity and trophic relationships; observations of fish impingement on the station's traveling screens; recreational fishing; and movements of tagged fish.

Northern Arizona University conducted aquatic studies on Morgan Lake for APS from 1975 through 1977 (Blinn et al. 1975, 1976, 1977). These studies continued the overall monitoring program of the lake begun in the 1960's, as the limnology and fish community evolved under added thermal loading. These studies documented the composition and relative abundance of species in the fish community; the occurrence of fish kills; annual variation in seasonal water temperatures and DO; seasonal and annual benthos, zooplankton and algal abundance; and fish spawning. In 1975, sampling was limited to physico-chemical measurements and phytoplankton from late May until mid-September. In 1976, sampling was extended to include zooplankton and fish, and in 1977 benthos sampling was added. In 1976, sampling occurred monthly from June 10 to October 1. Sampling in 1977 also was monthly, from March 25 to September 8. Fish were sampled using 21.3-m x 1.8-m variable mesh (2.5, 3.8, 5.0 and 6.4 cm) gill nets set for 24 hours at the surface, thermocline, and bottom at mid-lake locations. In 1977, the shoreline of the island near the terminus of the discharge canal was added as a gill net sampling location. A 6.1-m x 1.0-m seine with 3-cm mesh was used to sample the shoreline during June 1976 and June 1977. Data recorded by species from all samples included numbers captured, lengths, weights, gonadal weights, reproductive condition, and stomach contents.

The NDF&W and the USFWS continue to collect data on fish in Morgan Lake as part of the management activities for the lake's recreational fishery. A fisheries survey was conducted in November 2004 and another survey is proposed for March 2005. Data from the November 2004 survey were not available at the time of the preparation of this sampling plan.

Available results from the studies discussed above are incorporated into a description of the fish community presented in Section 3.2.

2.3.3 Sufficiency of Existing Information for IM Characterization Study

As described in Section 1.2, the IM Characterization Study requires biological data on the following:

1. Identification of fish and shellfish life stages and species in the vicinity of the CWIS and susceptible to impingement;
2. Their abundance and spatial/temporal distribution, sufficient to characterize the annual, seasonal and diel variations in impingement mortality; and
3. Documentation of current impingement mortality of these species and life stages.

As demonstrated above, there is some information available on the fish community of Morgan Lake. However, most of the information is dated.

The requirement for documentation of current impingement mortality at Four Corners would not be satisfied, since formal impingement monitoring has not been previously conducted. Therefore, an impingement monitoring program is proposed to document diel, seasonal and annual impingement mortality that reflect the current status of the fish community and the current intake operation.

The remaining sections of this sampling plan are devoted to describing the fish community for the purpose of a preliminary selection of representative species and to outlining a recommended sampling scope for monitoring impingement at Four Corners.

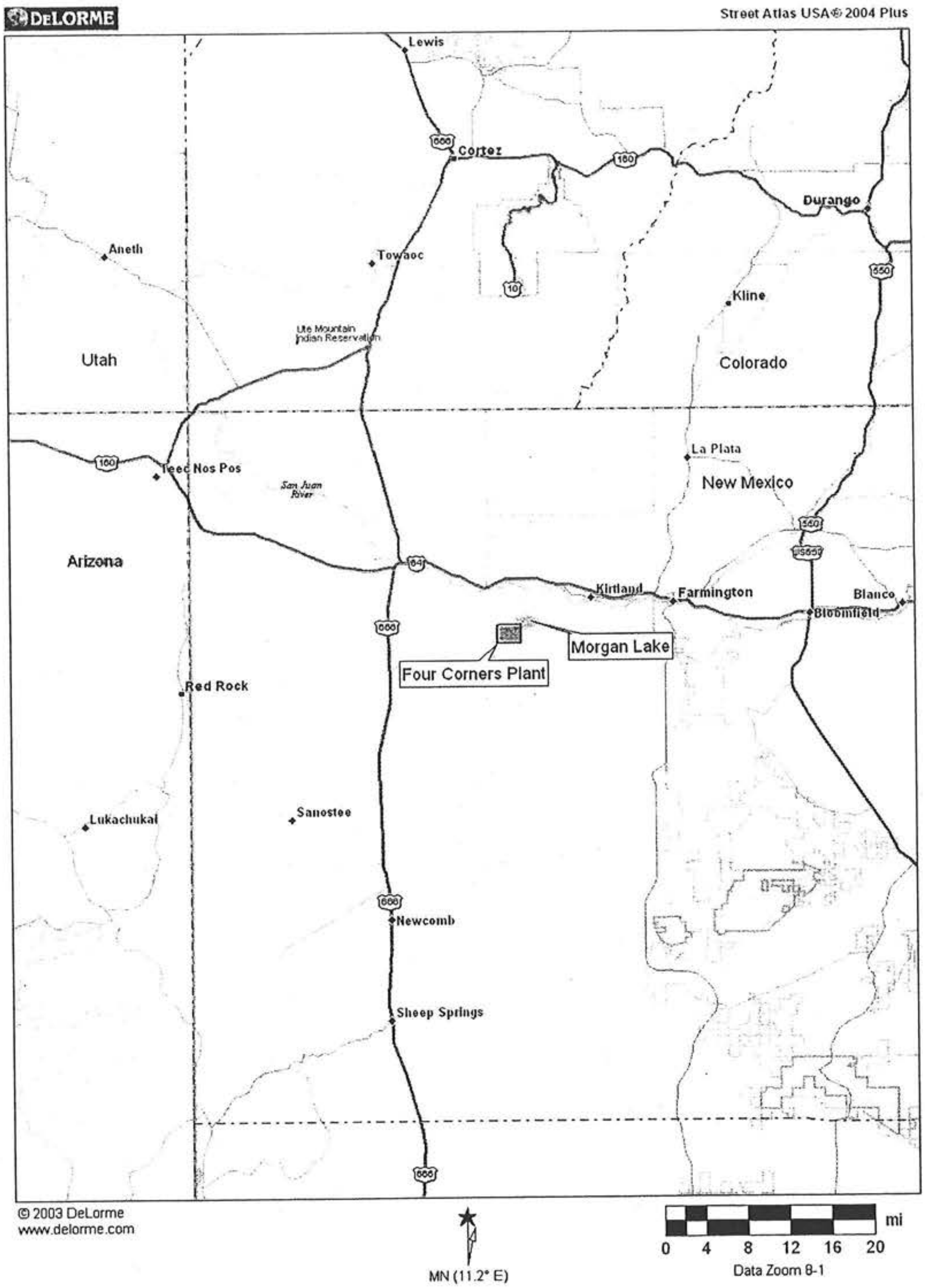

Figure 2-1 Location of the Four Corners Generating Station.

