

## **REQUIREMENTS STATEMENT**

### **DEVELOPMENT OF DAILY SNOW WATER EQUIVALENT AVERAGES FOR SNOTEL SITES**

#### **ACTIVITY DESCRIPTION**

Every time that a new SNOTEL site is installed, there is an immediate need to produce daily snow water equivalent (swe) averages. When these data are analyzed to provide information for water resource management decisions, the data are often compared to average conditions. This need is especially critical now, because each Data Collection Office (DCO) must, within the next year and a half, produce 1971 to 2000 averages to comply with interagency policy to adopt the World Meteorological Organization (WMO) guidelines. In the past, this has been a very labor intensive activity required by each DCO to produce hand calculated charts and graphs that defined the average on the first and fifteenth of each month. Application programs then use these averages to estimate a specific daily average. The following process describes how a program can be used with existing information in our current operational database to calculate these daily averages. This would result in significant savings in manpower and produce a more accurate product.

#### **TIMING**

Producing average daily swe at a new site is performed by the responsible DCO after sufficient data have been collected to compare the daily swe with another, close proximity site, either a snow course or another SNOTEL site. Every ten years, daily averages at all SNOTEL sites within the system must be calculated, using data from the most recent thirty-year period. This complete reevaluation is due to be completed prior to October 1, 2001.

#### **RESPONSIBILITY**

Developing new daily swe averages for each SNOTEL site is the responsibility of each DCO. The DCO may ask that the individual state water supply specialists participate in this effort, however the responsibility for completion ultimately rests with the DCO. Without the ability to produce these averages quickly and accurately, using computer facilities, this becomes a difficult task for the under-staffed DCO's to complete within the mandated time frame.

#### **TIME REQUIRED**

As stated above, the daily swe averages are produced for a new site as soon as the site characteristics can be determined statistically. Additionally, the averages within the entire system must be reevaluated every ten years. It is estimated that it takes four hours to develop daily swe averages for a SNOTEL site that has a relatively long period of record (i.e., more than 15 years). For sites that have a short record, the process could take considerably longer. When you consider that each DCO has in excess of one hundred SNOTEL sites that must be reevaluated, this becomes a considerable workload. Also, swe is only one of the parameters that must be analyzed.

#### **INPUT DATA REQUIREMENTS**

The required input data would be the entire historical daily record for each SNOTEL site (table 1) and the monthly swe data for a co-located or adjacent snow course (table 2) that has the required period of record. This would be thirty years for an unconditional average, or twenty-five to twenty-nine years for a conditional average.

