SUMMERTIME CLOUD SEEDING PROGRAMS IN CENTRAL AMERICA DESIGNED TO ENHANCE HYDROELECTRIC GENERATION

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ABSTRACT

North American Weather Consultants has conducted summer cloud seeding programs in Guatemala and Honduras. These two countries along with their neighboring countries in Central America derive a majority of their electrical energy from hydroelectric generation facilities. The Chixoy Reservoir in Guatemala and the El Cajon Reservoir in Honduras normally supply in excess of 50 percent of the electrical energy consumed in those two countries. Chixoy Reservoir has normally filled each summer season. It did not fill in 1991, perhaps a result of a strong El Nino episode, which resulted in power disruptions. A cloud seeding program was conducted in a portion of October and November which represented the end of the rainy season. Limited seeding opportunities were encountered. A more comprehensive program was conducted in late May through early July and late September to late October, 1992. The goal of these programs was to increase rainfall over the Chixoy drainage basin. A preliminary assessment of possible seeding effects during June 1992 indicated an average 17 percent more rainfall at several precipitation sites in the drainage based upon some upwind control precipitation gauge sites. A rudimentary calculation indicated the potential cost of runoff that may have been realized from the cloud seeding program was in the range of a few dollars (U.S.) per acre foot. A similar program was conducted over the El Cajon drainage area of Honduras from late August to late November, 1993. A preliminary analysis of the potential effects of this seeding program is currently in progress.

1.0 INTRODUCTION

Central American countries are heavily dependent upon hydroelectric facilities for the generation of electricity. In most of these countries the hydroelectric power production provides a majority and in some cases a large majority of the power consumed in these countries. During the 1991 rainy season and through most of the 1992 and 1993 rainy seasons, drought conditions persisted over most of Central America. This drought may have been related to an El Nino - Southern Oscillation event. The drought significantly impacted reservoir storage and as a consequence hydroelectric power production. As a consequence, North American Weather Consultants (NAWC) was contacted by Empresa Electrica and the Instituto Nacional De Electrificacion (INDE) in the fall of 1991 to determine the potential of applying cloud seeding technology to offset some of the impacts of the drought in Guatemala. Chixoy Reservoir was selected as a target area for a program. A brief cloud seeding program was conducted in the fall of 1991 and a more extensive program was conducted in the

summer of 1992. Adequate rainfall returned to Guatemala in the summer of 1993 and therefore no program was conducted. Officials of the Empresa Nacional De Energia Electrica in Honduras expressed an interest in the program being conducted in Guatemala. As a consequence a program was designed and conducted for the El Cajon reservoir area in Honduras for three months during the summer of 1993.

2.0 PROGRAM DESIGN

The primary seeding mode in both programs consisted of an aircraft seeding platform. Both acetone-silver iodide generators and droppable silver iodide flare racks were utilized. The flare racks were used in an attempt to achieve a dynamic seeding response in cumulus cloud based upon the Florida Area Cumulus Experiment (FACE) design (Simpson, 1980). NAWC has applied this design in the performance of other summertime cloud seeding programs (Griffith, and Brown, 1976; Griffith, 1982; Griffith, 1987). The acetone-silver iodide generators were used in more stratiform cloud situations in an attempt to achieve a static seeding response. Several ground based silver iodide generators were also used on each program. Aerial seeding operations were only conducted in daytime hours. Ground generators were used in both daytime and nighttime seeding opportunities. A five cm weather radar served as an operations center for each program. The radar and aircraft operated from Guatemala City in the conduct of the Chixoy Reservoir program and from San Pedro Sula in support of the El Cajon Reservoir program. A special computer modem link to NAWC's headquarters in Salt Lake City, Utah USA provided GOES weather satellite data used to support each program.

3.0 OPERATIONS

A one month program was conducted from October 11 to November 9, 1991 for the Chixoy Reservoir target area. There were limited seeding opportunities during this period. A second program was conducted May 26 through July 8 and September 21 through October 30, 1992. There were 37 days with seeding activity during the first period and 27 days during the second period. The times of cloud seeding operations coincide with increases in reservoir storage. The program in Honduras operated from August 24 to November 23, 1993. Cloud seeding was conducted on 30 days during this period.

4.0 RESULTS

A target/control evaluation was performed for a portion of the 1992 Guatemala program. A similar evaluation is in progress for the Honduras program. The Guatemala evaluation was based upon monthly precipitation data from the historical period of 1980-89. A longer historical period would have been desirable but such data were not available in Guatemala. The month of June 1992 was selected for analysis since this was the only month with seeding activities conducted for the entire month. Nine control precipitation stations were selected upwind of the target area. Eight precipitation stations were available within the target area. Average values were calculated in each area for each of the historical years. A linear correlation equation was developed from this data set. A high correlation coefficient (r) of .959 was obtained. This linear regression equation was then used to predict the target area

precipitation for June, 1992. There was an indicated 17 percent increase in average precipitation in the target area over that predicted from the regression equation. Obviously, additional seeded data are needed to establish any statistical confidence in such an evaluation. A hypothetical analysis of the potential benefit/cost ratio of this program can provide some interesting information. The calculated 17 percent increase in June precipitation over the Chixoy drainage was equivalent to 1.81 inches. The Chixoy drainage is approximately 2,140 square miles or 1,369,837 acres. INDE officials indicated that the Chixoy watershed converts precipitation to runoff with an efficiency of approximately 30 percent. The additional June streamflow into Chixoy as a result of the cloud seeding program can be estimated as follows: 1,369,837 acres x 1.81 inches 12 inches/foot = 206,617 acre feet. With the 30 percent efficiency factor applied, this equals 61,985 acre feet (76,427,505 cubic meters). The cost of this program can be pro-rated to estimate the program costs for June. This cost is $79,700 (U.S.). Consequently, the estimated cost of the additional runoff is $1.29 (U.S.) per acre foot or $0.001 (U.S.) per cubic meter.

5.0 DISCUSSION

There are a number of potential advantages in utilizing cloud seeding to augment hydroelectric production including: The cost of production is generally less than ten dollars per acre foot. No additional capital improvements are required. Cloud seeding programs can be started and stopped quickly without any long-term commitment. There are normally additional benefits in terms of increased water supplies to downstream water users. Water used to produce hydroelectric power is reusable and is also less expensive than thermal power.

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