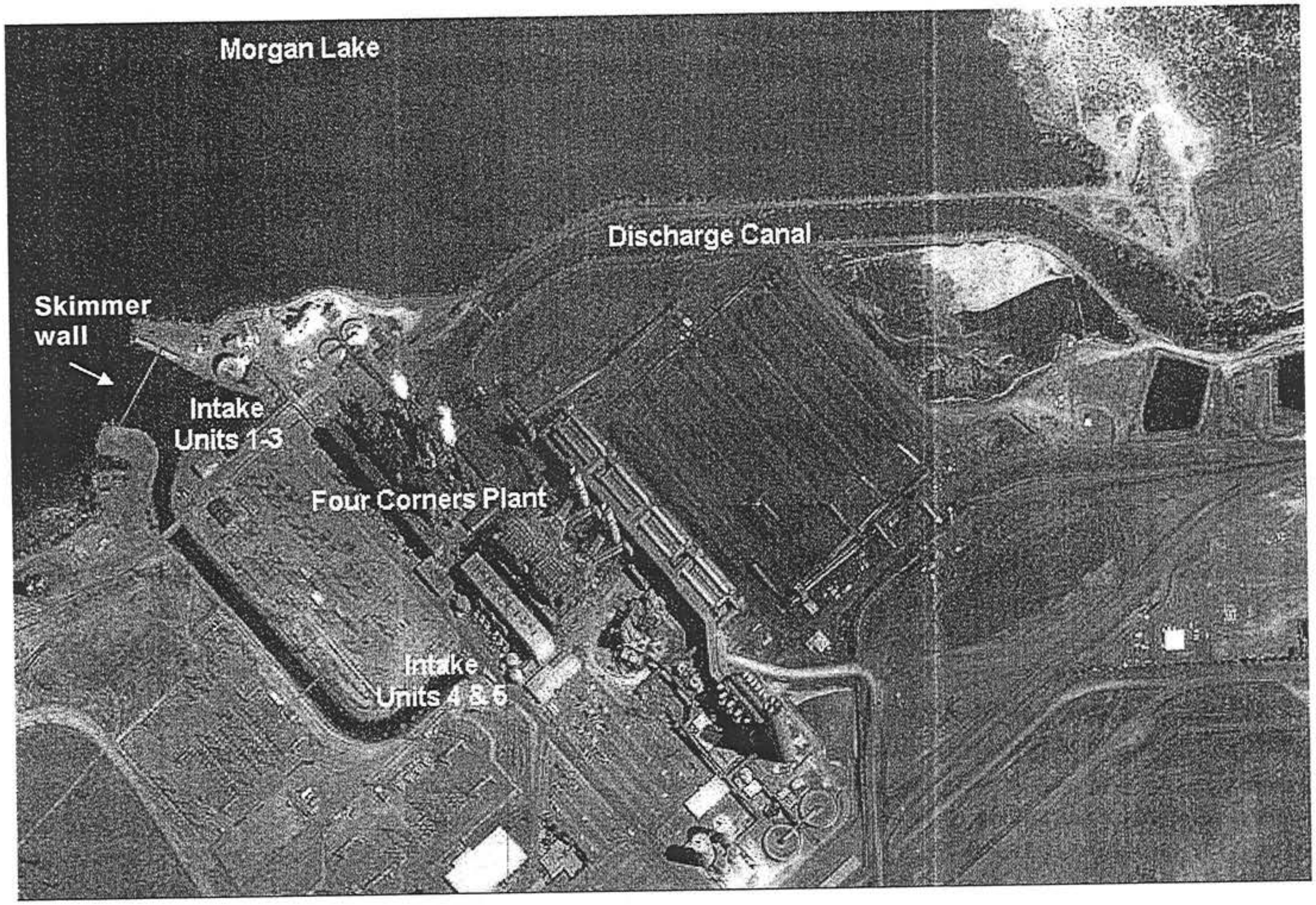

Figure 2-2 Aerial view of the Four Corners Generating Station.

3. FISH COMMUNITY

This section describes the aquatic habitat and the fish community of Morgan Lake. A preliminary list of Representative Species for detailed study is then recommended for the Four Corners Generating Station on the basis of their apparent abundance in the lake or importance due to their economic value, ecosystem role, or protected status.

3.1 AQUATIC HABITAT

At full pond with the surface elevation at 5327.5 feet above mean sea level, Morgan Lake has a surface area of 1200 acres and storage of 39,000 acre-feet. Average depth in the lake is approximately 15 m (49.2 feet). The lake stratifies during warm months, which results in dissolved oxygen (DO) deficits in the hypolimnion. In 1977, the thermocline began to form in late May at a depth of 14 to 16 m, and the lake remained stratified until September 1 (Blinn et al. 1977). Maximum water temperatures (33 °C) were reached by the end of June. When surface water temperatures reached 33 °C, DO saturation levels were less than 50 percent in the epilimnion (3.1 mg/l) and were as low as 0 percent in the hypolimnion. In the spring, turbidity increased as the result of the inflow from the San Juan River carrying sediments from spring runoff. Overall Secchi disc transparency (0.6-1.3 m) may have been reduced to some degree by the fly ash load in the water column (Blinn et al. 1977). The pH ranged from 8.1 to 8.7 during the March to September study period in 1977.

As the lake environment evolved under the increased thermal loading from the station's discharge, changes in the biological community were noted, including the elimination of species that could not adapt to the thermal loading and its effects. In 1977, zooplankton populations were observed to decrease in favor of dominance by blue green algae as water temperatures increased and DO concentrations decreased (Blinn et al. 1977). Benthic populations (primarily chironomids and oligochaetes) also declined from the effects of increased temperatures, which together with decreased zooplankton resulted in a decreased forage base for fish. Fish kills occurred in some warmer summers, such as 1973 and 1974, from stress brought on by the higher water temperatures and lower DO concentrations, and possibly related to the decline in the condition of fish species attempting to adapt to the lake's environment. This phenomenon was not as apparent in the summers of 1975 through 1977 (Blinn et al. 1976, 1977). Hypoxic conditions in the hypolimnion restricted fish and plankton distribution to the shorelines or above the thermocline during the summer.

More recent data on the health of the ecosystem were not available at the time of the preparation of this sampling plan. NDF&W recently has conducted mercury and fish tissue analysis for the lake, but the results were not available. A recent accidental introduction of gizzard shad to Morgan Lake has resulted in an abundance of this species, and likely a major shift in the trophic relationships of the lake.

3.2 COMMUNITY COMPOSITION

When Morgan Lake was created in 1961 there was concern over the species that would become established in the lake to create an active sport fishery, and whether they could adapt to the thermal environment. In October 1961, rainbow trout (*Oncorhynchus mykiss*) and channel catfish (*Ictalurus punctatus*) were stocked when there was no thermal input to the lake (SCE 1966). Rainbow trout stocking continued in 1962, as well as threadfin shad

(*Dorosoma petenense*) in April 1962. In this year, it became apparent that some species, such as fathead minnow (*Pimephales promelas*) and the native species speckled dace (*Rhinichthys osculus*), also had been introduced unintentionally to the lake, possibly from the San Juan River. In 1963, black bullheads (*Ameiurus melas*) were discovered in the lake, and threadfin shad were again stocked. Largemouth bass (*Micropterus salmoides*) were stocked as fingerlings in July 1963. After Unit 2 went on line, rainbow trout appeared to have succumbed to the increased thermal loading and to an infestation of parasitic anchor worms by August 1963. Threadfin shad did not appear to take on, so this species was stocked again in the spring of 1964, along with northern pike (*Esox lucius*). In the fall of 1964, the exotic species *Tilapia mossambica* was stocked. Green sunfish (*Lepomis cyanellus*) became established in the lake in 1965, and fingerling channel catfish were stocked again to supplement natural reproduction. By 1966 largemouth bass and channel catfish became the dominant sport fish species in the lake. *Tilapia* were eliminated by winter temperatures below their lower lethal limit (55 °F), and fathead minnows and northern pike were much reduced in abundance due to predation or lack of natural reproduction. Bluegills (*Lepomis macrochirus*), flannelmouth suckers (*Catostomus latipinnis*), and desert minnow (*Lepidomeda* sp.) were discovered in the lake. The flannelmouth sucker is a native species for this drainage basin.

By 1976, gill net catches in Morgan Lake were dominated by common carp (*Cyprinus carpio*) and channel catfish, with green sunfish and the native species bluehead sucker (*Catostomus discobolus*) present in much smaller numbers (Blinn et al. 1976). Some species present during the 1960's may have been eradicated during the fish kills experienced in the summers of 1973 and 1974. Sampling in 1977 found channel catfish, common carp, and bluegill to be the numerically dominant species. Green sunfish, largemouth bass, black bullhead, and western mosquitofish (*Gambusia affinis*) were less abundant.

More recent data on fish species composition and relative abundance in Morgan Lake are not available. NDF&W states that largemouth bass, channel catfish and green sunfish are now the primary game fish species in the lake. Bluegill previously were abundant and were the preferred forage species for largemouth bass, but a die-off of bluegill recently occurred and the population has not rebounded (personal communication, Jeff Cole, NDF&W). Summer fish kills from high temperatures and low DO concentrations have reduced the populations of both largemouth bass and bluegill. Gizzard shad is now serving as the primary forage species although it is considered a nuisance species by the fisheries management agencies. Gizzard shad apparently were introduced to the lake accidentally in a shipment of largemouth bass from a national fish hatchery in Texas. Fathead minnows and green sunfish also are important as forage fish.

