

Utah Cloud Seeding Program

Increased Runoff/Cost Analyses



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Introduction

Cloud seeding in Utah began in the early 1950's. In 1973 the legislature passed the Utah Cloud Seeding Act and seeding projects have been ongoing ever since. Currently there are five projects being sponsored. These include the Central and Southern Utah project areas, the Northern Utah project areas, the West Uintas project area, the High Uintas project area and the Emery propane project area. Local sponsors run the silver iodide programs and the cloudseeding operations are contracted out to a weather modification company. The Utah Division of Water Resources provides financial assistance to the sponsors.

Cloud seeding is a viable way to augment the natural water supply. The purpose of this study is to estimate how much of an increase in runoff should be expected and how much it costs per acre-foot of water. The procedures used to make these estimates are:

1. Estimate the total average annual runoff from the areas that are being seeded.
2. Estimate the increase in April 1st snow water content due to cloud seeding based on target and control analysis.
3. Determine the relationship (equations) between annual runoff and April 1st snow water content for major gaged rivers and streams in the target areas.
4. Estimate the increase in average annual runoff due to cloud seeding based on 1, 2, and 3 above.
5. Compute the estimated cost per acre-foot by dividing the project cost by the increase in average annual runoff determined in 4 above.

Cloud Seeding Project Areas and Operational Costs

There are currently four large-scale silver iodide cloud seeding projects being sponsored, as shown in Figure 1. Most of the cloud seeding programs in Utah occur during the December-March period with the exception of the High Uintas and Central and Southern Utah project which run longer. Starting in 2007, the Lower Colorado River Basin States have funded an cloud seeding period EXTENSIONS in the High Uintas project (November 1-30) and the Central and Southern Utah project (November 1-15 and March 16-April 15).

