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IDAHO PUBLIC
UTILITIES COMMISSION

BEFORE THE IDAHO PUBLIC UTILITIES COMMISSION

IN THE MATTER OF THE)
APPLICATION OF IDAHO POWER)
COMPANY TO DEFER EXPENSES)
ASSOCIATED WITH ITS CLOUD)
SEEDING PROGRAM FOR INCLUSION)
IN THE COMPANY'S PCA ON AN)
ONGOING BASIS.)
_____)

CASE NO. IPC-E-05-36

IDAHO POWER COMPANY

DIRECT TESTIMONY

OF

GARY RILEY

October 2005

1 Q. Please state your name and business address.

2 A. My name is Gary Riley and my business address
3 is 1221 West Idaho Street, Boise, Idaho.

4 Q. By whom are you employed and in what
5 capacity?

6 A. I am employed by Idaho Power Company as
7 Senior Meteorologist in the Water Management department.

8 Q. Please describe your educational background.

9 A. I attended the USAF Weather Observers School
10 in 1965 and the Weather Forecasters School in 1970-71,
11 graduating from both with honors. I received a Bachelor of
12 Science Degree from Longwood College (now Longwood
13 University) in 1981, graduating *Summa Cum Laude* with a major
14 in physics and a minor in mathematics. I received a Master
15 of Science degree in Atmospheric Science from the State
16 University of New York at Albany in 1984.

17 Q. Please describe your work experience with
18 Idaho Power Company.

19 A. I was hired by Idaho Power Company in June
20 2002 to implement and run the Company's cloud seeding
21 project on the Payette River Basin and to provide weather
22 forecasting support tailored to the Company's needs and
23 interests.

24 The cloud seeding project is designed to augment the
25 wintertime snowpack in the Payette River Basin and thereby

1 increase spring and summer runoff through the Company's
2 Hells Canyon Complex. The project became operational in
3 late January of 2003, with the first seeding on February 1,
4 2003. Operations ended for the season on April 15, 2003 and
5 resumed between November 1, 2003 and April 21, 2004. The
6 third season of seeding was operational between November 1,
7 2004 and April 21, 2005.

8 Q. Please describe your experience in the field
9 of weather modification.

10 A. Prior to joining Idaho Power, I was Vice
11 President and Chief Scientist for Atmospherics Incorporated
12 in Fresno, CA. Founded in the mid 1960s, Atmospherics is
13 one of the oldest and most respected weather modification
14 companies in the world. I first began working for
15 Atmospherics in December 1991, and while there I supported,
16 operated, and/or managed weather modification projects in
17 California, Nevada, Colorado, and Texas. Internationally,
18 projects were conducted in Spain, India, Indonesia, and
19 Costa Rica.

20 From 1987 through early 1991, I was employed by
21 Intera Technologies of Calgary, Alberta, Canada as a Senior
22 Meteorologist and I was the Assistant Manager of the Greek
23 National Hail Suppression Project.

24 Q. What is the purpose of your testimony in this
25 proceeding?

1 available water into ice and finally, into snowfall. Cloud
2 seeding to augment wintertime snowfall works by partially
3 reducing the deficit by introducing more of these particles
4 into the storm system.

5 Q. What factors are necessary for cloud seeding
6 to be effective and provide the benefit of additional
7 snowfall?

8 A. To be effective, three fundamental and
9 necessary conditions need to exist in the airmass passing
10 over the target area - in our case, the Payette River Basin.

11 First, the air must already be producing, or be
12 about to produce, precipitation (this is snow *enhancement*,
13 not snow *making*). Such a winter storm can produce a
14 thermodynamic environment favorable for activation and
15 transport of the seeding material into the part of the storm
16 where the precipitation forms.

17 Second, the air must contain an appreciable amount
18 of supercooled liquid water. Supercooled liquid water is
19 simply water suspended in the air at temperatures below
20 freezing, that is below 32 °F or 0 °C. Pure water can exist
21 in the liquid state to temperatures as cold as -40 °C (or °F
22 - they are the same at that temperature). This liquid water
23 is converted, first to ice, and then to snow, by contact
24 with a nucleating particle by processes called contact and
25 condensation nucleation.

1 composition of the seeding agent. Our network of ground-
2 based generators each release 20 grams per hour. Depending
3 on the configuration and other constraints, the project
4 aircraft can release from 151 to as much as 1500 grams per
5 hour.