NDF&W is managing Morgan Lake as a quality fishery for largemouth bass, which currently is requiring stocking of 4,000 8-inch long largemouth bass every other year. Stocking in the future may become annual. When available, 4000 to 8000 channel catfish also are being stocked. Stocked fish come from the national fish hatchery system in Texas or are removed from the San Juan River as non-native species as part of the recovery efforts by the San Juan River Recovery Implementation Program for two endangered species, the Colorado pikeminnow and the razorback sucker (see Section 3.2.1).

Several species other than those reported in previous studies likely occur in Morgan Lake, including aquaria fish species introduced by the public, such as pacu (*Piaractus brachypomus*) and *Plecostomus* catfish (personal communication, Jeff Cole, NDF&W). Impingement sampling at Four Corners may identify additional fish species in the lake.

3.2.1 Gizzard Shad as a Nuisance Species

The NDF&W in January 2005 identified nuisance species, including the gizzard shad, as those species that were inadvertently introduced into Morgan Lake. These species negatively impact the management of recreational sport fish and preferred prey species and may even pose a risk to threatened or endangered species in nearby waterbodies (i.e. San Juan River fisheries management and recovery projects). In 1999 the USFWS identified gizzard shad in Morgan Lake as a threat to the downstream systems and had considered methods for extirpating the gizzard shad from Morgan Lake (e-mail correspondence). Although gizzard shad are an abundant forage species, APS proposes to exclude the gizzard shad from the IM Characterization Study in concurrence with the management interests of the Navajo Department of Fish and Wildlife (NDF&W letter, dated January 2005).

3.2.2 Protected Species

No regional native fish species have been found in Morgan Lake (personal communication, Jeff Cole, NDF&W). Therefore, none of the species collected from the lake are currently listed or proposed (http://www.endangeredspecie.com/states/nm.htm) as endangered or threatened species or species of concern.

Four of 14 fish species native to the upper Colorado River basin are listed as endangered (http://www.r6.fws.gov/coloradoriver/Crovervu.htm): Colorado pikeminnow (*Ptychocheilus lucius*), razorback sucker (*Xyrauchen texanus*), bonytail (*Gila elegans*), and humpback chub (*Gila cypha*). Of these, only the Colorado pikeminnow and razorback sucker are native to the San Juan River, the water source for Morgan Lake. Efforts to reestablish these two species in the San Juan River are led by the San Juan River Recovery Implementation Program (SJRIP), formed in October 1991 by the States of New Mexico and Colorado, USFWS, U.S. Bureau of Reclamation, U.S. Bureau of Indian Affairs, U.S. Bureau of Land Management, and several tribes including the Navajo Nation.

The stated goals for the SJRIP are to reestablish the endangered fish in the San Juan River Basin and to accommodate the needs of future water development. Recovery of the two endangered species is being pursued by directed research on the river, stocking of the two species, and water flow management, potentially through seasonal releases from the Navajo Dam mimicking a natural hydrograph and water rights management. Morgan Lake may be the recipient of non-native fish intentionally transplanted from the San Juan River in an effort to reduce competition and predation on the two endangered species and other species native to the river. Presently, there is only very limited natural reproduction of the Colorado pikeminnow in the river (Platania et al. 2000) and no wild razorback suckers have been found there (Ryden 2000a, 2000b).

3.3 REPRESENTATIVE SPECIES

Representative Species (RS) typically would be those most frequently observed in impingement collections, or the most important based on their economic value, value to the ecosystem, or protected status. In addition to being the target species for evaluating compliance with impingement mortality reductions, RS can be used to estimate the economic losses by fish impingement mortality for a cost-benefit analysis under the EPA site-specific compliance alternative #5 or for scaling restoration efforts and verifying the success of restoration alternatives. It would be important to collect length, weight, and age data from RS during the impingement monitoring program in order to estimate individual growth rates and biomass production for species used in the cost-benefit and restoration analyses. Such detailed analyses would not be possible or practical for all species impinged. Therefore, RS would serve as surrogates for other species of less critical importance or abundance.

Since no impingement monitoring has been conducted at the station, a preliminary selection of RS instead can be made based on current abundance in the lake and importance as either forage species or recreational species. Three species are proposed as potential RS because of their importance to the recreational fishery of Morgan Lake and the possibility that they will be among the more frequently impinged species. These species are the largemouth bass, channel catfish, and green sunfish.

This section presents the rationale for choosing each species, along with a brief summary of its life history. As impingement monitoring progresses, this list could be modified to reflect actual conditions.

3.3.1 Largemouth Bass

The largemouth bass is a candidate RS because of its importance as a recreational species and a predator at the top of the food chain. Morgan Lake is actively managed by NDF&W as a largemouth bass fishery. NDF&W regularly stocks 8-inch bass into the lake to maintain the fishery, since natural reproduction of this species in Morgan Lake may be limited and survival may be reduced by summer water temperatures and low DO. Preferred water temperatures range from 26.6 °C to 27.7 °C, and DO concentrations must be above 1.5 mg/l (Emig 1966a). At this time, the extent of impingement of largemouth bass at the Four Corners Generating Station and the relationship of stressful temperatures or DO conditions to impingement are unknown.

In most locations, largemouth bass spawn in May-June when water temperatures reach 60-75 °F (15.5-23.9 °C). The male builds a nest in substrate that typically is rocky or gravel, but may include submerged vegetation or at least a silt-free environment. The nests are 2-3 feet in diameter and usually widely spaced (e.g., 30 feet apart) unless the available nesting area is limited. Nests are built in areas of no current or wave action at depths of 1 to 15 feet. More than one female may spawn in a nest. Males remain at the nest to fan the eggs to keep them silt-free and to protect the young for up to 2 weeks (Pflieger 1997). Eggs hatch in 3-4 days and the fry form tight schools over the nest and begin to feed in 5-8 days. The schools break up approximately 1 month after hatching and when the young bass are approximately 1 inch long. Growth rates are variable and depend on the lake productivity and food availability. Largemouth bass mature at about ages II to III, or about 10 inches in length (Pitlo et al. 2004a).

Adult largemouth bass typically spend the daylight hours at depths near submerged structures and move into shallow water at night to feed. They remain within a home area both in summer and in winter, but the summer and winter areas may be distant from each other. Like other species in Morgan Lake, their seasonal distribution in the lake will be determined by the local thermal and DO environment. Their growth and abundance is related to the availability of their forage base.

Unless natural reproduction of largemouth bass is significant in Morgan Lake, the vulnerability of this species to impingement would be reduced, since they would occur primarily as adults of a stockable size (8 inches) or larger.

3.3.2 Channel Catfish

The channel catfish also has been an important recreational fish species in Morgan Lake and apparently is relatively abundant, indicating it has adapted to the thermal environment of the lake. It is a large predator, in some locations reaching more than 25 pounds and 36 inches (Smith 1985, Pitlo et al. 2004b). In the early stages of the lake's development, it was apparent that natural reproduction of channel catfish in Morgan Lake may have been limited. Whether or not channel catfish are now successfully reproducing is uncertain. NDF&W continues to stock this species into the lake.

Channel catfish spawn in May and June when water temperatures reach 65°F or more (Pitlo et al. 2004b). Often there are two or more spawning peaks. Several weeks prior to spawning, males select and clear suitable nest sites, usually consisting of secluded, dark areas such as hollow logs, drift piles, undercut banks, muskrat or beaver burrows, or rip rap. Eggs are deposited in a gelatinous mass. The male tends the nest while eggs hatch and stays there for about 1 week to guard the fry. Early growth is variable among year classes and apparently is dependent upon existing conditions (Pitlo et al. 2004b). Channel catfish begin to mature at age IV and 12 inches in length, and 75 percent are mature by age VI.

Adults may be found in many habitats but in daylight appear to prefer cool, deep areas with woody debris, bank cavities or other structure (Koel et al. 1998). Adult channel catfish will feed in daylight or darkness, but at night they tend to feed in shallower depths.