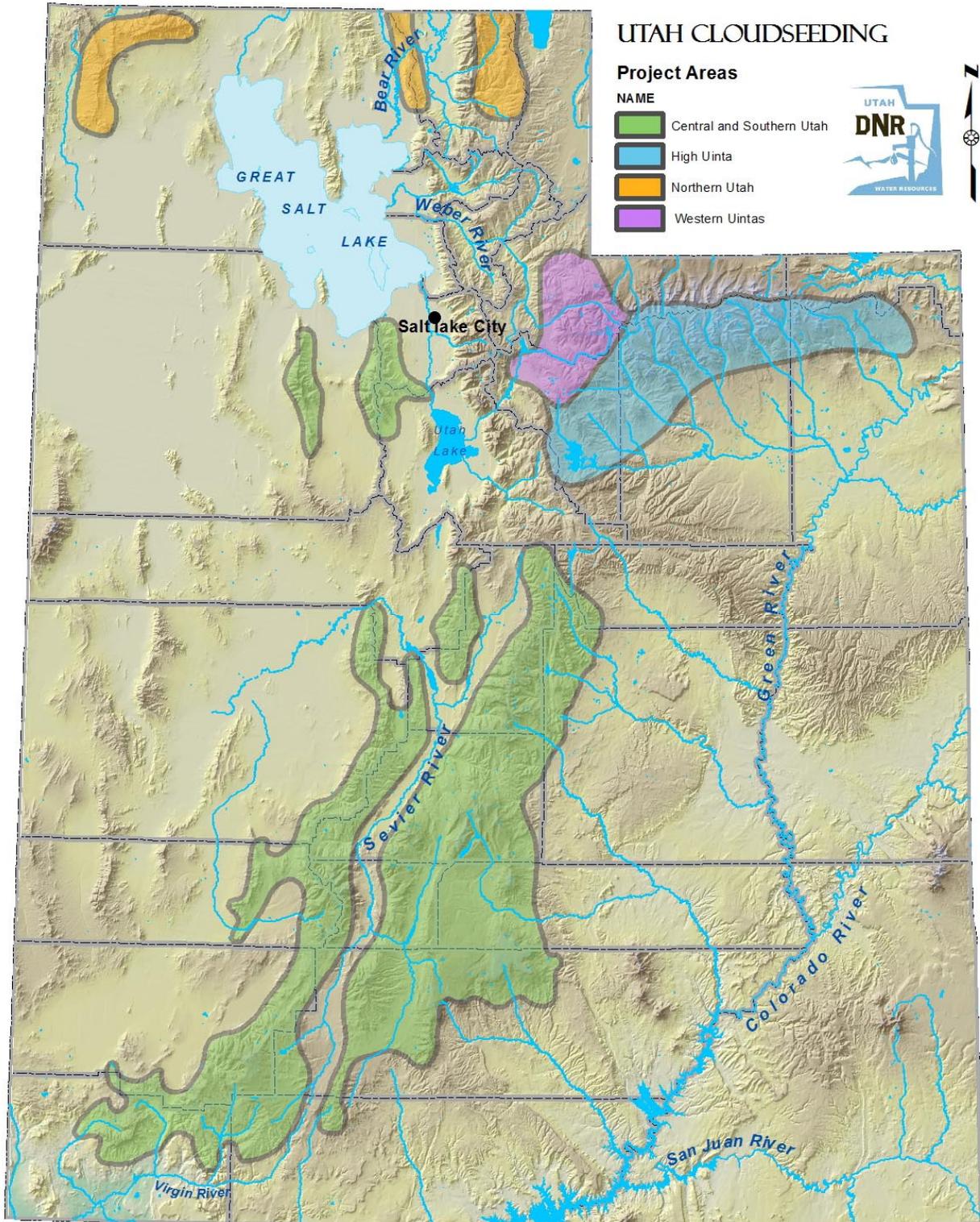


Figure 1. Current Cloud Seeding Project Areas

Winter storms are being seeded with ground-based generators using silver iodide. The Northern Utah project, comprised of the West Box Elder and the East Box Elder/Cache County areas, is sponsored by the Bear River Conservancy District and Cache County. The Central and Southern Utah Project, comprised of Central/Southern Utah and Tooele County areas, is sponsored by the Utah Water Resources Development Corporation. The West Uintas Project is sponsored by the Weber Basin Water Conservancy District. The High Uintas project is sponsored by the Central Utah Water Conservancy District, the Duchesne County Water Conservancy District, and the Uintah Water Conservancy District. The extended seeding periods in November and April are funded by the Lower Colorado River Basin States in an effort to augment water supply in the Colorado River. The contractor for all of the projects is North American Weather Consultants located in Sandy, Utah.

For the 2009-2010 season, the cost for the Northern Utah Project was \$87,097, the cost for the Central and Southern Utah Project was \$188,768, the cost for the Western Uintas Project was \$45,703, and the cost for the High Uintas Project was \$90,432. That is a total of \$412,000. The Division of Water Resources was cost sharing with the local sponsors at 50% (\$206,000).

Average Annual Runoff in the Cloud Seeding Project Areas

To determine the amount of increased runoff due to cloud seeding, it was necessary to estimate the average annual runoff in the different project areas. The Utah Division of Water Resources has published annual stream flow charts for the 1941-1990 period for most streams in the state, found in Appendix A. Based on data from these charts and hydrologic inventories, an estimate of the average annual runoff for the 50-year period has been made for the cloud seeding project areas. A summary of the estimated annual average runoff is in Table 1.

Table 1. Cloud Seeding Project Area Estimated Average Annual Runoff (1941-1990)

Project Runoff Areas	Project	Annual Runoff (acre-feet)
Cache County	NUP	424,000
West Box Elder	NUP	57,800
Tooele County	CSUP	43,300
Sevier River	CSUP	653,000
Cedar-Beaver	CSUP	135,000
West Colorado	CSUP	411,500
Virgin River	CSUP	192,400
Western Uintas	WUP	492,000
High Uintas	HUP	773,300
Total		3,181,500
Northern Utah Project (NUP)		481,800
Central and Southern Utah Project (CSUP)		1,435,200
Western Uintas Project (WUP)		492,000
High Uintas Project (HUP)		773,300

Precipitation Increase

The increase in precipitation due to cloud seeding is determined by using a technique called target and control analysis. The technique is based on variables that are affected by cloud seeding such as precipitation and snowpack. The control sites are unseeded areas located upwind from the target sites. The target and control analyses have been made and published by North American Weather Consultants. The data and analyses have been reviewed and confirmed by the Division of Water Resources. A summary of the results from the analyses is described and is summarized in Table 2.