/cdb/ut/snot49 79 pill

Station : UT10J30S, BROWN DUCK

----- Unit = inches

day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
1	0.00	0.30	4.40	7.80	11.80	15.60	19.50	20.50	9.90	0.00	0.00	0.00
2	0.00	0.30	4.40	7.80	11.90	15.60	19.60	21.00	9.60	0.00	0.00	0.00
3	0.00	0.90	4.70	7.90	11.90	15.60	19.60	21.00	8.70	0.00	0.00	0.00
4	0.00	0.90	4.90	8.00	11.90	15.80	19.80	21.00	7.60	0.00	0.00	0.00
5	0.00	0.90	5.40	8.00	11.90	16.00	19.80	21.10	6.40	0.00	0.00	0.00
6	0.00	0.90	5.50	8.00	12.10	16.00	19.80	21.10	5.20	0.00	0.00	0.00
7	0.00	0.90	5.60	8.00	12.10	16.20	19.80	21.20	4.00	0.00	0.00	0.00
8	0.00	0.90	5.70	8.00	12.30	16.20	19.80	21.50	3.10	0.00	0.00	0.00
9	0.00	0.90	5.80	8.00	12.30	16.20	19.80	21.60	2.90	0.00	0.00	0.00
10	0.00	0.90	5.90	8.00	12.30	16.20	20.00	21.60	1.90	0.00	0.00	0.00
11	0.00	2.10	5.90	8.20	12.40	16.30	20.00	21.60	0.50	0.00	0.00	0.00
12	0.00	3.10	5.90	9.50	12.40	16.30	20.00	21.70	0.00	0.00	0.00	0.00
13	0.00	3.20	5.90	9.70	12.40	16.30	20.10	21.70	0.00	0.00	0.00	0.00
14	0.00	3.40	5.90	9.90	13.20	16.30	20.20	21.70	0.00	0.00	0.00	0.00
15	0.00	3.40	5.90	10.10	13.90	16.30	20.20	21.80	0.00	0.00	0.00	0.00
16	0.00	3.40	5.90	10.30	13.90	16.30	20.20	21.30	0.00	0.00	0.00	0.00
17	0.00	3.40	5.90	10.60	14.00	16.60	20.20	20.60	0.00	0.00	0.00	0.00
18	0.00	3.40	6.70	10.90	14.00	16.60	20.20	20.30	0.00	0.00	0.00	0.00
19	0.00	3.50	7.20	10.90	14.10	16.90	20.20	19.60	0.00	0.00	0.00	0.00
20	0.00	3.50	7.20	11.20	14.30	17.20	20.20	18.60	0.00	0.00	0.00	0.00
21	0.30	3.50	7.50	11.20	14.50	17.20	20.30	17.70	0.00	0.00	0.00	0.00
22	0.30	3.50	7.50	11.30	14.90	17.00	20.30	16.80	0.00	0.00	0.00	0.00
23	0.30	3.50	7.60	11.30	15.00	17.30	20.30	16.00	0.00	0.00	0.00	0.00
24	0.30	3.50	7.80	11.30	15.20	17.30	20.30	15.20	0.00	0.00	0.00	0.00
25	0.30	3.50	7.80	11.60	15.30	17.30	20.30	14.50	0.00	0.00	0.00	0.00
26	0.30	3.50	7.80	11.60	15.30	17.30	20.30	14.00	0.00	0.00	0.00	0.00
27	0.30	3.60	7.80	11.60	15.30	18.00	20.40	13.20	0.00	0.00	0.00	0.00
28	0.30	3.70	7.80	11.60	15.60	19.00	20.40	12.50	0.00	0.00	0.00	0.00
29	0.30	3.90	7.80	11.60	---	19.30	20.40	11.70	0.00	0.00	0.00	0.00
30	0.30	4.00	7.80	11.60	---	19.30	20.40	10.70	0.00	0.00	0.00	0.00
31	0.30	---	7.80	11.80	---	19.40	---	10.40	---	0.00	0.00	---
mean	0.11	2.55	6.44	9.91	13.44	16.87	20.08	18.49	1.99	0.00	0.00	0.00
max	0.30	4.00	7.80	11.80	15.60	19.40	20.40	21.80	9.90	0.00	0.00	0.00
min	0.00	0.30	4.40	7.80	11.80	15.60	19.50	10.40	0.00	0.00	0.00	0.00

Table 1 – SNOTEL Daily Data

/cdb/ut/snow49

Station : 10J30S, BROWN DUCK PILLOW

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Unit = inches

year/ June	January	February	March	April	May
card date	date	date	date	date	date
dep	dep	dep	dep	dep	dep
swe	swe	swe	swe	swe	swe

71-1				E/ST	19.2
72-1	E/ST	8.8		E/ST	22.8
73-1				E/ST	21.0
74-1				E/ST	14.7
75-1				E/ST	23.8



86-2	1/15	12.1	2/15	15.5	3/15	24.5	4/15	30.7	5/15	31.9
	6/15	7.0								
87-2	1/15	9.4	2/15	11.5	3/15	14.1	4/15	18.3	5/15	12.0
	6/15	0.0								
88-2	1/15	7.8	2/15	10.5	3/15	12.2	4/15	12.6	5/15	10.4
	6/15	0.0								
89-2	1/15	8.0	2/15	10.9	3/15	13.4	4/15	16.2	5/15	9.1
	6/15	0.0								
90-2	1/15	6.7	2/15	10.9	3/15	14.7	4/15	16.5	5/15	18.1
	6/15	1.1								
91-2	1/15	6.7	2/15	8.1	3/15	12.5	4/15	15.0	5/15	14.7
	6/15	3.1								
92-2	1/15	6.8	2/15	8.5	3/15	10.6	4/15	10.9	5/15	4.6
	6/15	0.0								
93-2	1/15	11.2	2/15	14.3	3/15	18.1	4/15	22.0	5/15	23.1
	6/15	7.7								
94-2	1/15	6.7	2/15	9.9	3/15	12.3	4/15	14.0	5/15	11.7
	6/15	0.0								
95-2	1/15	11.3	2/15	15.9	3/15	20.0	4/15	23.7	5/15	32.3
	6/15	29.3								
96-2	1/15	7.3	2/15	12.8	3/15	19.0	4/15	20.1	5/15	17.4
	6/15	4.0								
97-2	1/15	16.9	2/15	20.3	3/15	22.7	4/15	24.4	5/15	22.7
	6/15	8.6								
98-2	1/15	7.6	2/15	12.3	3/15	16.6	4/15	21.7	5/15	23.9
	6/15	17.7								