3.3.3 Green Sunfish

Green sunfish have been documented as residents of Morgan Lake since 1965. This species can serve as a forage fish for predators such as channel catfish and largemouth bass, and is a recreational panfish species. The green sunfish is not a native species in New Mexico. It is tolerant of a wide range of environmental conditions including turbidity and silt loading, DO concentrations, flow and temperature (Smith 1985, Pflieger 1997). This tolerance may be the reason why this species persisted in the lake after die-offs of bluegill and largemouth bass caused by low summer DO levels.

Green sunfish begin to spawn as water temperatures reach 68 to 70°F, and continue spawning, often until early August or when temperatures reach 82 °F (Smith 1985). Males build nests in water typically 1 foot deep or less, or in areas protected by rocks or logs. Nests often can be grouped by green sunfish are not considered to be colonial spawners (Pflieger 1997). Eggs hatch in 3 to 5 days, and fry leave the nest after an additional 6 or 7 days. The male fish will tend to the nest and young during this period. This spawning process can be repeated in a single season.

Adult green sunfish are usually associated with areas of vegetation or shelter. Sexual maturity is reached at age II (Smith 2002). Green sunfish can live up to 4 or 5 years and reach 12 inches or 2 lb in size, but few exceed 9 inches in length or 0.75 lb (Pfleiger 1997).

4. PROPOSED IMPINGEMENT MONITORING

As discussed in Sections 2.3.1 and 2.4, impingement data have not been collected previously at the Four Corners Generating Station. The objective of the proposed impingement monitoring plan is to design and implement a program that will produce accurate estimates of impingement rates under rigorous quality assurance/quality control procedures. Data produced by this monitoring program will define the species and life stages impinged, as well as their numbers and biomass on a time (diel, seasonal, and annual) and per-volume-pumped (million gallons of cooling water) basis. The results will be incorporated into the IM Characterization Study, as described in Section 1.2.

This section addresses the proposed sampling plan, sampling methods, sample processing procedures, collection of relevant ancillary information, and data analysis. A quality assurance program for the impingement monitoring program is described in Section 5.

4.1 SAMPLING DESIGN

The impingement monitoring program is recommended to span at least one year (12 months) and to include both intakes and all five units. A decision on a second year of monitoring can be made once the magnitude of impingement and/or the species and life stages impinged becomes apparent. Impingement will be sampled at both intakes at the same time. If either intake is not scheduled to operate during the specified sampling period, a request will be made to turn on a circulating water pump for the duration of sampling in order to get representative density measurements for impinged fish for that intake.

Sampling frequency will be biweekly over a 12 month period. Samples will be collected over a 24-hour period during each biweekly period. Sampling days will be scheduled for the same day(s) in each period (e.g., Tuesday-Wednesday). One sample will be taken every 12 hours according to the following time intervals: 0600-1800 hours and 1800-0600 hours.

4.2 SAMPLING GEAR AND DEPLOYMENT

Prior to sampling, the traveling screens of both intakes will be rotated for at least one full cycle to remove fish and debris accumulated prior to the sampling interval. Once this cleaning process has been accomplished, the sampling will be initiated by placing a collection device in line with the screen wash troughs of each intake. For the Unit 1-3 intake, the collection device could consist of net frame and net gear (Figure 4-1) set into the screen wash trough on the screenhouse decking downstream from the screen housings. Two sets of this gear would be recommended, placed in series so that when one net is being removed, the second net would be in place to continue the sampling. Alternatively, a collection basket could be installed at the end of the Unit 1-3 screenwash trough, possibly suspended off the end of the intake deck. For the Unit 4-5 intake, the existing collection basket at the end of the screen wash sluice can be used with a removable net liner of the proper mesh size placed inside the collection basket and removed at the conclusion of the sample. The collection baskets or nets will have ¼-inch mesh.

The collection baskets (or nets) will be left in place for as long as possible, up to the entire 12-hour collection period, and the duration of the sample will be recorded. If fish or debris volumes become too great, screens will be rotated and washed as frequently as necessary to reduce the volume of debris and fish being directed to the collection baskets at once. If necessary, screen rotation will be continuous, in which case the sampling crew will monitor the screen washwater troughs and the collection baskets to prevent snags or overflow. To prevent collection basket overflow, the crew will temporarily interrupt sampling, empty the collection basket's contents, and resume sampling, while recording the start and end times of the interruption. Total impingement during the 12-hour sampling period will be estimated by extrapolating from the timed sample(s) to a full 12-hour sample.

At the completion of the sample collection, the collection baskets will be removed and their contents will be emptied onto a processing table. Collections from the Unit 1-3 intake will be maintained separately from collections from the Unit 4-5 intake. This sampling process will be repeated during the second 12-hour sampling interval in the 24-hour sampling period.

Two times during the year a test of impingement collection efficiency will be conducted at each group of intakes. Approximately 100 specimens each of species and sizes representative of dominant fish species being impinged will be marked (e.g., with a fin clip or biological stain) and released in front of the screens at each intake at the start of the 24-hour sampling period. These specimens will have been collected during previous weekly samples and frozen for use in these tests. The recovery of these marked specimens will be recorded during the subsequent sampling, separate from the impingement counts. The results will indicate the efficiency of collection of impinged fish from the traveling screens. The data can be used to adjust impingement collection statistics to reflect the estimated total impingement for samples consisting of fish species that these test specimens would represent in terms of size and shape.

4.3 SAMPLE PROCESSING

Samples from the two intakes will be processed separately. Each screen sample will be processed by counting and identifying all fish to the lowest practicable taxonomic level. Individuals that cannot be identified to species in the field will be preserved for identification by taxonomic specialists.

Fish in the sample will be sorted by species and size category. Two size categories will be established prior to sampling, if possible, to separate young-of-the-year (YOY) individuals from yearling and older individuals. Size categories will be determined according to cut-off lengths used during the previous weekly sampling period and anticipated growth, based on observation and literature sources. Following sorting, up to 50 randomly chosen individual specimens within each size category will be measured to the nearest mm total length (TL) and their condition will be recorded as live, dead or stunned. A total batch weight measurement will be taken for each size category.

If the number of specimens in the sample for a particular species and size category is large, then the species/size category count will be estimated by subsampling. A subsample of 100 randomly chosen individuals will be weighed and the total sample will be weighed. The number of individuals in the whole sample will be estimated from the ratio of the total sample weight to the subsample weight total and the count within the subsample. Lengths will be measured for 50 randomly chosen individuals in the subsample.

Quarterly the scales, spines, fin rays and/or otoliths (depending on species) from 20 measured yearling and older individuals of each of the RS from each 50-mm length interval (e.g., 200 – 249 mm, 250 – 299 mm, etc.) will be removed and stored in individual envelopes or glass vials. For each sampled fish, the collection date and location, species, and total length will be recorded. These samples will be collected in anticipation that age information for older individuals may be required for application of equivalent loss models as part of a site-specific cost-benefit calculation.

The general condition of impinged organisms will be observed as they are processed. Unusual condition, such as signs of disease, parasites or injury, will be noted. Fish that were obviously dead before being impinged (e.g., presence of fungus or decay) will not be included in the sample. Indications of a mass die-off of fish will be observed and recorded, and examples of physical evidence (e.g., floating fish in the lake or dead fish on shore) will be photo-documented. If available, scientifically defensible methods to detect or predict the occurrence of moribund fish entering the intake will be used to document episodic impingement events that would represent anomalous impingement data.

Samples may be frozen at the completion of processing and saved for possible inclusion in quality control (QC) testing. Once it is determined that a sample is no longer needed for QC purposes, the sample will be disposed of in an approved manner. QC of sample processing is discussed in Section 5.