6 Q. Are you able to target where the additional
7 snow will fall?

8 A. To place this additional snowfall in the
9 proper place, the target area, requires a clear
10 understanding of how, and how fast, the process works. For
11 effective cloud seeding, accurate information about the
12 temperature and moisture structure and about the wind flow
13 into and across the target area is needed. The seeding
14 material must be released so that there is the correct
15 amount of time available for it to be transported into the
16 portion of the storm having the proper temperature and
17 humidity structure and where the factors mentioned earlier
18 exist.

19 Q. How long does it take to form snow once the
20 silver iodide has been introduced into the storm?

21 A. The typical timeframe required for the
22 additional particles to be transported into a suitable
23 environment, induce freezing and grow into snowflakes is on
24 the order of twenty to forty minutes, but it can be as long
25 as 100 minutes. The amount of time required can be

1 controlled to some extent by adjusting the formula of the
2 seeding material. For the material IPCo uses, the silver
3 iodide needs to be introduced into the storm system in a
4 wind regime that will carry it into a zone of favorable
5 temperatures and moisture and transport it into and across
6 the target area in a time "window" of fifteen to forty
7 minutes.

8 Q. How do you know that the snow on the ground
9 is the result of cloud seeding efforts rather than snow that
10 would have been present without cloud seeding?

11 A. Cloud seeding projects have, until recently,
12 relied on statistical analysis of Target - Control, or
13 seeded area vs. non-seeded area, data sets. Because the
14 yield from any particular cloud seeding season lies well
15 within the natural range of variability of precipitation, it
16 can take many years to obtain statistically significant
17 results and determine a reliable measure of success or
18 failure. For that reason, many scientists and statisticians
19 were reluctant to accept the results indicative of success.
20 Nevertheless, this procedure is still commonly used.

21 In the last ten to fifteen years however,
22 significant advances have been made in both our
23 understanding of the physics involved and in our ability to
24 confirm and evaluate results through trace chemistry
25 investigations.

1 Because the materials used for cloud seeding are
2 known, as is the time of their release, analysis of the
3 snowpack itself provides information about where the seeding
4 material fell, how much of the material went towards
5 additional snowfall, and how much was simply scavenged, or
6 swept out of the air, by precipitation already occurring.

7 The presence of enhanced silver in the target area
8 snowpack indicates accurate targeting, but it says nothing
9 about whether it was deposited in the form of additional
10 snow or scavenged. Releasing an inert, non-nucleating
11 tracer simultaneously with the active seeding agent makes it
12 possible to determine if the source was additional
13 precipitation or scavenging. That information, when
14 combined with density variations within the snow samples,
15 allows quantification of the amount of additional snow
16 falling on the area.

17 Q. Did Idaho Power Company take steps to measure
18 the effect of its cloud seeding program using this new,
19 sophisticated approach?

20 A. Yes. Idaho Power contracted Desert Research
21 Institute (DRI), an extension of the Community College of
22 Nevada, to perform an analysis of snowpack samples from the
23 Payette River Basin the past two winters. The tracer used
24 was indium sesquioxide (In_2O_3), whose particles are similar
25 in size and dispersion characteristics to the nucleating

1 silver iodide (AgI). However, unlike the active material,
2 the tracer is non-nucleating and is removed from the air
3 only by scavenging. Therefore, any change in the ratio of
4 silver to indium from what it was at the point and time of
5 release gives a measure of how many of the silver particles
6 went into making additional snow and how many were
7 scavenged.

8 Q. Did Idaho Power measure the success of its
9 cloud seeding efforts in the winter of 2002-2003?

10 A. Yes. The original project plan did not
11 include an evaluation of benefit for the first season. The
12 combination of start-up operations and a short operational
13 season, only 2 ½ months, severely limited the amount of data
14 available. However, two direct, and one indirect, analyses
15 were conducted, and all produced similar results. All three
16 of the analyses were independent. No Idaho Power Company
17 personnel involved in seeding decisions took part in the
18 evaluation.

19 Q. Please describe the two direct analyses of
20 the cloud seeding effort during the winter of 2002 - 2003.

21 A. The first was by an Idaho Power employee not
22 otherwise involved in the project. The second evaluation
23 was done by an independent consultant (RHS Consulting of
24 Reno, NV). A traditional Target - Control analysis,
25 consisting of a linear regression of precipitation at sites

1 inside and outside of the target area indicated a 17%
2 increase in precipitation during the 2 ½ month period
3 between February 1 and April 15, 2003. That translates to
4 2.4 inches of additional water when averaged over the
5 Payette River Basin. Given a target area of approximately
6 938 square miles, that works out to 120,000 acre-ft of
7 water.