FIRST OF MONTH MEASUREMENTS

average depth and swe :

		7.9		11.3		14.7		18.4		20.1
13.4										
years	0	23	0	23	0	22	0	26	0	25
	0	20								
1961-1990		average :								
		8.2		11.4		14.7		18.6		20.1
12.9										
years	0	15	0	15	0	14	0	18	0	17
	0	12								

MID-MONTH MEASUREMENTS

average depth and swe :

		10.1		13.3		17.0		20.1		19.7
6.2										
years	0	20	0	20	0	20	0	20	0	20
	0	20								
1961-1990		average :								
		10.7		13.7		17.4		20.9		20.3
4.5										
years	0	12	0	12	0	12	0	12	0	12
	0	12								

NOTES: O/dd - October, J/dd - November, K/dd - December, E/ST - estimate  
Card type 1 = First of Month, 2 = Mid-Month, and 3 = Special Measurement

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**Table 2 – Snow Course Monthly Data**

## OUTPUT DATA REQUIREMENTS

The output required is shown in Table 3. This table would contain the average daily swe for the specified period. For WMO compliance, the period would be thirty years. This table could then be used to plot against the current year, a specified year, the site historical average, etc. Chart 1 is a graphical representation of the required output.

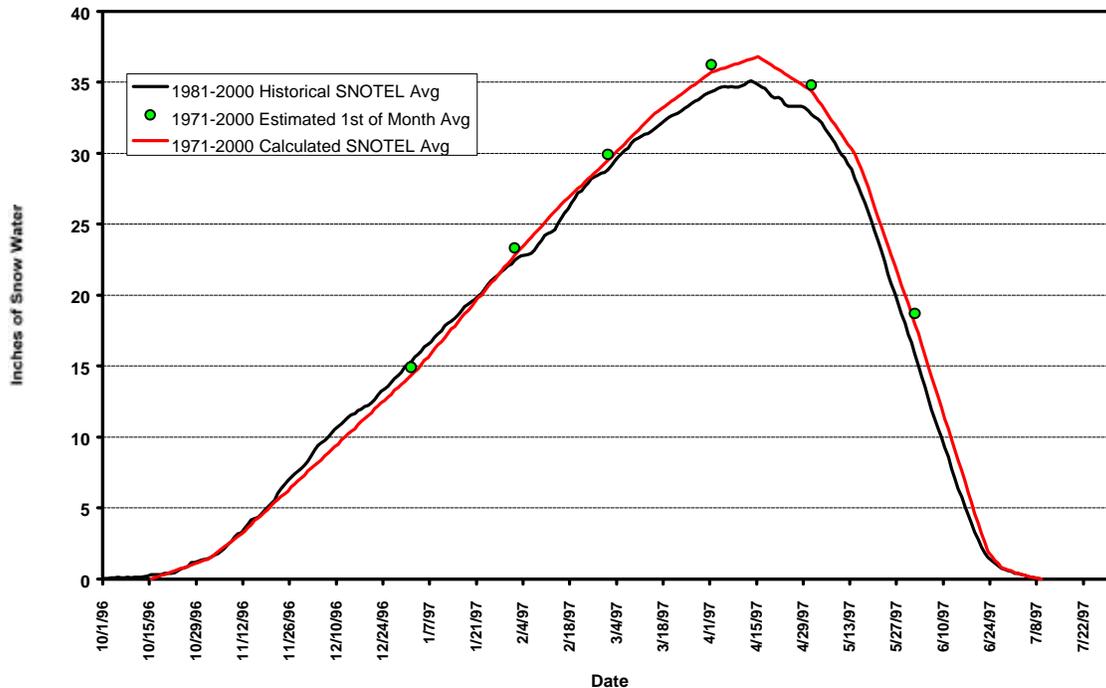
Station : UT10J30S, BROWN DUCK

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day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
	---	---	---	---	---	---	---	---	---	---	---	---
1	0.4	2.4	5.4	8.2	11.8	15.4	18.9	21.0	13.8	1.4	0.0	0.0
2	0.5	2.4	5.4	8.4	11.9	15.5	19.1	21.1	13.6	1.2	0.0	0.0
3	0.5	2.6	5.5	8.5	12.0	15.7	19.3	21.1	13.3	1.1	0.0	0.0
4	0.6	2.6	5.6	8.5	12.0	15.9	19.3	21.0	12.7	1.0	0.0	0.0
5	0.7	2.6	5.7	8.7	12.0	16.0	19.4	21.0	12.3	0.9	0.0	0.0
6	0.7	2.7	5.9	8.8	12.1	16.0	19.5	21.0	11.8	0.8	0.0	0.0
7	0.6	2.8	5.9	8.9	12.1	16.2	19.5	21.0	11.4	0.7	0.0	0.0
8	0.7	2.8	6.0	9.0	12.3	16.2	19.6	21.0	10.8	0.6	0.0	0.0
9	0.7	2.9	6.1	9.0	12.4	16.3	19.6	20.9	10.4	0.5	0.0	0.0
10	0.7	3.0	6.2	9.2	12.6	16.3	19.8	20.8	9.9	0.4	0.0	0.0
11	0.8	3.2	6.3	9.4	12.7	16.4	19.8	20.8	9.2	0.4	0.0	0.0
12	0.9	3.4	6.4	9.6	12.8	16.7	19.8	20.7	8.6	0.3	0.0	0.1
13	0.8	3.6	6.6	9.7	12.9	16.8	19.9	20.5	8.0	0.3	0.0	0.1
14	0.9	3.7	6.7	9.9	13.2	16.8	20.0	20.5	7.5	0.2	0.0	0.1
15	1.0	3.8	6.7	10.0	13.4	17.0	20.1	20.3	7.0	0.2	0.0	0.1
16	1.1	3.8	6.8	10.1	13.5	17.1	20.1	20.0	6.4	0.3	0.0	0.0