4.4 RELEVANT ANCILLARY INFORMATION

There is ancillary information that will be recorded relevant to environmental conditions at the time of impingement monitoring, as well as plant operation data needed to estimate total impingement. Environmental data relevant to each sample will be recorded on an accompanying field data sheet. In addition to date and sample start/end time recordings, these data will include operation parameters for the intake (identify screens and pumps operating); and water temperature, dissolved oxygen concentration, and conductivity, all recorded at the beginning and end of each 24-hour collection period. A unique sample identification number will be assigned to each sample. Other relevant observations may be recorded, including weather conditions, such as air temperature, wind speed and direction, cloud cover, precipitation, etc.

Plant operation records will be obtained to determine the operation regime during the sampled and unsampled days in each month. Data required include hourly pumping rates (or volumes) for each unit, generation output (MWh) and discharge water temperature. Pumping rate or volume data will allow impingement estimates to be based on per unit volume pumped.

4.5 DATA ANALYSIS

The objectives of the impingement data analysis will be to:

1. define the fish species impinged;
2. estimate impingement rates expressed as density per million gallons (MG) of cooling water pumped on a diel, biweekly, and annual basis;
3. estimate total numbers and biomass by species on a daily, biweekly, and annual basis for the year of sampling; and
4. characterize impinged fish in terms of size and age distribution by species.

The results will be incorporated into the IM Characterization Study in the CDS, as discussed in Section 1.2.

The estimated total numbers and biomass impinged will represent the actual impingement for the year of sampling. However, the impingement rates expressed as density per million gallons (MG) of cooling water pumped can be used to estimate impingement totals under differing operating scenarios, such as might be required to determine the calculation baseline for the station.

To estimate the density of impinged organisms for a particular species, the number of fish of that species collected at each intake (adjusted for collection efficiency) will be divided by the total intake flow during the 24-hour sampling period. This density estimate then will be multiplied by the total intake flow during the biweekly period to estimate the total number of impinged fish for the biweekly period. Annual totals will be the sum of all biweekly totals. The same calculations will be performed for estimating total biomass impinged using weight totals.

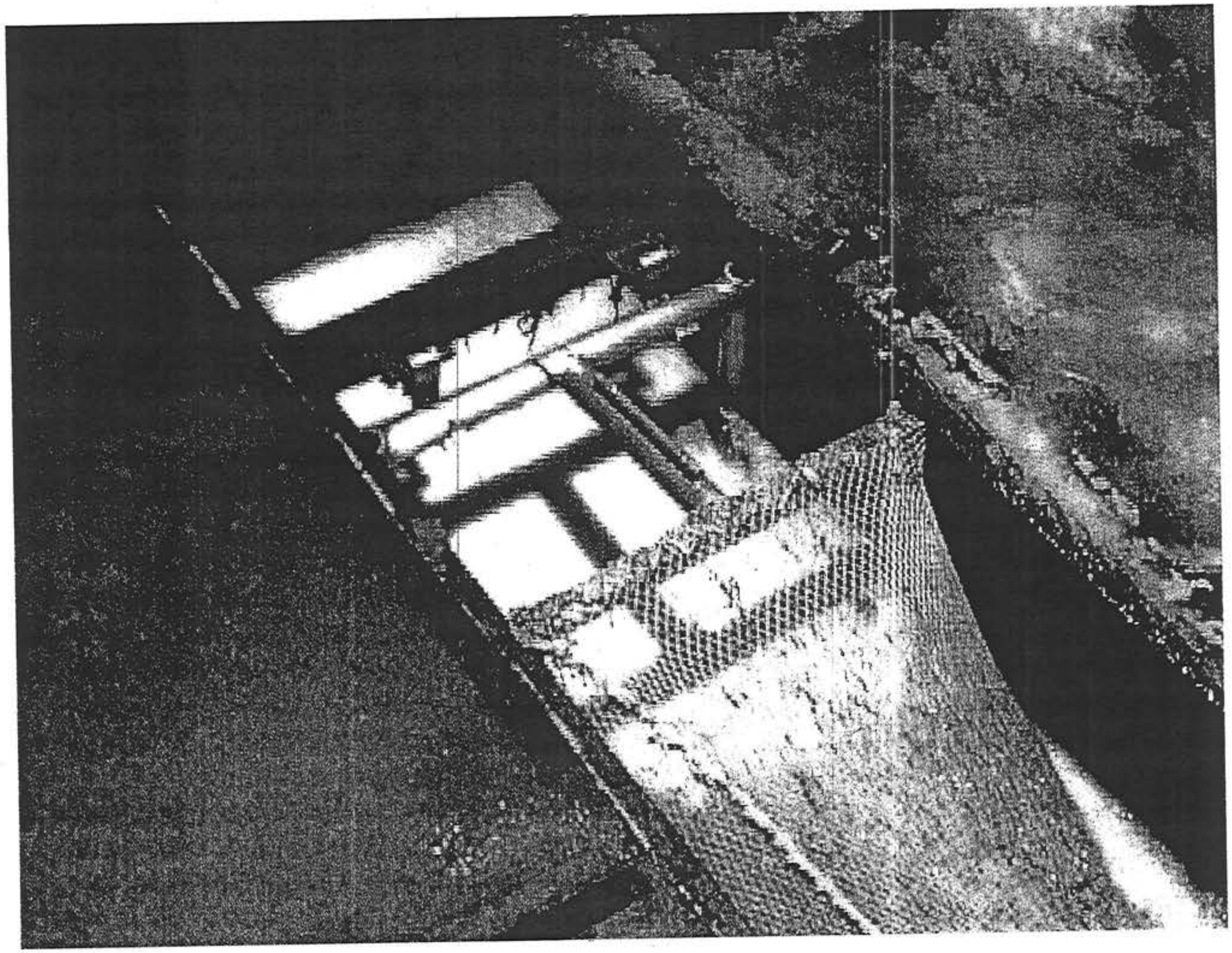

Figure 4-1 Impingement sampling net and frame set in floor trough.

5. QUALITY ASSURANCE

An essential part of the proposed monitoring program will be a quality assurance plan instituted to ensure that the data generated by the program meet an acceptable standard of quality. Quality assurance (QA) is defined as an integrated system involving quality planning, quality control, quality assessment, quality reporting, and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence. The EPA has published guidance documents (e.g., EPA 2000; 2002a, 2002b) for preparing and implementing project-specific quality assurance plans for their staff and for contractors funded by their organizations to follow, known as Quality Assurance Project Plans (QAPPs). These documents will be used to prepare a QAPP that fits the needs of the proposed impingement program prior to the initiation of sampling.

A QAPP has four basic element groups: project management, data generation and acquisition, assessment and oversight, and data validation and usability. The following highlights aspects that are particularly relevant to the execution of the program.

5.1 PROGRAM MANAGEMENT

This Impingement Mortality Sampling Plan provides many of the elements necessary for the program management functions of a QAPP, such as problem definition and background, and project and task descriptions. Other program management functions of a QAPP that are provided in the Plan include presentation of the project objectives and the interrelationships among the project tasks that direct the course of studies and identify information endpoints. An important element is the project organization, which identifies the roles and responsibilities of project personnel. A project organization chart identifies project personnel, whose qualifications (e.g., experience and specialized training) can be reviewed, as well as lines of communication and authority. The project organization chart will show individuals whose responsibility is to conduct various aspects of the quality assurance program.

The QAPP will set data quality objectives and criteria. Methods will be specified to ensure the desired level of precision, comparability, and completeness. In terms of impingement mortality quantification, the EPA has not set standards for precision of estimates, so the sampling design proposed in this Plan conforms to sampling effort and precision levels that currently are standard practice. If the EPA publishes guidance on sampling methods in the future, including QA standards and desired or required levels of precision, the program design and methodology will address these standards.

5.2 DATA GENERATION AND ACQUISITION

This component of the QA program is the heart of the field and laboratory tasks undertaken to generate data on current impingement rates at Four Corners. Elements include sampling design, sampling methods, sample handling and custody, analytical methods, instrument maintenance and calibration, and quality control. Quality control is defined as activities whose purpose is to measure and control the quality of a procedure so that it meets the needs of its user. Quality control (QC) activities monitor the outgoing quality of the data and can lead to response actions to bring the data within control limits through various actions, such as retraining of personnel, repair or recalibration of equipment, or other similar actions.

