

*North American Weather Consultants, Inc*

## **WEATHER MODIFICATION FEASIBILITY STUDY FOR UPPER BOISE RIVER BASIN, IDAHO**

*Prepared for*  
**Idaho Water Resource Board**  
*by*  
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## **INTRODUCTION**

- North American Weather Consultants (NAWC) completed a Weather Modification Feasibility/Design Study for the Wyoming Water Development Commission for the Salt and Wyoming Ranges in western Wyoming in December 2006.
- NAWC completed a Weather Modification Feasibility/Design Study for the Idaho Water Resource Board for the Upper Snake River Basin in Idaho in October 2008.
- NAWC completed a Weather Modification Feasibility/Design Study for the Idaho Water Resource Board for the Big and Little Wood River Drainages in August 2009.
- NAWC was contracted by the Idaho Water Resource Board (IWRB) to conduct a Weather Modification Feasibility/Design Study for the Upper Boise River Drainage. A draft report was provided to IWRB in October 2009.

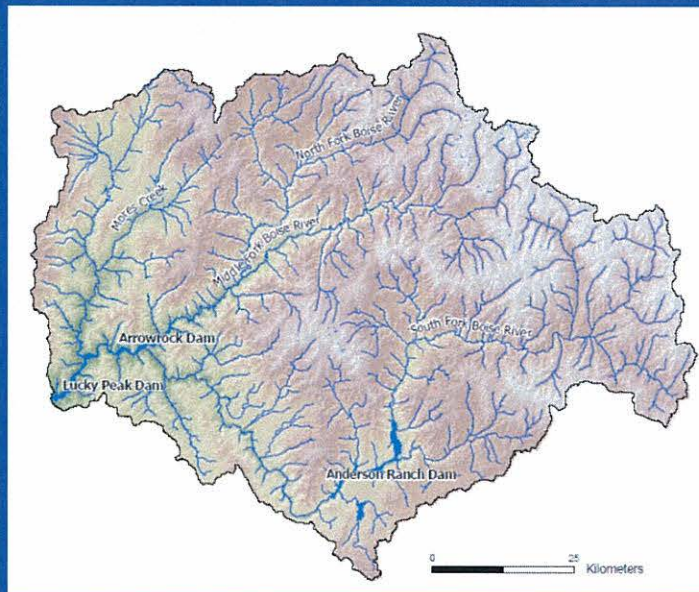
## WEATHER MODIFICATION FEASIBILITY STUDY BOISE RIVER BASIN

Contract between Idaho Water Resource Board (IWRB) and North American Weather Consultants (NAWC), July 9, 2009.

### Tasks

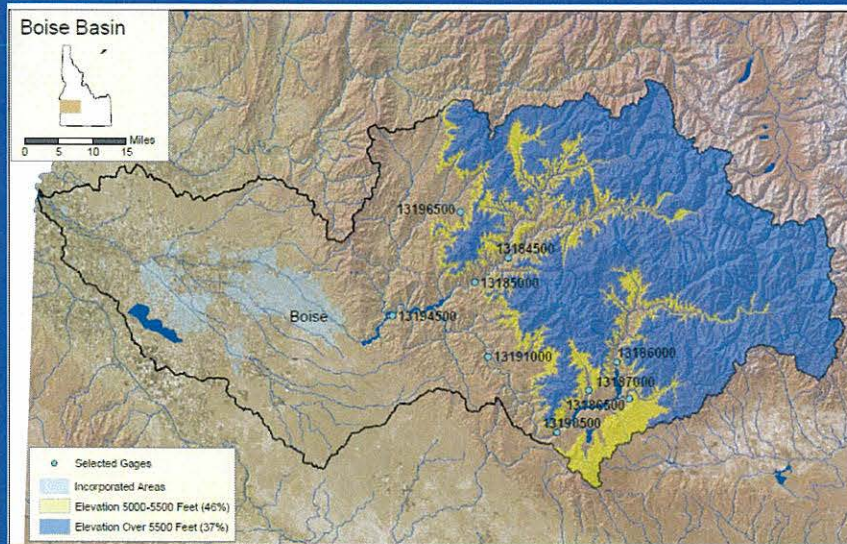
1. Review and Analysis of Climatology of Target Area
2. Review and Assessment of the Existing Program
3. Evaluate Enhancements to Existing Program
4. Establish Criteria for Program Operation
5. Development of Monitoring and Evaluation Methodology
6. Operation Suspension Criteria
7. Final Report Preparation
8. Coordination Meetings and Presentations