Cloud seeding in the Eastern Box Elder/Cache County area has been ongoing since 1989. There were 23 cloud seeding generators in the project area for the 2009-2010 winter season. Target and control regression analyses covering 22 seasons of seeding show an average increase in precipitation of 16% and an average increase in April 1st snow water content of 9%.

Table 2. Summary of Cloud Seeding Project Areas

Project Area	Number of Cloud Seeding Generators		Precipitation	April 1 Snow
	2009-2010 Season	Seeded Seasons	Increase during Seeding Period	Water Content Increase
Central/Southern Utah	65	32	13%	4%
Tooele County	7	25	12%	10%
East Box Elder/Cache County	23	22	16%	9%
West Box Elder	10	17	NA	15%
Western Uintas	15	15	1%	3%
High Uintas	25	7	3%	4%

In the West Box Elder project area cloud seeding began in 1989 but was suspended during 1998, 1999, 2002 and 2003. The project area has 10 cloud seeding generators. The target area has no precipitation gages but it does have two snow courses. A target and control regression analysis covering 17 seasons shows an average increase in April 1st snow water content of 15%.

Cloud seeding began in Tooele County in 1976 and continued through 1982. Seeding resumed in 1989 through 1992 and again in 1996. The project area has nine cloud seeding generators, but seven were in operation during the 2009-2010 season. Target and control regression analyses covering 25 seasons show an average increase in precipitation of 12% and an average increase in April 1st snow water content of 10%.

The primary target area of the Central/Southern Utah project has operated continuously since 1974, with exception of the period from 1984-1987. There were 65 cloud seeding generators in the project area for the 2009-2010 winter season. Target and control regression analyses covering 32 seasons show an average increase in precipitation of 13% and an average increase in April 1st snow water content of 4%.

Through 2010, fifteen winter seasons of cloud seeding have now been conducted in the Western Uinta Mountains. There are 14 cloud seeding generators in the project area. Target and control regression analyses show an average increase in precipitation of 1% and an average increase in April 1st snow water content of 3%.

The High Uinta Mountain region has been seeded for 7 years now. There were 25 operational cloud seeding generators in the project area during the 2009-2010 season. Target and control regression analyses indicates an average 3% increase in precipitation and an average 4% increase in April 1st snow water content.

Annual Runoff Estimated from April 1st Snow Water Content

April 1st snow water content is often considered a predictor of the spring runoff to come. Because spring runoff is a large percentage of annual runoff, snow water content can also be a predictor of annual runoff. Regression equations were derived by relating annual runoff to April 1st snow water content. The snow water content was then increased by 10 percent and the equations were used to determine what the increase in annual runoff would be.

The 10 percent increase was chosen, because it is considered an expected nominal increase of the April 1st snow water content due to cloud seeding. The actual increases in April 1st snow water content are used in the following analysis to estimate the increase in runoff for each project area. Table 3 shows the gaged streamflow stations used for each project area, the correlated SNOTEL/snow course stations, the regression equation correlation coefficients, and the percent annual runoff increase for a 10 percent increase in April 1st snow water content.