Sampling methods will be standardized so that they are repeatable and produce data that are comparable through time. This will be accomplished by preparing detailed Standard Operating Procedures (SOPs) for all activities, including sampling location and frequency, sampling gear and deployment, sample processing, data coding and recording, database entry, and to some degree, data analysis. The SOPs can be reviewed by all parties to reach consensus on their applicability, and will be adhered to by all project personnel. SOPs will provide a description of procedures to follow if obstacles to sampling or completion of all sampling activities are met, so that the acquisition of quality data can be maximized. The SOPs will describe procedures for sample handling and custody, including required signatures and blank forms for associated labels and logs. Also included will be project-specific data sheets, variable definitions and coding instructions. Equipment and instrument specifications will be described, including levels of precision and calibration methods for ensuring accuracy.

Systematic QC procedures will be instituted to verify recorded data. The primary area where these QC procedures will be used is sample processing, e.g., sorting of impinged fish from debris in the collections, fish counts, species identification, and length and weight measurements. Processed impingement samples will be subjected to a statistically-based QC procedure, such as continuous sampling plans (CSP) or MIL-STD 105 methodology derived from a manufacturing environment and applied to environmental monitoring programs (Young et al. 1992). The sampling plans implemented under these procedures have a specified average outgoing quality limit (AOQL), which represents the maximum fraction of all items (e.g., measurements, taxonomic identifications or counts) or lots (e.g., whole samples) that could be defective as a worst case. A defective item could be a measurement or count that falls outside of a specified tolerance limit (e.g., plus or minus 1 to 10 percent). In practice, the average outgoing quality (AOQ) is typically much better than the AOQL.

5.3 ASSESSMENT AND OVERSIGHT

Assessment and oversight is the process of determining whether the QA plan is being implemented as designed. For the proposed programs, this will be accomplished primarily by conducting technical audits or surveillance of field, laboratory and data management activities. Experienced senior staff, designated by the organization chart, will accompany field personnel during a set number of sampling events to observe sampling activities and to verify that SOPs are being followed properly. These auditors also will observe laboratory and data management personnel during their activities on specified occasions. Variances from approved procedures will be documented and corrected, either by modifying SOPs to address any systematic problems or by testing and/or retraining staff, as necessary. Prior to the first scheduled sampling, a readiness review will be conducted to ensure that trained personnel, required equipment, and procedural controls (e.g., SOPs) are in place. A technical audit will be scheduled for the first month of sampling (or very soon thereafter) so that any necessary corrections can be made before significant data losses occur. Follow-up audits will be scheduled (e.g., quarterly) to monitor progress and address changing conditions, such as recruitment of new life stages or species, impingement abundances, river stage or flow, new personnel, or plant operations.

Another QC aspect for oversight is the maintenance of a voucher specimen collection and library of taxonomic keys and references to assist personnel with taxonomic identification. The voucher specimen collection will consist of preserved specimens that have been positively identified by a qualified taxonomist. Oversight also will be provided by procedures requiring that specimens that are not positively identifiable by field or lab personnel will be preserved and given to a qualified taxonomist for identification.

5.4 DATA VERIFICATION, VALIDATION AND USABILITY

Data verification and validation will be conducted by qualified biologists (e.g., QA manager or field/lab supervisors) during the course of the project to ensure that the resulting data will be suitable for use as intended. Project records, including field sampling logs, raw data sheets, sample chain-of-custody forms and instrument calibration logs, will be reviewed to verify that data were collected according to the QAPP. Data will be validated first by a review of datasheets and data files to find whether data are incomplete or appear to be inappropriate or out of a reasonable range of values. Data entry into the database also will undergo a 100 percent visual QC comparison to the data on the corresponding data sheets. Finally, data files will be subjected to error checking programs to detect outlying values either to investigate further or to eliminate if shown to be spurious. This investigation will require tracing the data to raw data sheets and consulting with field or lab personnel who recorded the data. All raw data sheets, log books and data files will be maintained for future reference. All computer files will be backed up on a daily basis while any data entry or editing procedures are ongoing.

6. LITERATURE CITED

Blinn, D.W., J. Parrott, and T. Tompkins. 1975. Aquatic Environmental Report for 1975 on Morgan Lake, New Mexico. Annual Report. Period: May 1 to December 31, 1975. Department of Biological Sciences, Northern Arizona University, Flagstaff, Arizona. 58 pp.

Blinn, D.W., C.O. Minckley, J. Parrott, and T. Tompkins. 1976. Aquatic Environmental Report for 1976 on Morgan Lake, New Mexico. Annual Report. Period: June 1 to December 31, 1976. Department of Biological Sciences, Northern Arizona University, Flagstaff, Arizona. Contract Agreement #76-00729. 101 pp.

Blinn, D.W., T.C McCall, and C.O. Minckley. 1977. Aquatic Environmental Report for 1977 on Morgan Lake, New Mexico. Annual Report. Period: March 1 to December 31, 1977. Department of Biological Sciences, Northern Arizona University, Flagstaff, Arizona. Contract Agreement #E77-00844. 144 pp.

Emig, J.W. 1966a. Largemouth bass. In: Inland Fisheries Management. A. Calhoun (ed.) State of California, Department of Fish and Game.

Emig, J.W. 1966b. Bluegill sunfish. In: Inland Fisheries Management. A. Calhoun (ed.) State of California, Department of Fish and Game.

Koel, T.M., R.M. Sparks, and R.E. Sparks. 1998. Channel catfish populations in the Upper Mississippi River System. Illinois Natural History Survey Reports, September-October 1998.

Pflieger, W.L. 1997. The Fishes of Missouri. Missouri Department of Conservation, Jefferson City, MO. 372 pp.

Pitlo, J., D. Dieterman, and G. Jones. 2004a. Largemouth bass (*Micropterus salmoides*). *In:* Pitlo, J.M. Jr. and J.L. Rasmussen (*eds*.). UMRRC Fisheries Compendium. 3rd Edition. Upper Mississippi River Conservation Committee. Rock Island, Illinois. January 2004. pp. 169-173.

Pitlo, J., K. Brummet, and M. Endris. 2004b. Channel catfish (*Ictalurus punctatus*). *In:* Pitlo, J.M. Jr. and J.L. Rasmussen (*eds*.). UMRRC Fisheries Compendium. 3rd Edition. Upper Mississippi River Conservation Committee. Rock Island, Illinois. January 2004. pp. 151-155.

Platania, S.P., R.K. Dudley, and S.L. Maruca. 2000. Drift of fishes in the San Juan River 1991-1997. Final Report. 1 February 2000. University of New Mexico, Albuquerque, New Mexico. 65 pp.

Ryden, D.W. 2000a. Adult fish community monitoring on the San Juan River, 1991-1997. Final Report. January 31, 2000. U.S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 269 pp.

Ryden, D.W. 2000b. Monitoring of experimentally stocked razorback sucker in the San Juan River: March 1994 through October 1997. Final Report. January 31, 2000. U.S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 132 pp.

Schmidt, E. 1970. Fisheries Study, Morgan Lake, 1966-1970.

Smith, C.L. 1985. The Inland Fishes of New York State. New York State Department of Environmental Conservation. Albany. 522 pp.

Smith, P.W. 2002. The Fishes of Illinois. University of Illinois Press, Urbana and Chicago. 314 pp.

Southern California Edison Company (SCE). 1966. Four Corners Project – Morgan Lake Fish and Wildlife Evaluation. Administrative Report. February 3, 1966. 56 pp.

U.S. Environmental Protection Agency (EPA). 2000. Guidance for Technical Audits and Related Assessments for Environmental Data Operations. (*G-7*). EPA/600/R-99/080, January 2000.

U.S. Environmental Protection Agency (EPA). 2002a. Guidance for Quality Assurance Project Plans. (*G-5*). Office of Environmental Information. EPA/240/R-02/009. December 2002.

U.S. Environmental Protection Agency (EPA). 2002b. Guidance on Environmental Data Verification and Validation. (*G-8*). Office of Environmental Information. EPA/240/R-02/009. December 2002.