8 The precipitation data was also provided to RHS
9 Consulting who determined that the project would likely have
10 produced a 9% increase had it been operational for the
11 entire winter. Using the quality controlled data available
12 now that number rises to 11%

13 Q. Please describe the indirect evaluation of
14 the cloud seeding effort during the winter of 2003 - 2003.

15 A. An indirect evaluation was provided by North
16 American Weather Consultants of Sandy, UT. North American
17 operates a snow enhancement project on the adjacent Boise
18 River Basin for the Boise Project Board of Control. Their
19 initial analysis of the Boise Basin 2002 - 2003 season data
20 indicated a "no effect" result until it was realized that
21 the "non-seeded" Control sites being used for the Boise
22 project were seeded Target sites for Idaho Powers' Payette
23 project. After developing a new set of unseeded Control
24 sites, North American arrived at a 13% increase for the
25 Boise project, and by inference, for Idaho Power's project

1 as well.

2 Q. Did Idaho Power measure the success of its
3 cloud seeding efforts in the winter of 2003 - 2004?

4 A. Yes. Similar to the analysis done on the
5 2002 - 2003 season, a Target - Control analysis indicated a
6 6% increase in precipitation in the Payette River Basin for
7 that season. This reduced yield - 6%, down from 17% - was
8 expected because it was a dryer than normal year and the
9 inclusion of the trace chemistry analysis mentioned earlier
10 placed several constraints on operations. Still, even with
11 only 80% of normal precipitation, the yield represents an
12 additional 85,000 acre-ft of water.

13 Snow samples collected by DRI and analyzed in their
14 ultra-clean laboratory in Reno showed very high levels of
15 silver present and very little indium. Further, comparison
16 of the depth at which the silver was found with data from
17 nearby SNOTEL sites shows it to be consistent with seeded
18 events. Degradation of the snowpack prior to sample
19 collection prevented the laboratory from quantifying the
20 yield in augmented precipitation, but the 2002 - 2003 data
21 indicate scavenging was not a significant factor and Idaho
22 Power has an effective project.

23 That conclusion is substantiated by the results of
24 measurements made by an aircraft especially modified for
25 airborne cloud physics data collection. Measurements were

1 made prior to, during, and after a seeding flight on March
2 26, 2005. The data indicate water production from the
3 aircraft alone to have been in excess of 600 acre feet per
4 hour.

5 Q. What were the results of the cloud seeding
6 program undertaken during the winter of 2004 - 2005?

7 A. This last season's SNOTEL data indicate a 26%
8 increase in precipitation for the Payette River basin.
9 While a percentage increase of that magnitude is possible,
10 the number seems very high and should be viewed in the
11 context of an ongoing effort to obtain a statistically
12 significant evaluation of the cloud seeding project.
13 However, the results from the second year of trace chemistry
14 evaluation performed during the 2004-2005 season are very
15 positive and similar to those of the preceding years and
16 they are consistent with results obtained by other
17 successful programs.

18 Samples collected by both DRI and RHS Consulting
19 found positive evidence of an effective project. Using
20 newly developed procedures and sampling equipment, DRI was
21 able to correlate the silver, indium, and cesium in the snow
22 with density gradients, allowing a quantitative estimate of
23 augmentation. This makes it possible to distinguish between
24 the seeding material released by the ground-based and
25 airborne equipment and mathematically determine how much

1 additional snow fell on the sampling site. The data provide
2 clear evidence of an effective program.

3 Q. Can you provide examples from this analysis
4 to help the Commission understand how the silver and indium
5 relate to each other and how they relate to seeded snowfall?

6 A. Yes. As an example, I would like to offer
7 Exhibit 1. These figures were provided by Dr. Ross Edwards
8 of DRI. The first shows the concentrations of silver and
9 indium detected in a snow sample from the east side of the
10 Payette River Basin target area. The sample was collected
11 on Mount Zumwalt at an elevation of 8,225 feet. Note the
12 different scales for silver (left side) and indium (right
13 side). Three seeding events are depicted and the silver to
14 indium ratios show that for every silver iodide particle
15 scavenged, between 6 and 19 other silver iodide particles
16 contributed to additional snowfall.