Table 3. Increase in Annual Runoff for a Ten Percent Increase in April 1st Snow Water Content

Stream Gages	Correlated SNOTEL / Snow Course Stations	Correlation Coefficient	Annual Increase
10109001 LOGAN RIVER COMBINED FLOW	TONY GROVE LAKE, BUG LAKE, DRY BREAD POND, BEN LOMOND PEAK, MONTE CRISTO	0.85	11.5%
10113500 BLACKSMITH FORK	BUG LAKE, MONTE CRISTO, BEN LOMOND PEAK	0.79	13.4%
10104700 LITTLE BEAR NEAR AVON	BEN LOMOND PEAK, LITTLE BEAR, FARMINGTON	0.83	9.5%
10172952 DUNN CREEK NEAR PARK VALLEY	GEORGE CREEK SNOW SURVEY	0.83	16.0%
13077700 GEORGE CREK NEAR YOST UTAH	GEORGE CREEK SNOW SURVEY	0.83	11.3%
10172800 SOUTH WILLOW CREEK NEAR GRANTSVILLE	DESERET PEAK, MINING FORK, ROCKY BASIN-SETTLEME, VERNON CREEK	0.77	11.0%
10172700 VERNON CREEK NEAR VERNON	VERNON CREEK, ROCKY BASIN-SETTLEME	0.67	10.0%
09405500 NORTH FORK VIRGIN RIVER	MIDWAY VALLEY, WEBSTER FLAT, KOLOB	0.93	12.0%
09406000 VIRGIN RIVER AT VIRGIN	MIDWAY VALLEY, KOLOB, WEBSTER FLAT, CASTLE VALLEY	0.94	12.0%
09409880 SANTA CLARA RIVER AT GUNLOCK	LONG FLAT, KOLOB, MIDWAY VALLEY	0.88	16.7%
10174500 SEVIER RIVER AT HATCH	MIDWAY VALLEY, BIG FLAT, MERCHANT VALLEY, CASTLE VALLEY	0.93	12.0%
10194200 CLEAR CREEK NEAR SEVIER	KIMBERLY MINE, BOX CREEK, PINE CREEK	0.78	14.0%
10205030 SALINA CREEK NEAR EMERY	PICKLE KEG, FARNSWORTH LAKE, PINE CREEK, DILL'S CAMP	0.83	15.0%
10215900 MANTI CREEK	RED PINE RIDGE, SEELEY CREEK, CLEAR CREEK #1, PAYSON R.S., PINE CREEK	0.83	11.0%
10183500 SEVIER RIVER NEAR KINGSTON	MIDWAY VALLEY, BIG FLAT, MERCHANT VALLEY, CASTLE VALLEY	0.86	11.0%
10183900 EAST FORK SEVIER RIVER NEAR RUBYS INN	MIDWAY VALLEY, KOLOB, CASTLE VALLEY	0.9	13.1%
10234500 BEAVER RIVER NEAR BEAVER	KIMBERLY MINE, MERCHANT VALLEY, BIG FLAT, BOX CREEK	0.87	13.0%
10242000 COAL CREEK NEAR CEDAR CITY	MIDWAY VALLEY, WEBSTER FLAT, CASTLE VALLEY	0.91	12.0%
09310000 GOOSEBERRY CREEK NEAR SCOFIELD	CLEAR CREEK #1, RED PINE RIDGE	0.82	12.5%
09310500 FISH CREEK ABOVE RESERVOIR, NEAR SCOFIELD	CLEAR CREEK #1, RED PINE RIDGE, MAMMOTH-COTTONWOOD, PAYSON R.S.	0.87	12.0%
09312600 WHITE RIVER BL TABBYUNE C NEAR SOLDIER SUMMIT	WHITE RIVER #1, MAMMOTH-COTTONWOOD, CLEAR CREEK #1, PAYSON R.S.	0.87	16.0%
09317997 HUNTINGTON CREEK NEAR HUNTINGTON	MAMMOTH-COTTONWOOD, CLEAR CREEK #1, PAYSON R.S.	0.73	9.4%
09326500 FERRON CREEK (UPPER STATION) NEAR FERRON	BUCK FLAT, FARNSWORTH LAKE, DILL'S CAMP, PICKLE KEG	0.87	13.0%
09329050 SEVEN MILE CREEK NEAR FISH LAKE	BOX CREEK, FARNSWORTH LAKE	0.76	12.6%
09330500 MUDDY CREEK NEAR EMERY	DILL'S CAMP, PICKLE KEG, BUCK FLAT, FARNSWORTH LAKE	0.82	12.8%
09337500 ESCALANTE RIVER NEAR ESCALANTE	MIDWAY VALLEY, WIDSTOE #3, DONKEY RESERVOIR, CASTLE VALLEY	0.7	14.0%
10128500 WEBER RIVER NEAR OAKLEY	TRIAL LAKE, CHALK CREEK #1, CHALK CREEK #2, MONTE CRISTO, DRY BREAD POND, BEN LOMOND PEAK	0.83	9.9%
10130500 WEBER RIVER NEAR COALVILLE	TRIAL LAKE, CHALK CREEK #1, CHALK CREEK #2, MONTE CRISTO, DRY BREAD POND, BEN LOMOND PEAK	0.78	13.7%
10131000 CHALK CREEK	SMITH&MOREHOUSE, CHALK CREEK #1, CHALK CREEK #2, MONTE CRISTO, DRY BREAD POND, BEN LOMOND PEAK	0.75	16.5%
10154200 PROVO RIVER	TRIAL LAKE, CLEAR CREEK #1, TIMPANOGOS DIVIDE, LOOKOUT PEAK, DANIELS-STRAWBERRY	0.84	9.3%
09266500 ASHLEY CREEK	KINGS CABIN, MOSBY MTN., TROUT CREEK, CHEPETA, FIVE POINTS LAKE, LAKE FORK BASIN	0.77	9.4%
09277500 DUSCHESNE RIVER NEAR TABIONA	ROCK CREEK, BROWN DUCK, LAKE FORK BASIN	0.72	13.9%
09299500 WHITEROCKS RIVER	CHEPETA, MOSBY MTN., BROWN DUCK, ROCK CREEK, TROUT CREEK, CURRANT CREEK	0.81	11.0%
09279000 ROCK CREEK	LAKE FORK #1, FIVE POINTS LAKE, ROCK CREEK, BROWN DUCK, LAKE FORK BASIN	0.66	11.4%