17	1.2	3.9	6.9	10.3	13.7	17.3	20.1	19.8	6.1	0.1	0.0	0.0
18	1.3	4.0	6.9	10.4	13.9	17.4	20.1	19.5	5.8	0.0	0.0	0.0
19	1.4	4.1	7.0	10.5	14.2	17.5	20.2	19.2	5.3	0.0	0.0	0.0
20	1.5	4.2	7.2	10.6	14.4	17.6	20.3	18.7	4.9	0.0	0.0	0.1
21	1.5	4.3	7.2	10.7	14.6	17.7	20.4	18.4	4.4	0.0	0.0	0.1
22	1.5	4.3	7.4	10.8	14.7	17.7	20.4	18.0	4.0	0.0	0.0	0.1
23	1.5	4.4	7.5	10.9	14.8	17.8	20.6	17.6	3.6	0.0	0.0	0.0
24	1.6	4.5	7.5	11.0	14.9	17.8	20.7	17.1	3.3	0.0	0.0	0.0
25	1.6	4.7	7.6	11.1	15.0	17.9	20.6	16.7	3.0	0.0	0.0	0.1
26	1.7	4.8	7.7	11.3	15.1	17.9	20.8	16.3	2.8	0.0	0.0	0.1
27	1.9	5.0	7.8	11.4	15.2	18.2	20.9	16.0	2.5	0.0	0.0	0.1
28	2.0	5.1	7.9	11.5	15.3	18.4	20.9	15.6	2.2	0.0	0.0	0.2
29	2.1	5.2	8.0	11.6	---	18.6	21.0	15.2	1.9	0.0	0.0	0.2
30	2.2	5.3	8.1	11.6	---	18.7	21.1	14.6	1.6	0.0	0.0	0.3
31	2.3	---	8.2	11.7	---	18.8	---	14.1	---	0.0	0.0	---

**Table 3 – Daily Average SNOTEL swe**

### SNOTEL 30-Year SWE Average Development



**Chart 1 – Graphical Output of Daily 30-Year Average Data**

### CURRENT METHODOLOGY

Since the current process of producing swe averages for SNOTEL sites varies with each DCO, I'll describe the process that the Idaho DCO uses. And, even though there are minor differences in the way each DCO does the mechanics, the method and results are similar.

For the Jan-May period, the first of month 1971-2000 values are used. This may include 10-15 years of estimated values (back generated values). If someone investigates the archive database (CDBS) the 30-year average values at the bottom of the tables should agree with the 30-year average values being used. Because of program imposed analysis standards, back generated values are generally good to excellent.

To find the snow graph start date, determine the average or median Julian start date when seasonal swe occurs. This is based on daily snow pillow data for all years through 2000 and will usually be based on less than 20 years of data.

To calculate the daily averages from the start date to Jan 1, manually perform a linear interpretation between the two dates. This will gradually convert into a 30-year average by Jan 1. A French curve is used to transition from the start date to match the linear accumulation arm. This is all very subjective.