## Boise River Basin above Lucky Peak Dam

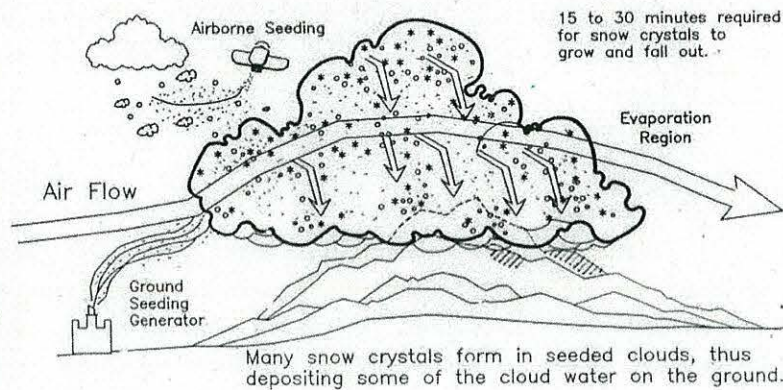




**Proposed Target Area above 5000 Feet (area includes those areas outlined in yellow and blue)**



**SEEDED WINTER STORM SYSTEM**



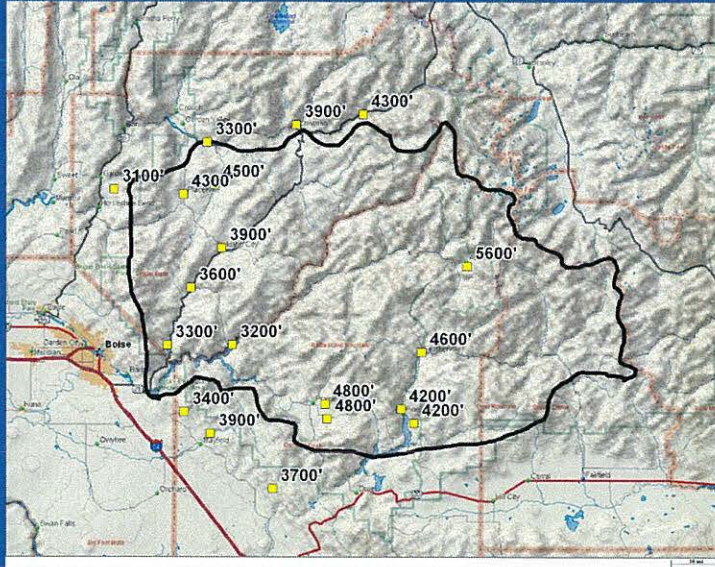
## **TASK 2 REVIEW AND ASSESSMENT OF EXISTING PROGRAM**

### **BOISE PROJECT BOARD OF CONTROL EXISTING WINTER CLOUD SEEDING PROGRAM**

- Weather modification activities for the Boise Project Board of Control (BPBC) began during the winter season of 1992-93.
- North American Weather Consultants (NAWC) conducted this program for four consecutive winter seasons (1992-1996).
- The program was discontinued for the next five seasons (1997-2001).
- The program was conducted again for another four seasons from 2001-2005.
- After being discontinued during the 2005-2007 period, the program was conducted again during the 2007-2008 and 2008-2009 seasons.
- The target area encompasses the drainage of the Boise River above Anderson and Lucky Peak Reservoir. The target area covers approximately 3,500 square miles of mountainous terrain and ranges in elevation from around 3,000 to 4,000 feet on its western side to just over 10,000 feet on its eastern side. Operations typically conducted for a five-month period. Approximately 20 ground based silver iodide generators used each seeded season.
- The program has the goal of augmenting the snowpack that accumulates in the target drainages.
- Benefits from the program are derived from increased hydropower production (Lucky Peak and Anderson Ranch Dams), enhanced streamflow used for irrigated agriculture, and underground aquifer recharge.



## Target Area Outline and Ground Generator Locations, 2008-2009 Winter Season



## Manually Operated Silver Iodide Ground Generator



## Results of December through March Precipitation Evaluation for Ten Seeded Seasons for the Boise River Program

Water Year	Control Avg. (inches)	Target Avg. (inches)	Target Predicted	Obs/Pred Ratio	Excess (inches)
Regression Equation: $Y_c = 0.46 + 1.31X_o$					
1993	14.83	22.17	19.92	1.11	2.25
1994	8.59	13.41	11.72	1.14	1.69
1995	15.29	24.34	20.52	1.19	3.82
1996	16.72	25.34	22.40	1.13	2.94
2002	13.83	18.15	18.61	0.98	-0.46
2003	14.03	21.26	18.87	1.13	2.39
2004	14.12	18.44	18.99	0.97	-0.55
2005	10.00	13.28	13.58	0.98	-0.29
2008	15.28	21.57*	20.51	1.05*	1.06*
2009	14.11	19.71	18.98	1.04	0.73
<b>Average*</b>	<b>13.67</b>	<b>19.77</b>	<b>18.40</b>	<b>1.07**</b>	<b>1.37</b>