Estimated Increased Runoff and Cost per Acre-Foot

The percent increase in annual runoff for a 10 percent increase in April 1st snow water content was estimated for each streamflow station. All of the streamflow stations in each project area were volume weighted to determine the average percent increase in annual runoff for a 10 percent increase in snow water content for the entire project area. See Appendix B for calculations. This weighted value was then multiplied by the actual percent increase in April 1st snow water content determined from target and control analysis and divided by 10 to obtain a runoff factor. The runoff factor was multiplied by the average annual runoff for the project area to determine the increase in annual runoff due to cloud seeding. The results are shown in Table 4. The estimated average annual increase in runoff for all of the projects combined is 181,700 acre-feet. This is nearly a 6 percent increase overall. The increase in runoff for the Northern Utah Project is 56,300 acre-feet. The Central/Southern Utah Project increase is 72,089 acre-feet. The Western Uinta Mountain project increase is 17,122 and the High Uinta Mountain project increase is 36,190.

The cost analysis results are shown in Table 5. The cost for the 2009-2010 cloud seeding project is \$412,000. With the estimated increased runoff being 181,700 acre-feet, the cost per acre-foot equals \$2.27. This cost will fluctuate year-to-year as a longer record of data is collected. The April 1st snow water content reflects climate variations such as drought therefore as more years of data are collected a better average can be determined.

Table 4. Cloud Seeding Project Area Estimated Increased Runoff

Project Areas	Average Annual Runoff (ac-ft)	Increase in April 1 SWC* (percent)	Increase in Runoff** (percent)	Runoff Factor*** (percent)	Increased Runoff (ac-ft)
Cache County	424,000	9.0	11.8	10.62	45,029
West Box Elder	57,800	15.0	13	19.5	11,271
Western Uintas	492,000	3.0	11.6	3.48	17,122
High Uintas	773,300	4.0	11.7	4.68	36,190
Tooele County	43,300	10	10.4	10.4	4,503
Sevier River	653,000	4	11.9	4.76	31,083
Cedar-Beaver	135,000	4	12.9	5.16	6,966
West Colorado	411,500	4	12.1	4.84	19,917
Virgin River	192,400	4	12.5	5	9,620
Total	3,182,300				181,700
Northern Utah Project	481,800				56,300
Central and Southern Utah Project	1,435,200				72,089
Western Uintas Project	492,000				17,122
High Uintas Project	773,300				36,190

*April 1 snow water content
**Increase in annual runoff for a 10% increase in April 1 SWC
***Runoff Factor (percent) equals increase in April 1 SWC times increase in runoff for a 10% increase in April 1 SWC divided by 10.

