ENVIRONMENTAL STUDIES FOR PACIFIC GAS AND ELECTRIC'S GEOTHERMAL AND HYDROELECTRIC PROJECTS

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ABSTRACT

Pacific Gas and Electric Company (PGandE) conducts environmental studies on geothermal and hydroelectric power plants to plan and evaluate mitigation measures done to minimize negative biological impacts. Representative studies are presented to describe impacts inherent to these facilities and to illustrate the approaches PGandE biologists use to minimize them.

The main types of impacts due to geothermal development are loss of vegetation and the resulting effects on wildlife, erosion and the resulting sedimentation of streams, and condensate spills. Many of the impacts inherent to hydroelectric facilities are the same as for geothermal and other power facilities. These include impacts due to the loss of vegetation and the resulting effects on wildlife. Other impacts specific to hydroelectric development are due to the diversion of streamflow, and the formation of barriers limiting the migration of fish and wildlife. As a result of impact studies, PGandE has been able to make these power facilities more compatible with existing plant, fish, and wildlife species.

INTRODUCTION

Pacific Gas and Electric Company (PGandE) conducts environmental studies on its geothermal and hydroelectric power plants. These are done to define biological impacts, to design and evaluate appropriate mitigation measures, and to fulfill regulatory requirements. Environmental studies also help PGandE plan future developments that minimize adverse environmental effects.

This paper provides an overview of geothermal and hydroelectric facilities and then describes impacts inherent to these facilities. Representative environmental studies and resulting measures are then described for each impact as examples of PGandE's efforts. They show how PGandE biologists study and minimize potential impacts by avoiding sensitive areas, mitigating for impacts, and enhancing unaffected areas.

GEOTHERMAL DEVELOPMENT

All of PGandE's geothermal facilities are located at The Geysers-Calistoga Known Geothermal Resources Area, also known as The Geysers. The Geysers is a 350-square mile area about 90 miles north of San Francisco in the Mayacmas Mountains of California's North Coast Range. This is the only commercial geothermal power plant facility in the United States, and the largest one in the world. PGandE began operating its first power plant at The Geysers in 1960. There are now 17 operating power plant units which produce over 1100 megawatts. This is almost ten percent of the total electric generating capacity produced by PGandE. Other developers at The Geysers include four other utilities constructing power plant units, and steam suppliers who drill wells to tap the superheated steam used by the utilities .

Several types of facilities are associated with each power plant unit at The Geysers. They include about 15 wells for initial operation and about 15 additional wells drilled during the estimated 30-year lifetime of the power plant units. The steam is transported from the wells through insulated steel steam lines to the power plant's turbine building. Other facilities include a cooling tower associated with each turbine building, access roads, electric transmission lines, switchyards, and support facilities such as administrative buildings.

The main impacts resulting from geothermal power development are loss of vegetation and wildlife habitat, erosion, sedimentation of streams, and condensate spills. Each has been studied and approached through measures described below to minimize adverse effects.

Vegetation disturbance is the main impact at The Geysers. It results from the clearing of areas for the development of power plant facilities and from leaf damage caused by cooling tower emissions. Since most of these impacts are due to clearing vegetation, they were evaluated by measuring cleared areas on aerial photographs for each power plant unit and for each type of power plant facility. These data were used to predict impacts of future power plant units on the vegetation cover for each leasehold. (Leaseholds are areas dedicated to supply steam to each associated power plant.)

The study results show that the average area disturbed over the estimated 30-year life of each power plant unit is 103.5 acres per leasehold or 11.5% of the total developed area. This is equivalent to about 0.94 acres per megawatt produced which is similar to other types of power facilities when all aspects of fuel production are considered. Well pads developed by the steam suppliers account for more than half of the vegetation removal, and roads account for almost a third. Clearing of vegetation for power plant and cooling tower buildings causes less than a tenth of the total leasehold disturbance. The rest of the facilities account for just over a tenth of the total vegetation loss in each leasehold. Over half of these affected areas are revegetated to minimize the effects of clearing. On the average, about two thirds of all the land cleared for each leasehold occurs during the five year period before the power plant unit begins operation. The remaining clearing impacts occur at an almost constant rate during the 30-year lifetime of the power plant unit. This information is used to plan mitigation for anticipated impacts of future power plant units.