Determine the average or median Julian day that the pillow returns to zero, based upon all years of daily data through 2000. Develop a linear interpretation between meltout and May 1, using the method described in the last paragraph.

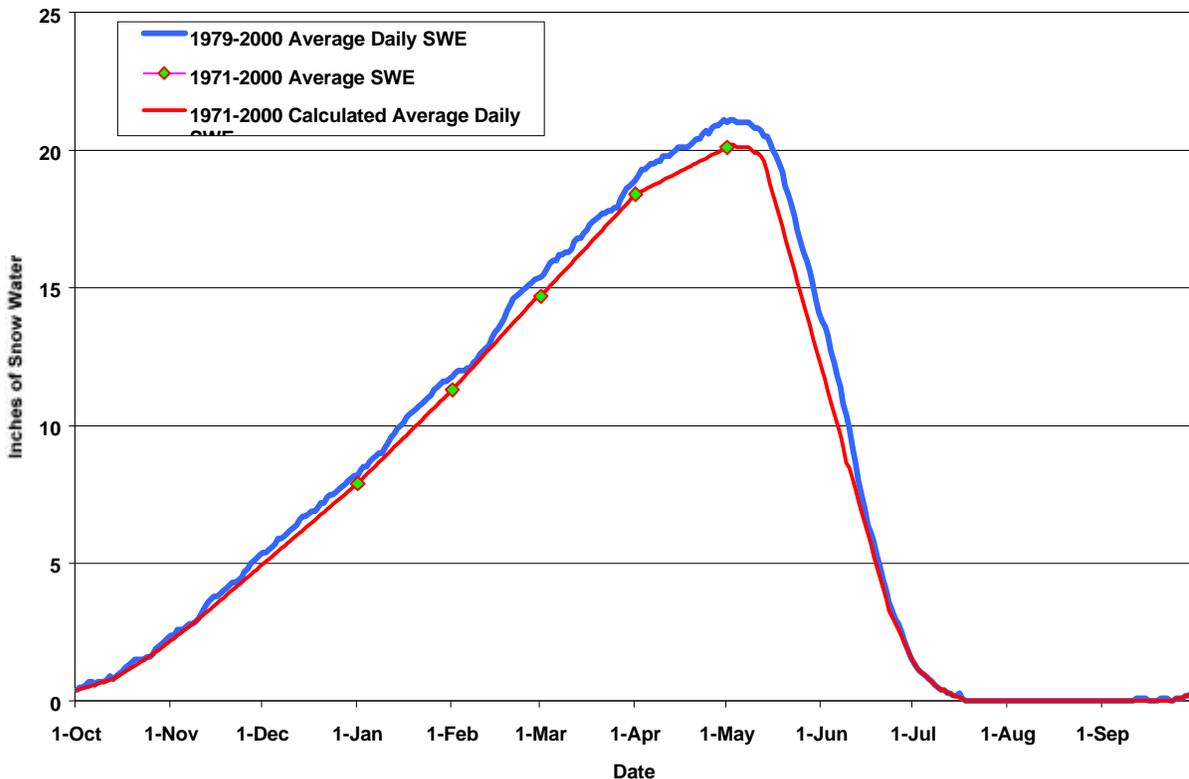
Consult Chart 1 to view the various transition periods.

## **REQUIRED IMPROVEMENTS**

All of the input data needed are stored within the current operational database (see input data requirements). Two data tables are needed: an average SNOTEL table that depicts the daily averages from the beginning of the historical record through September 30, 2000, and first-of-month 30-year averages at the SNOTEL site, based on statistical relationships with a co-located or close proximity snow course (control points).

The developed daily averages are integrated values that are derived from the known 30-year average, the control points, and the SNOTEL site characteristics. The calculated 30-year average SNOTEL swe dataset will have a zero value at the start of accumulation and a zero meltout value, based on the site characteristics. The remainder of the daily values will be derivatives of these two points, the average daily SNOTEL data characteristics and the snow course control points. Basically, there are linear relationships between control point to control point, from start of accumulation to control point, or from control point to melt out. The calculated 30-year swe average curve will have to be adjusted to the control values, while maintaining the same shape as the historical average curve. Chart 2 is a graphical representation of this process. The desired output is shown in Table 4.