Table 5. Increased Runoff and Cost for the Cloud Seeding Projects

Project	Increased Runoff (ac-ft)	Cost (\$)	Cost (\$/ac-ft)
Northern Utah	56,300	87,097	1.55
Central and Southern	72,089	188,768	2.62
Western Uintas	17,122	45,703	2.67
High Uintas	36,190	90,432	2.50
Total	181,700	412,000	2.27

Conclusion

The cost per acre-foot for cloud seeding has increased from the 2005 runoff/cost analysis. This increase in cost comes from a lower estimate of the increase in runoff in 2010 as compared to the 2005 estimate. In 2005 the estimated increase in runoff was 223,000 ac-ft and the estimate runoff in 2010 was 182,000 ac-ft. Also, the High Uintas Project had the largest decrease in expected cloud seeding runoff; 70,500 ac-ft in 2005 to 36,190 ac-ft in 2010. This decrease could be attributed to the short evaluation period of two years in the 2005 analysis. Cloud seeding in the Uinta basin can be challenging due to low elevation atmospheric inversions and the southerly and northwesterly wind regimes (Yorty et al, 2010). As more years of data are collected a better average can be determined. In addition, there has been a significant increase in the cost of silver iodide, approximately 240% which has increased the cloud seeding cost. A summary of the 2005 versus 2010 results is shown in Table 6. The total cost per acre-foot increased from \$1.69 in 2005 to \$2.27 in 2010.

Overall the runoff results may be a conservative estimate. By using April 1st snow water content we are underestimating the results compared to using December through March precipitation amounts.

Table 6. Comparison of 2005 versus 2010 Cloud Seeding Project Area Results

Project Areas	Increase in April 1 SWC 2005	Increase in April 1 SWC 2010	Increased Runoff (ac-ft) 2005	Cost/ac- ft	Increased Runoff (ac-ft) 2010	Cost/ac- ft
Cache County	10%	9%	50,000		45,029	
West Box Elder	18%	15%	13,600		11,271	
Tooele County	18%	10%	9,400		4,503	
Sevier River	4%	4%	30,800		31,083	
Cedar-Beaver	4%	4%	6,700		6,966	
West Colorado	4%	4%	19,600		19,917	
Virgin River	4%	4%	9,000		9,620	
Western Uintas	2.30%	3%	13,200		17,122	
High Uintas	6%	4%	70,500		36,190	
Total			222,800	\$1.69	181,700	\$2.27
Northern Utah Project			63,600	\$1.20	56,300	\$1.55
Central and Southern Utah Project			75,500	\$2.11	72,089	\$2.62
Western Uintas Project			13,200	\$4.96	17,122	\$2.67
High Uintas Project			70,500	\$1.08	36,190	\$2.50