Young, J.R., R.G. Keppel, and R.J. Klauda. 1992. Quality assurance and quality control aspects of the Hudson River Utilities Environmental Studies. In: Smith, C.L.. Estuarine research in the 1980's: Proceedings of the Seventh Symposium of the Hudson River Environmental Society. pp. 303-322.

C. Proposed Method for Evaluation of Environmental Benefits

Deriving Economic Benefits of Reduced Impingement at APS's Four Corners Power Generation on Morgan Lake

Background

For use of the Cost-Benefit test under the site-specific standards, APS is required to have a Benefits Valuation Study prepared. The final 316(b) Phase II Final Rule (herein after referred to as the Rule) requires use of a comprehensive methodology to value fully the impacts of impingement mortality at the Four Corners steam electric generating facility on Morgan Lake. Other requirements for use of the test include:

- A description of the methodology(ies) used to value commercial, recreational, and ecological benefits (including non-use benefits, if applicable);
- Documentation of the basis for any assumptions and quantitative estimates. If the valuation includes use of an impingement survival rate other than zero, a determination of impingement survival at the facility based on a study approved by the NPDES permitting authority must be submitted;
- An analysis of the effects of significant sources of uncertainty on the results of the study;
- If requested by the NPDES permitting authority, a peer review of the items submitted by APS in the Benefits Valuation Study. APS must choose the peer reviewers in consultation with the Director who may consult with EPA and Federal, State, and Tribal fish and wildlife management agencies with responsibility for fish and wildlife potentially affected by the facility's cooling water intake structure. Peer reviewers must have appropriate qualifications depending upon the materials to be reviewed.
- A narrative description of any non-monetized benefits that would be realized at the facility if APS were to meet the applicable performance standards and a qualitative assessment of their magnitude and significance.

All benefits, whether expressed qualitatively or quantitatively, should be addressed in the Benefits Valuation Study and considered by the NPDES permitting authority and in determining whether compliance costs significantly exceed benefits.

The benefits assessment begins with an impingement mortality study that quantifies both the baseline mortality as well as the expected change from rule compliance. Based on the information generated by the impingement mortality studies, the benefits assessment includes a qualitative and/or quantitative description of the benefits that would be produced by compliance with the applicable performance standards at the facility site. To the extent feasible, dollar estimates of all significant benefits categories would be made using well-established and generally accepted valuation methodologies.

In order to have the appropriate information if the benefit/cost option is chosen, we propose a strategy for the collection and analysis of economic information. It should be noted that one particular benefit category, benefits accruing to individuals even if they have no plans ever to use Morgan Lake (non-use benefits), are to be estimated only

> "In cases where the impingement or entrainment study identifies **substantial harm** to a threatened or endangered species, to the sustainability of populations of important species of fish, shellfish or wildlife, or to the maintenance of community structure and function in a facility's water body or watershed ." (Final Rule, Federal Register page 41648).

"Substantial harm" is a stringent requirement to necessitate estimation of non-use values and thus non-use values usually would not be included in the final analysis. However, because the Final Rule does raise the potential for estimation of non-use values, we do provide some contingency for their estimation.

Description of Methodologies to Determine Benefits

The 316(b) rule defines a performance standard that the EPA has established for all existing power plant facilities to meet. Because the facility is located on a freshwater lake, only the impingement mortality (IM) performance standard (requiring reduction of IM by 80% to 95%) is required to be met. The PIC in Section 3 identifies a number of technologies that could meet the requirements of the performance standard. However, the Final Rule Option 5 states that facilities do not have to meet the IM performance standard if it can be shown that the costs of achieving the performance standard are significantly greater than the benefits. Therefore we are providing a plan to collect information on benefits to determine whether the costs of the identified technologies are significantly greater than costs of benefits.

At present, there are no studies that investigate IM at Morgan Lake and we must hypothesize which species are likely to be affected by the Final Ruling. The Navajo Fish and Wildlife Department has provided some helpful information on current fishery management. The information supplied indicates the primary game species in the Lake are largemouth bass, channel catfish, and green sunfish. There appear to be no commercial fisheries on the Lakes so that the only benefits accruing from the identified technologies would be recreational values from increased catch and possibly non-use values.

The EPA examined a technology (closed-cycle cooling) to achieve a national standard for entrainment and impingement mortality. In determining benefits at a national level, EPA used certain economic concepts of benefits associated with using the assets that cooling water adversely effects and methodologies to estimate the benefits (U.S. EPA, 2004a; U.S. EPA 2004b; U.S. EPA 2004c). In order to make the benefits comparable to costs, they presented benefits in a monetary unit, dollars. Their benefit estimates reflected the willingness to pay of individuals to go from the current environmental status to one associated with an identified technology. All of the methods proposed in this PIC were also used in EPA's national analysis.

More specifically, this benefit analysis will seek to provide a recreational unit value per fish caught ($/fish) for Representative Important Species (RIS). With this information, total recreational benefits can be determined by multiplying the unit value times the expected increase in recreational catch arising from the identified technology. In addition, some information will be provided with respect to non-use values.

Recreational Angling

For the recreational anglers, there are two potential ways to proceed:

1.) Benefit Transfer- the application of benefit estimates provided in other studies to the Four Corners Station situation;
2.) Primary research- collection and/or assemblage of data on recreational fishing on Morgan Lake and using the data to derive an estimate of the value per fish for the important species.

While the two approaches initially will be discussed independently, there is a sound reason to consider them in concert with one another. That is, the benefit transfer information provides a reality check for any values derived in the primary research. Any primary research effort should contain a thorough literature review, a component that would have information very similar in nature to the benefits transfer analysis. Also, the benefit transfer approach may provide a fallback position if the primary research is unsuccessful in providing benefit estimates. After both have been discussed independently, a strategy that integrates them will be offered.

A Benefit Transfer Approach

The use of benefit transfers requires finding a previous economic study (or studies) that considers a comparable situation to fishing at the Morgan Lake and contains dollar values per unit fish caught. Particularly important would be having species similar to the RIS species and a fishing population similar to the Morgan Lake situation. Although there are numerous other aspects of the fishing situation that might be important, these two are the most critical.

In order to identify an appropriate study or studies, it would be essential to visit the site to examine first-hand the type of recreational fishing that is occurring. At the same time, contact with key people in the area will be made to determine if any relevant studies do exist. We would consider it essential that the following sources be contacted or examined:

1. State or Federal Hearings on previous Four Corners facilities' license renewal.

2. State or Federal Hearings on previous power plant facilities in the general area of Four Corners.
3. Navajo Fish and Wildlife Department personnel.
4. Key Informants at Universities or other research facilities
   a. University of Arizona
      Dr. William Martin had several Masters students that studied sportfishing in Arizona.
   b. New Mexico State University
      Dr. Frank Ward has done several sport fishing studies in the southwest.
   c. University of Wisconsin
      Dr. Richard Bishop analyzed sportfishing for the Glen Canyon Dan project.
   d. University of New Mexico
      Dr. Robert Berrens (Department of Economics)

5. Existing bibliography sources available by internet
   a. National Marine Fisheries Service, Southwest Fisheries Center
   b. Sportfishing Values Database
   c. Environmental Valuation Reference Inventory (EVRI): Canadian based.
   d. Beneficial Use Values Database (BUVD)
   e. Regulatory Economic Analysis Inventory, (REAI) maintained by the U.S. EPA
   f. ENVALUE, an environmental value database maintained in Australia.
6. *Investigation and Valuation of Fish Kills* (American Fisheries Society, 1992) Excerpt: "Chapter 4 ("Monetary and Economic Valuation of Fish Kills") dates back to the Pollution Committee's *Monetary Values of Fish* booklets of 1970 and 1975, which dealt with southern U.S. species. In 1978, the AFS North Central Division's Monetary Values of Fish Committee published *Reimbursement Values for Fish,* addressing species in 12 northern states and 2 Canadian provinces. To integrate these and other regional values, a special AFS Monetary Values of Freshwater Fish Committee collected values from 135 federal, state, provincial, and private agencies and hatcheries. These data were published in 1982 as Part I of AFS Special Publication 13. For the present book, the Socioeconomics Section has repeated the earlier survey to update replacement costs for killed fish and summarized procedures for estimating the broader economic losses resulting from a fish kill."
7. Data from U.S. Fish and Wildlife.