**SNOTEL 30-Year SWE Average Development**



**Chart 2 – Graphical Output of Calculated Daily 30-Year Average Data**

Station : UT10J30S, BROWN DUCK

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day	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
	---	---	---	---	---	---	---	---	---	---	---	---
1	0.4	2.2	5.0	7.9	11.3	14.7	18.4	20.1	12.0	1.4	0.0	0.0
2	0.4	2.3	5.1	8.0	11.4	14.8	18.5	20.2	11.6	1.2	0.0	0.0
3	0.5	2.4	5.2	8.1	11.5	14.9	18.5	20.2	11.2	1.1	0.0	0.0
4	0.5	2.5	5.3	8.2	11.7	15.1	18.6	20.1	10.8	1.0	0.0	0.0
5	0.5	2.6	5.4	8.3	11.8	15.2	18.6	20.1	10.5	0.9	0.0	0.0
6	0.6	2.6	5.4	8.4	11.9	15.3	18.7	20.1	10.1	0.8	0.0	0.0
7	0.6	2.7	5.5	8.6	12.0	15.4	18.7	20.1	9.7	0.7	0.0	0.0
8	0.6	2.8	5.6	8.7	12.2	15.5	18.8	20.1	9.3	0.6	0.0	0.0
9	0.7	2.9	5.7	8.8	12.3	15.6	18.8	20.0	8.7	0.5	0.0	0.0
10	0.7	3.0	5.8	8.9	12.4	15.8	18.9	19.9	8.5	0.4	0.0	0.0
11	0.7	3.1	5.9	9.0	12.5	15.9	19.1	19.9	8.1	0.4	0.0	0.0
12	0.8	3.2	6.0	9.1	12.6	16.0	19.0	19.8	7.7	0.3	0.0	0.0
13	0.8	3.3	6.1	9.2	12.8	16.1	19.1	19.6	7.3	0.3	0.0	0.0
14	0.9	3.4	6.2	9.3	12.9	16.2	19.1	19.2	6.9	0.2	0.0	0.0
15	0.9	3.5	6.3	9.4	13.0	16.4	19.2	18.8	6.5	0.2	0.0	0.0
16	1.0	3.6	6.4	9.6	13.1	16.5	19.2	18.4	6.1	0.1	0.0	0.0
17	1.1	3.6	6.5	9.6	13.2	16.6	19.3	18.0	5.7	0.1	0.0	0.0
18	1.2	3.7	6.6	9.8	13.4	16.7	19.4	17.6	5.3	0.0	0.0	0.0
19	1.2	3.8	6.7	9.9	13.5	16.8	19.4	17.2	4.9	0.0	0.0	0.0
20	1.3	3.9	6.8	10.0	13.6	17.0	19.5	16.8	4.5	0.0	0.0	0.0
21	1.4	4.0	6.9	10.1	13.7	17.1	19.5	16.4	4.1	0.0	0.0	0.0
22	1.4	4.1	7.0	10.2	13.8	17.2	19.6	16.0	3.7	0.0	0.0	0.0
23	1.5	4.2	7.0	10.3	14.0	17.3	19.6	15.6	3.3	0.0	0.0	0.0
24	1.6	4.3	7.1	10.4	14.1	17.4	19.7	15.2	3.1	0.0	0.0	0.0
25	1.6	4.4	7.2	10.5	14.2	17.6	19.8	14.8	2.8	0.0	0.0	0.1
26	1.7	4.5	7.3	10.6	14.3	17.7	19.8	14.4	2.6	0.0	0.0	0.1
27	1.8	4.6	7.4	10.8	14.5	17.8	19.9	14.0	2.4	0.0	0.0	0.1
28	1.9	4.7	7.5	10.9	14.6	17.9	19.9	13.6	2.1	0.0	0.0	0.2
29	2.0	4.8	7.6	11.0	---	18.0	20.0	13.2	1.9	0.0	0.0	0.2
30	2.0	4.9	7.7	11.1	---	18.2	20.0	12.8	1.6	0.0	0.0	0.3
31	2.1	---	7.8	11.2	---	18.3	---	12.4	---	0.0	0.0	---

**Table 4 – Calculated 1971-2000 Daily Average SNOTEL swe**

**STORAGE OF CALCULATED DAILY SNOTEL AVERAGES**

The calculated daily SNOTEL swe averages will be stored in a location that is easily accessible to database queries from data users and operational software applications.

**TIMING**

This software must be completed on or before January 1, 2001. In all probability, the edited water year 2000 SNOTEL data will not be available prior to this date. However, once the edited data is available, the DCO offices will have just nine months to complete SNOTEL average calculations.