References

1. Stauffer, Norman E. and Kevin Williams, *Utah Cloud Seeding Program Increased Runoff/Cost Analyses*, unpublished report, 2000.
2. Merrill, Ann, Adams, Todd, and Cole, Dave, *Utah Cloud Seeding Program Increased Runoff/Cost Analyses*, unpublished report, 2005.
3. Yorty, David P., Weston, T. Warren, Griffith, Don A., and Solak, Mark E., *Summary and Evaluation of 2009-2010 Winter Cloud Seeding Operations in the Box Elder and Cache Counties, Utah*, North American Weather Consultants, Inc., Sandy, Utah, 2010.
4. Yorty, David P., Weston, T. Warren, Griffith, Don A., and Solak, Mark E., *Summary and Evaluation of 2009-2010 Winter Cloud Seeding Operations in Central and Southern Utah*, North American Weather Consultants, Inc., Sandy, Utah, 2010
5. Yorty, David P., Weston, T. Warren, Griffith, Don A., and Solak, Mark E., *Summary and Evaluation of 2009-2010 Winter Cloud Seeding Operations for the Upper Weber Basin in the Western Uinta Mountains of Utah*, North American Weather Consultants, Inc., Sandy, Utah, 2010
6. Yorty, David P., Weston, T. Warren, Griffith, Don A., and Solak, Mark E., *Summary and Evaluation of 2009-2010 Winter Cloud Seeding Operations for the South Slope of the Uinta Mountains, Utah*, North American Weather Consultants, Inc., Sandy, Utah, 2010
7. Utah Division of Water Resources, State Water Plan, Basin Plans:
 - Bear River Basin – February 2004
 - Cedar/Beaver Basin – April 1995
 - Kanab Creek/Virgin River Basin – 1993
 - Sevier River Basin – June 1999
 - Weber River Basin – September 2009
 - West Colorado River Basin – August 2000
 - West Desert Basin – April 2001

Appendix A

Average Annual Runoff 1941-1990
for the Cloud Seeding Project Areas

Western Uintas		West Box Elder		Tooele-Rush Valleys		West Colorado	
Weber	312,000	Raft River	39,900	Tooele Valley	22,987	Price River	96,300
Chalk Creek	58,000	Lynn	9,100	Box Elder Creek	3,630	Gooseberry	16,500
Misc.	27,000	Yost	5,700	South Willow Creek	4,778	Ungaged Inflow	21,800
Beaver Creek	69,000	Clear Creek	14,400	North Willow Creek	3,205	Mud Creek	11,600
Weber River	115,000	Goose Creek	10,700	Devenport Creek	1,379	White River	20,600
Smith & Morehouse	43,000	Grouse Creek	7,100	Pine Creek	1,430	Beaver Creek	3,300
		Pine Creek	2,000	Middle Creek	4,865	Willow Creek	8,400
Provo		Ungaged	1,400	Settlement Creek	3,700	Coal Creek	4,100
Upper Provo River	36,000	Etna Area	3,700	Rush Valley	20,263	Misc	10,000
Shingle Creek	5,000	Park Valley	10,800	Vernon Creek	2,070	San Rafael	200,700
North Fork	27,000	Indian Creek	2,900	Bennion Creek	405	Huntington Creek	76,100
Weber/Provo Diversion	35,000	Dove Creek	900	Dutch Creek	125	Cottonwood Creek	75,900
Francis	65,000	Fish Creek	2,200	Harker Creek	270	Ferron Creek	48,700
Misc.	12,000	Dunn Creek	4,100	Clover Creek	3,168	Dirty Devil	67,100
		Ungaged	700	Big Hollow Creek	2,030	Muddy Creek	28,700
Total	492,000	Total	57,800	Hickman Creek	2,540	Ivie Creek	2,900
				Soldier Creek	2,422	Fremont River	32,300
				Ophir Creek	6,205	Pine Creek	3,200
				Mercur Creek	1,028	Escalante	39,600
				Total	43,250	Paria	7,800
						Total	411,500
High Uintas		Sevier River		Cache County			
Current Creek	41,400	Mammoth Creek	83,900	Logan River	184,000		
West Fork Duchesne	34,400	Panguitch	26,400	Blacksmith Fork	98,000		
Upper Duchesne	66,100	Otter Creek	19,200	East Fork Little Bear	26,000		
Upper Rock Creek	109,100	East Fork	42,200	South Fork Little Bear	41,000		
Brown Duck	6,900	Piute Reservoir	12,500	High Creek	21,000		
Lake Fork	82,500	Marysville	32,300	Summit Creek	14,000		
Red Creek	6,100	Richfield	55,100	Misc	40,000		
Yellowstone River	102,600	San Pitch	207,000	Total	424,000		
Uinta River	134,500	Gunnison	45,000				
Farm Creek	4,800	Scipio-Levan-Eureka	13,800				
White Rocks River	84,200	Oak-Fool Creeks	16,400				
Misc	100,700	Fillmore	74,200				
		Nephi-Salt Creek	25,000				
Total	773,300	Total	653,000				