17 The second figure graphically shows enhanced levels
18 of both cesium and silver in a sample collected in December
19 of 2004. Recall that ground-based units release only silver
20 iodide while the airborne generators released a solution
21 that included the cesium tag. Superimposing these diagrams
22 (third figure, prepared by IPCo for purposes of
23 demonstration) allows one to distinguish between silver
24 released by the aircraft and that released at ground level.

25 The fourth figure shows how the presence of enhanced

1 silver content that coincide with a layer of anomalous
2 density can be evaluated for the amount of augmented snow in
3 the sample. In the example shown, there is a 13% increase
4 due to seeding. DRI found augmentation values ranging from
5 13 to 34%, with a mean of 22%. Consequently, this is a
6 conservative example. DRI concluded that the overall
7 augmentation in the target area for this past season was
8 between 7 and 9%.

9 Finally, the fifth figure shows where the samples
10 were taken and gives an indication of how the degree of
11 silver content departs from what would be expected in
12 pristine snow. As noted by Dr. Edwards, this provides
13 evidence of effective targeting of the watershed.

14 Q. Is DRI preparing a final report containing
15 the analysis that supports your testimony?

16 A. Yes. The report is in the final stages of
17 completion and will be filed with the Commission as
18 Exhibit 4 to my testimony as soon as it is received from
19 DRI.

20 Q. Were the results of your measurement of cloud
21 seeding success consistent with those for other projects and
22 entities?

23 A. Yes. The yields I have indicated, 6 to 17%,
24 are within the range of expectations from wintertime
25 orographic cloud seeding contained in statements from the

1 World Meteorological Organization, the American
2 Meteorological Society, the American Society of Civil
3 Engineers, the Weather Modification Association, and even
4 the Idaho Department of Water Resources. All of these
5 indicate cloud seeding to augment wintertime snowpack can
6 produce increases of from 5 to 20% when done correctly.
7 Both RHS Consulting and DRI have said the results of their
8 trace chemistry evaluations are consistent with and similar
9 to those from investigations of this type in California and
10 Nevada and elsewhere. Two of the comparable projects in
11 California are operated by power companies (Pacific Gas and
12 Electric and Southern California Edison) for the same
13 purpose as Idaho Power's program. The results of trace
14 chemistry evaluations of the Lake Almanor project run by
15 Pacific Gas and Electric and those from Southern California
16 Edison's project on the San Joaquin River have appeared in
17 peer reviewed publications of the American Meteorology
18 Society and the North American Hydroelectric Industry.

19 Q. Can you provide one of these articles that is
20 written in non-technical language that is easier to
21 understand by someone not familiar with weather and cloud
22 seeding?

23 A. Yes. I have here a copy of an article by
24 Brian McGurty reporting on the results of the study on the
25 San Joaquin River project that appeared in *Hydro Review*. I

1 think the Commission will find it very readable, and I offer
2 it as Exhibit 2.

3 Q. Given a quantification of additional snow
4 resulting from the Company's cloud seeding efforts, have you
5 quantified how the additional snow translated into
6 additional stream flows at the Company's hydro facilities
7 over the past three winters?

8 A. Yes. The process is complex and requires a
9 review of what was done in each of the three individual
10 years to fully describe the process. First, the preliminary
11 data from the 2002 - 2003 Target - Control evaluation was
12 fed into the CHEOPS hydrological model to determine the
13 generation potential of the augmented water when it passed
14 through the Hells Canyon Complex. That allowed the
15 determination of the benefit gained from the augmented water
16 to be evaluated under several scenarios of seeding
17 effectiveness and varying losses of the augmented water
18 prior to reaching the Hells Canyon Complex. The model
19 indicated increased generation capacities ranging from
20 approximately 14,000 MWh if only 25% of the additional water
21 reached the power plants to as much as 56,000 MWh if all of
22 the water passed through the complex. These numbers would
23 be expected to increase if the model was re-run with the
24 quality controlled numbers available now.

25 The preliminary SNOTEL data from the 2003 - 2004

1 season was entered into the National Weather Service River
2 Forecast System Model, and the inflow into the reservoirs on
3 the Payette River was calculated for Seed and No-seed
4 scenarios. The computer simulation determined that an
5 additional 67,700 acre-ft of water flowed through the
6 Payette drainage in the seeded scenario. That is in very
7 good agreement with the 68,000 acre-ft determined from the
8 Target - Control regression that was also based on the
9 preliminary data. The difference is easily accounted for,
10 in that the model takes losses to soil moisture and
11 evaporation into effect and these factors are not included
12 in the simpler regression analysis. Also, software
13 limitations caused the input data to be cut off near the end
14 of March. Consequently, precipitation after that was not
15 included.