### Task 3 Evaluate Enhancements to Existing Boise River Program



## Options to Enhance the Existing Boise River Program

There are basically three options that could be considered to enhance the results being achieved in the current upper Boise River operational program:

- 1) extend the current operational program to six months (November through April) instead of five months.
- 2) adding remote generators to the program.
- 3) adding airborne seeding capabilities to the program.

## Remotely Operated Silver Iodide Generator





**Cloud Seeding Aircraft Equipped with  
Acetone/Silver Iodide Generators**



**Cloud Seeding Aircraft Equipped with Burn-in  
Place Silver Iodide Flares**





## Estimates of Potential Increases in Precipitation and Streamflow in the Boise Basin Target Area

## Estimates of Increases in Average March-July Streamflow based upon Estimated Increases in November – April Precipitation

	Total Increase (6.8%)	Ground (2.3%)	Remote (2.0%)	Air (2.5%)
Increase in AF				
USGS#13185000	40,967	13,656	12,049	15,262
USGS#13186000	31,361	10,454	9,224	11,684
<u>2-Gage Subtotal incr</u>	<u>72,328</u>	<u>24,110</u>	<u>21,273</u>	<u>26,946</u>
<u>Est Additional incr</u>	<u>26,902</u>	<u>8,967</u>	<u>7,912</u>	<u>10,022</u>
<u>Est Total Incr</u>	<u>99,230</u>	<u>33,077</u>	<u>29,185</u>	<u>36,968</u>

**Estimated Average Costs to Produce  
Additional  
March – July Streamflow, Remote Generators  
or Aircraft**

	Remote Generators*	Aircraft**
Ave. Cost to Produce Extra Water	\$173,350	\$460,400
Ave. Water Year <u>Streamflow</u> Increase	29,185	36,968
Cost Per Acre-foot	\$5.94	\$12.45

**Task 4 Establish Criteria for Program  
Operation**



## Summary of Recommended Preliminary Project Design

- The target area will be the upper Boise River Basin above 5,000 feet MSL.
- The primary operational period will be November through April.
- Silver iodide will be the seeding agent.
- The existing program, that utilizes lower elevation ground based generators, will be augmented by extending the operational programs seeding period by one month. The existing program would be enhanced through the addition of remotely controlled ground based generators and aerial seeding.
- The UBRB would be operationally oriented, with the following goals: The stated goal of the program is to increase winter snowpack in the target area to provide additional spring and summer streamflow and recharge under-ground aquifers at a favorable benefit/cost ratio, without the creation of any significant negative environmental impacts.

## Preliminary Design - Continued

- Evaluations of the effectiveness of the cloud seeding program would be based upon historical target and control techniques (target and control sites with corresponding regression equations are provided elsewhere in this report), and possibly some snow chemistry analyses verifying that silver above background levels is being observed at various sampling points in the target area.
- A Qualified/experienced meteorologist should direct the seeding operations.
- If aerial cloud seeding is employed, a winter season program field office should be established near the target area. The logical location of this program office would be at the Boise Air Terminal/Gowen Field.

## **Task 6 Operation Suspension Criteria**

### **Seeding Suspension Criteria**

There are four situations for which suspension criteria were considered. These are:

1. Excess snowpack accumulation
2. Rain and/or snowmelt-induced winter flooding
3. Severe weather
4. Avalanches



## Summary

- There is an existing cloud seeding program in the Boise River Drainage using manual ground based silver iodide generators that appears to be increasing precipitation by approximately 7.5%. A theoretical estimate of increase using this seeding mode was 2.3%. This may indicate that our theoretical estimates are on the conservative side.
- Means of enhancing this existing program were investigated. The primary recommendations for enhancement were to extend the five-month operational period by one month (April), add approximately 5 remotely controlled ground based silver iodide generators and add a seeding aircraft.
- The estimated March-July average streamflow increases from the three seeding modes were: 33,077 AF manual ground generators, 29,185 AF remote generators and 36,968 AF aircraft for a total of 99,230 AF.
- The approximate cost per acre-foot for the three seeding modes assuming a six month operational period would be: \$3.43/AF ground generators, \$5.94/AF remote generators and \$12.45/AF aircraft or \$7.53/AF for the combination of the three seeding modes.