Vegetation at The Geysers is affected also by small droplets emitted by the cooling towers as drift. Some vegetation near the cooling towers exhibit leaf tip burning which may be a symptom of boron toxicity. Since there is concern about possible long-term cumulative drift effects, PGandE is conducting an extensive six-year monitoring study to evaluate this impact. Approximately 150 sampling stations are monitored to determine the correlation between visible plant damage, concentrations of boron and other elements in the leaves and soil, and concentrations of these same elements in cooling tower drift collected at each sampling station. The results of this study should show the long-term effects of cooling tower drift on vegetation.

These impacts on vegetation have been minimized by protecting unique natural areas, avoiding sensitive areas, changing construction practices, and revegetating cleared areas. Revegetation is done to control erosion and to mitigate for impacts on rare plants and wildlife. An example of this type of mitigation is the propagation of the rare plant Lupinus sericatus, the Cobb Mountain lupine. PGandE has revegetated three slopes with more than 200 individual plants grown from seed collected at The Geysers. Ten different planting techniques were used and evaluated, with an overall success rate of about 75%. The results of this work have increased the populations of this plant, helped revegetate three sites, and have provided data on planting techniques for legumes that will help future revegetation efforts at The Geysers.

As a result of these effects on vegetation, geothermal development also impacts wildlife that occupy the disturbed habitat. To determine these impacts, PGandE biologists take inventories of the wildlife populations. The presence or absence of predators is monitored by using different types of scent stations which attract predators and record their tracks. Small mammal populations are monitored through live trapping so that

comparisons can be made of population trends from year to year. Populations of songbirds, raptors, and black-tailed deer are also inventoried. Fish populations are monitored to detect any reductions due to development. Monitoring studies include electrofishing to estimate fish populations and to assess habitat conditions. These data are used to characterize the major streams and to monitor the effectiveness of mitigation and enhancement efforts.

Several measures have been taken to mitigate for habitat loss and to improve wildlife values of unaffected areas. These measures include revegetating cleared areas with plants suitable for wildlife food and cover. Water developments are also used to enhance wildlife habitats. They include constructing artificial wildlife ponds and installing guzzlers that are rainwater catchment devices. Other measures include prescribed burning to enhance chaparral habitat for deer and other wildlife. This is done with a helitorch using alumagel, a napalm-like substance.

Several types of artificial nesting structures designed for songbirds and gray squirrels are used to replace natural cavities lost due to clearing trees during development. More than 600 of these structures were installed and more than 400 are monitored three times each year. The monitoring study results will be used to determine the types of nesting structures most frequently used, how and where they are used most, and their overall effectiveness for enhancing the area for cavity nesters.

Erosion is another impact source at The Geysers because of the extremely steep terrain and highly erosive soils that characterize the area. It results from the clearing of vegetation for roads and other geothermal facilities. Erosion is of concern because of potential stream sediment loading which can affect fish respiration, degrade fish spawning and rearing habitats, and reduce invertebrate production.

PGandE, in cooperation with others, is conducting a long-term comprehensive stream sediment monitoring study to determine if there are any cumulative sedimentation impacts. More than 40 stations in the major drainages are sampled in the spring and fall to detect changes in the particle size distribution of spawning gravel.

The procedures used to reduce erosion and sedimentation include paving roads and improving stream crossings. Sediment ponds are routinely constructed in natural drainages to intercept runoff from cut-and-fill slopes. The ponds capture sediments when runoff flows into the pond before the excess water is channeled out through a screened stand pipe. The ponds are maintained by periodic dredging. Unstable slopes are protected by the use of rip-rap and other structures. Willow cuttings woven together are used to form little check dams to minimize gully erosion. These have the added benefit of growing into mature willows which stabilize the soil and provide valuable food and cover for wildlife. The revegetation of disturbed areas is one of the most important methods used to reduce erosion. Over half of all areas cleared for geothermal development are revegetated. Affected areas are usually hydroseeded the first year with a herbaceous seed mix. Later, native woody species are selected for soil binding properties as well as for high wildlife values of forage and cover. They are planted individually and covered with a wire mesh to protect them from browsing animals. The areas surrounding the plantings are covered by plastic to retain soil moisture, and by burlap to reduce weed competition. The use of all of these methods has greatly reduced erosion impacts at The Geysers.