16 Q. Did you quantify the financial benefit of the
17 additional stream flow at the Company's hydro facilities?

18 A. Yes. Along with the calculation of
19 additional generation capacity, the CHEOPS data for the 2002
20 - 2003 season places the dollar value of the water at \$ 1.5
21 million if only 50% of the augmented water reaches Hells
22 Canyon Complex. However, the Payette River Basin was chosen
23 for the cloud seeding project in part, because the river's
24 reservoirs have a high probability of refill. Hence, the
25 actual value would be closer to the 100% expectation with a

1 value of \$2.1 million.

2 Using the yield from the quality controlled Target -
3 Control data, 120,000 acre-ft of water, and the in-house
4 rule that for every hour one acre foot of water passes
5 through Hells Canyon Complex, 0.5 MW can be generated, the
6 value can be readily estimated. Taking the average high
7 (\$32.13/MWh), the average low (\$29.47/MWh), and the average
8 average (\$30.47/MWh) price of power for the period May
9 through August 2003 gives a comparable value between \$1.77
10 and 1.93 million. For example, using the average price:
11 120,000 acre-ft times 0.5 MWh/acre-ft times \$30.47/MWh
12 indicates the water to be worth \$1.83 million for hydropower
13 generation alone. This number does not consider any
14 monetary value of ancillary benefits to the region in the
15 form of improved water conditions for fish and wildlife,
16 recreation and navigation, irrigation, or additional
17 drinking water, although these benefits also exist.

18 With the above-described results in hand, the value
19 of the 2003 - 2004 yield was estimated by taking the yield,
20 85,000 acre-ft, and using the approach identified above.
21 The generation potential from last season would be \$1.78
22 million at an average price of \$41.76/MWh. (85,000 acre-ft
23 times 0.5 MWh/acre-ft times \$41.76/MWh = \$1.77 million.)
24 That value is obtained by using the average of the On Peak
25 and Off Peak Mid-C prices for the period from 1 May through

1 31 August 2004. The value is closer to \$ 1.95 million if
2 the higher Border prices are used.

3 Similarly, using the 7 to 9% yield determined by DRI
4 for the 2004 - 2005 season and applying this same procedure
5 at an average price of \$36.71: the yield for 2004-2005 is
6 between 85,000 and 105,000 acre-ft of water, or between
7 43,000 and 53,000 MWh of additional production. That would
8 be worth \$1.5 to 1.9 million.

9 Both of the computer simulations reveal one
10 additional benefit from cloud seeding. The flow in the
11 Payette River is not only increased, the peak flow is
12 shifted later into the year and higher flows are maintained
13 longer. This means that more water will be available to the
14 Hells Canyon Complex as heavier summertime loads begin to
15 become a significant factor for operations.

16 Q. Can you provide an example of the computer
17 model output that illustrates this later peak in streamflow
18 and the enhanced flow duration?

19 A. Yes. Exhibit 3 was prepared using the model
20 output and shows the peak flow is shifted from late May into
21 June and that higher flow levels are maintained into early
22 July. Note that the figure does not include data for all of
23 July and August.

24 Q. Over the past three years, how have the
25 financial benefits of cloud seeding compared to the costs of

1 cloud seeding?

2 A. The answer to this question will depend to
3 some extent on the accounting period chosen. Because most
4 of the activity associated with the project is based on the
5 water year (October through the following September) rather
6 than the calendar year, the accounting period was defined as
7 July 1 through June 30.

8 The project expenses between July 1, 2002 and June
9 30, 2003 were:

10	Capital:	\$ 23,723 and
11	O & M:	<u>\$ 802,348</u>
12	Total:	\$ 826,071.

13 The project yield, based on the average results
14 already discussed was \$1.83 million. That gives a benefit
15 to cost ratio of 2.2 to 1.

16 For the twelve month period of July 1, 2003 through
17 June 30, 2004, the project incurred significant additional
18 expenses in association with the trace chemistry evaluation.
19 These included not only the direct costs of the evaluation
20 in payments to DRI, but the added burden of building and
21 maintaining seven additional ground-based generator units to
22 release the tracer. Consequently, the expenses during this
23 timeframe were:

24	Capital:	\$ 237,067 and
25	O & M:	<u>\$1,066,408</u>