These potential sources will be used to obtain "off-the-shelf" values that could possibly be relevant to the RIS species at Morgan Lake. In addition, some of these contacts may be useful as researchers, data sources, and/or witnesses for any hearings that evolve. They may also be useful as peer reviewers or as sources to identify peer reviewers. This will be the initial thrust of the benefit transfer work.

Primary Research

There are several other methodologies that could be used to determine economic values for the species considered, but they will require substantial primary research. Given the isolated location of Morgan Lake, it may take a large effort to obtain unit value estimates for fish.

As an initial approach, it would be useful to contact Dr. Frank Ward regarding the possibility of using information and analysis associated with a study conducted in 1988/89 on sportfishing demand in New Mexico. The results of the study with some additional analysis could shed light on the unit values of fish in Morgan Lake. In particular, the authors talk about the unit values of additional fish at different lakes in New Mexico but do not present any values.

If these data are not available or do not provide useful information, a study using combined on-site surveys of anglers and mail surveys targeted to residential users of electricity in Arizona, New Mexico, Colorado, and Utah would probably provide the highest quality information. With the data, one could use a demand system approach like Ward et al. or a random utility model (RUM) following the EPA's approach in many of the saltwater regions of the country.

Strategy to Obtain Recreational Unit Values per Fish Caught

The initial portion of the study would be to complete a benefits transfer analysis and determine whether or not the values obtained were reasonable for the purposes of the decisions to be made. That is, if the mitigation strategy returned recreational benefits of $100,000 per year and the corresponding costs were $70,000, it would probably be unwise and inefficient to move onto primary research because in all likelihood the estimate of costs would not be significantly larger than the benefits. If however, the benefit transfer method suggested that the benefits were to be small relative to costs, it may be useful to do one of the primary research plans suggested in the previous section.

Discussions with key informants in the benefit transfer work would determine the

1.) availability and reliability of data from the previous study of the New Mexico recreational fishing.
2.) potential for doing a survey across four states using the approach suggested above.

With this information and a better understanding on the costs of doing the primary research studies, decisions regarding which of the two primary research efforts could be made.

Non-use Valuation

Subsequent study by biologists will determine whether there is a necessity to assess non-use values. Based on current knowledge, it would not be necessary to estimate them (Jules Loos, personal communication). The fact that Morgan Lake is a man-made structure and that the RIS species are stocked reduces greatly the likelihood that the current state of knowledge will change.

But, in the unlikely event that non-use values will have to be estimated, we would look to using a benefit transfer approach or doing primary research for APS. Based on the draft Strategic Compliance Plan for the Four Corners Station (August 2004), we do not believe that the magnitude of the non-use values would justify undertaking a primary research study for non-use values associated with Morgan Lake.

Thus, if non-use values were needed, we would suggest using a benefit transfer method in all likelihood. There have not been any studies of non-use values associated with power plant activities *per se.* People have had to rely on studies associated with other types of activities. For example, EPA used this approach in their Proposal for the 316(b) regulations and in the NODA. EPA (Tudor et al., 2003) reviewed numerous studies of use and nonuse values that were associated with surface water improvements (their Appendix A). Of those shown, only three address both changes in fish populations and non-use values associated with them (Huang, et al. 1997; Whitehead and Groothuis, 1992; Olsen, et al. 1991).

We propose considering these three studies in addition to doing a review of the recent literature. The recent literature may be important because EPA has placed some emphasis on this ecological valuation recently. For example, there is a meeting entitled "Improving the Valuation of Ecological Benefits, a STAR Progress Review Workshop" that was held in Washington in October, 2004.

The results of this activity would likely be the development of a relationship (specifically a ratio) between use values and non-use values. For years, EPA used the 50% rule, a practice that implied that nonuse values were 50% of use values. Our approach, just like some of their 316(b) efforts (Tudor 2003), would be to refine this ratio for situations more akin to the changes associated with power plant operations.

References

Huang, J. T. Haab, and J. Whitehead. 1997. "Willingness to Pay for Quality Improvements: Should Revealed and Stated Preference Data Be Combined?", *Journal of Environmental Economics and Management* 34: 240-255.

Olsen, D., J. Richards, and R. Scott. 1991. "Existence and Sport Values for Doubling the Size of Columbia River Basin Salmon and Steelhead Runs", *Rivers* 2(1): 44-51

Tudor, L., R. Wardwell, E.Besedin, and R. Johnston. 2003. Comparison of Non-use and Use Values from Surface Water Valuation Studies. Memo to the 316 (b) Record. Office of Water, USEPA. Washington, D.C.

U. S. EPA. 2004a. "§316(b) Phase II Final Rule, Regional Studies, Part A: Evaluation Methods, Chapter A9: Benefit Categories and Valuation". http://www.epa.gov/waterscience/316b/econbenefits/final.htm.

U. S. EPA. 2004b. "§316(b) Phase II Final Rule, Regional Studies, Part A: Evaluation Methods, Chapter A10: Methods for Estimating Commercial Fishing Benefits", http://www.epa.gov/waterscience/316b/econbenefits/final.htm.

U. S. EPA. 2004c. "§316(b) Phase II Final Rule, Regional Studies, Part A: Evaluation Methods, Chapter A11:Estimating Benefits with a Random Utility Model". http://www.epa.gov/waterscience/316b/econbenefits/final.htm.

Ward, F., R. A. Cole, R. A. Deitner, and K. Green-Hammond, 1997, "Limiting Environmental Program Contradictions: A Demand Systems Application to Fishery Management". *American Journal of Agricultural Economics*, 79(3): 803-13

Whitehead, J. and P. Groothuis. 1992. "Economic Benefits of Improved Water Quality: A Case Study of North Carolina's Tar-Pamlico River", River 3(3): 170-178.

D. 316(B) RELATED AGENCY CORRESPONDENCE

See following pages.

February 18, 2005

Carl Woolfolk
Mail Station 4915
P.O. Box 355
Fruitland, NM 87416-0355

Dear Mr. Woolfolk:

The purpose of this letter is to document the Department of Fish and Wildlife's position in terms of important fish species present in Morgan Lake.

The important sport fish species in Morgan Like are largemouth bass, green sunfish and channel catfish. The important prey species in Morgan Lake is green sunfish and recent surveys indicate that the sunfish population is down.

There are several species of fish that have been accidentally introduced into the lake and are considered a nuisance due to the fact that they have a negative impact on Management of game fish and prey species in Morgan Lake. In addition, these species would have a negative impact to native fish species, including threatened and endangered fish species, that exist in the San Juan River, if Morgan Lake becomes a source of introduction of these exotic species into the San Juan River. These include the Pacu, Plecostomus sp., gizzard shad, mosquito fish and common carp. It is suspected that gizzard shad have been introduced into the San Juan River by way of Morgan Lake and have made it down to Lake Powel. Also, it is likely that the San Juan River has been the source of introduction of the common carp into Morgan Lake.

The department has limited survey information for the lake, and is currently awaiting a report from the U.S. Fish and Wildlife Service from a survey that was conducted last November. We are also planning to do a follow up survey during March. Recent surveys have failed to identify any native fish species being present in the lake. Several other species have not been identified as still being present in the lake, although they had been introduced into the lake during the 1960's. These species include the threadfin shad, rainbow trout, fathead minnow, Tilapia, black bullheads and northern pike.

The Department recommends that Largemouth bass, channel catfish and green sunfish be the species that are investigated during the impingement study.

If you have any questions, please give ma a call at (928) 871-7068.

Sincerely,

Jeffrey Cole, Wildlife Manager
Department of Fish and Wildlife

CONCURRENCE

____

Gloria M. Tom, Director
Department of Fish and Wildlife