Steam condensate spills represent another impact of geothermal development. Condensate can contain toxic chemicals harmful to aquatic organisms. Steam condensate accumulates in cooling tower basins because the rate of cooling tower evaporation is less than the rate of steam flow through the turbines. The condensate is then reinjected into the steam reservoir. To prevent these chemicals from reaching streams, asphalt berms are constructed around all of the power plant units to contain spills.

The studies described have resulted in better planning and improved mitigation measures at The Geysers. This has enabled PGandE to make geothermal development more compatible with existing plant, fish, and wildlife species.

HYDROELECTRIC DEVELOPMENT

PGandE has 65 operating hydroelectric power plants located primarily on rivers and streams of the Sacramento and San Joaquin drainages. These facilities account for more than 20 percent of PGandE's electric generating capacity.

Each hydroelectric facility is made up of several components which vary according to the specific power plant location. In general, water is diverted from a stream or reservoir through a canal, flume, or pipe to an enclosed penstock. The water then flows down the penstock to the powerhouse where it spins the turbine to produce electricity. In some instances water may flow directly from a reservoir into the powerhouse at the base of a dam. In either instance, water then flows out of the powerhouse either directly into the river or via a constructed channel known as a tailrace. Other facilities include access roads, transmission lines, switchyards, and construction areas, common to all power facilities. The main effects of these facilities are loss of vegetation, the resulting effects on wildlife, diversion of streamflow, and the formation of barriers limiting the migration of fish and wildlife. Each is discussed below with examples of how PGandE has studied and attempted to minimize them.

The main terrestrial impact of hydroelectric development is the loss of vegetation due to clearing for hydroelectric facilities. The resulting effects on wildlife have the same types of impacts as discussed for geothermal development. The same types of inventory studies are done for hydroelectric power plants to identify and avoid critical habitat, and to improve mitigation and enhancement measures. As for The Geysers, these measures include impounding water, enhancing chaparral for wildlife using burning and crushing techniques, and protecting rare plant and animal populations.

A major impact specific to hydroelectric development is the diversion of streamflow. Several studies are done to address the effects of reduced streamflow on fish populations. One includes describing and assessing the populations through sampling as described for The Geysers. Another includes instream flow studies conducted to better determine the flow requirements for the existing fish populations. Data collected for these studies include depth and velocity measurements at various flows along transects within the stream study reach. Substrate types are also noted along the transects. In addition, temperature studies are often conducted to help characterize the stream.

Hydroelectric facilities also affect the migration of wildlife. Canals and pipelines have been known to inhibit the safe movement of migrating wildlife, especially deer. Studies have been done to assess the effectiveness of facilities designed to minimize deer loss in the canals. These include bridge crossings and two types of deer escapes. One is a step-out escape with a log boom and flasher cable. These guide the deer to a gunite recess that acts as a step to dry land. The other type of escape consists of a gently sloping concrete ramp which extends from the bottom of the canal to dry land. Remote monitoring devices have been used to study deer crossings and other animal behavior.

In addition to studying and mitigating for impacts, habitat improvements have been implemented to improve waterfowl production in unimpacted areas. Studies were conducted at Big Lake in Shasta County to determine the effectiveness of these improvements. An artificial pond and potholes were created and monitored for waterfowl use. The potholes and pond were found to improve nesting and feeding habitat for ducks. This was probably due to increased interspersion of water and more vegetation cover around the potholes needed for waterfowl. Another study was conducted to increase vegetation cover for waterfowl in grazed areas. PGandE biologists installed and sampled small grazing exclosures to estimate the livestock carrying capacity for the entire management area. The results of this study provided data necessary to enhance waterfowl habitat while also accommodating existing stock levels.

PGandE biologists have conducted other studies to address the biological issues for these and other types of facilities. As a result, more effective measures are now used to minimize biological impacts inherent to geothermal, hydroelectric, and other types of power facilities.