Appendix B

Calculation of percent
increase in annual runoff

Stream	Project Area	Annual Runoff	Estimated Annual Increase for a 10% increase in SWE	Fraction of Total	Percent Increase in Runoff for the Entire Area
10109001 LOGAN RIVER COMBINED FLOW		179,738	11.5%	0.58	
10113500 BLACKSMITH FORK		90464	13.4%	0.29	
10104700 LITTLE BEAR NEAR AVON		41,542	9.5%	0.13	
	Cache County Total	311,744			11.8%
10172952 DUNN CREEK NEAR PARK VALLEY		3,757	15.8%	0.38	
13077700 GEORGE CREEK NEAR YOST UTAH		6,098	11.3%	0.62	
	West Box Elder Total	9,855			13.0%
10172800 SOUTH WILLOW CREEK NEAR GRANTSVILLE		4423	11.0%	0.60	
10172700 VERNON CREEK NEAR VERNON		3002	9.5%	0.40	
	Tooele County Total	7425			10.4%
09405500 NORTH FORK VIRGIN RIVER		78089	12.4%	0.33	
09406000 VIRGIN RIVER AT VIRGIN		137221	12.0%	0.59	
09409880 SANTA CLARA RIVER AT GUNLOCK		18911	16.7%	0.08	
	Virgin River Total	234220			12.5%
10174500 SEVIER RIVER AT HATCH		83216	11.9%	0.34	
10194200 CLEAR CREEK NEAR SEVIER		26279	13.8%	0.11	
10205030 SALINA CREEK NEAR EMERY		12420	14.9%	0.05	
10215900 MANTI CREEK		20668	11.2%	0.08	
10183500 SEVIER RIVER NEAR KINGSTON		89548	10.9%	0.36	
10183900 EAST FORK SEVIER RIVER NEAR RUBYS INN		13237	13.1%	0.05	
	Sevier River Total	245368			11.9%
10234500 BEAVER RIVER NEAR BEAVER		36992	13.2%	0.58	
10242000 COAL CREEK NEAR CEDAR CITY		26323	12.5%	0.42	
	Cedar-Beaver Total	63315			12.9%
09310000 GOOSEBERRY CREEK NEAR SCOFIELD		13494	12.5%	0.06	
09310500 FISH CREEK ABOVE RESERVOIR, NEAR SCOFIELD		34859	12.5%	0.16	
09312600 WHITE RIVER BL TABBUNE C NEAR SOLDIER SUMMIT		18401	15.6%	0.08	
09317997 HUNTINGTON CREEK NEAR HUNTINGTON		65408	9.4%	0.29	
09326500 FERRON CREEK (UPPER STATION) NEAR FERRON		45931	13.2%	0.20	
09329050 SEVEN MILE CREEK NEAR FISH LAKE		10896	12.6%	0.05	
09330500 MUDDY CREEK NEAR EMERY		28059	12.8%	0.12	
09337500 ESCALANTE RIVER NEAR ESCALANTE		7486	13.7%	0.03	
	West Colorado Total	224532			12.1%
10128500 WEBER RIVER NEAR OAKLEY		151228	9.9%	0.31	
10130500 WEBER RIVER NEAR COALVILLE		150581	13.7%	0.31	
10131000 CHALK CREEK		51598	16.5%	0.11	
10154200 PROVO RIVER		135201	9.3%	0.28	
	Western Uintas Total	488,608			11.6%
09266500 ASHLEY CREEK		67229.25	9.4%	0.20	
09277500 DUSCHESNE RIVER NEAR TABIONA		108320.75	13.9%	0.32	
09299500 WHITEROCKS RIVER		81757.724	11.0%	0.24	
09279000 ROCK CREEK		80163.138	11.4%	0.24	
	High Uintas Total	337,471			11.7%

