Cypress Bowl Liquid Chemical Case Study

Prepared for:

The Insurance Corporation of British Columbia

By:

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DISCLAIMER

The assessments and conclusions presented in this report are solely those of the Author(s) and do not reflect the opinions of Cypress Bowl Ski Area. Brand names are used only to provide clarity and context. As such, their use does not constitute an endorsement by Ice and Snow Technologies, LLC, The Insurance Corporation of British Columbia, or the Management of Cypress Bowl

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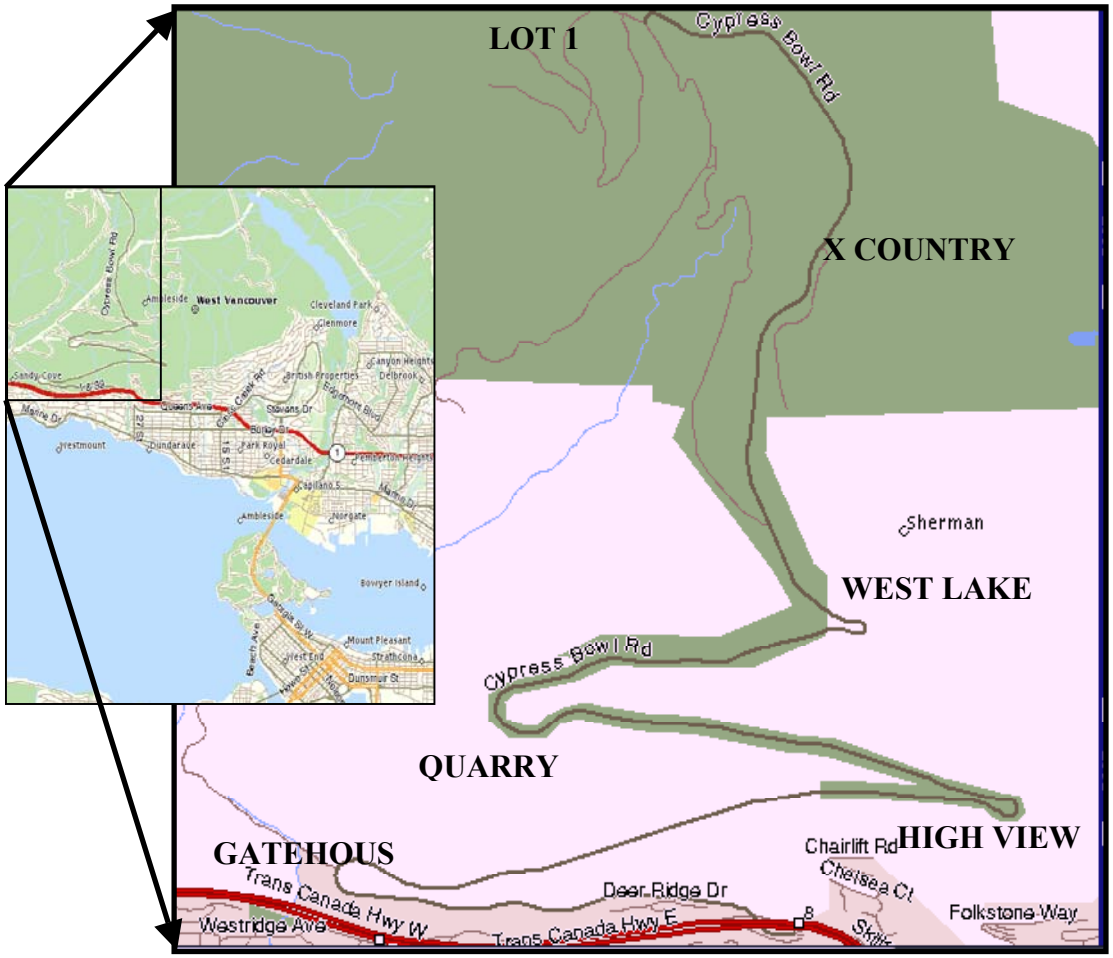
1.0 BACKGROUND

1.1. TOPOGRAPHY

Cypress Bowl is a ski area located in a Provincial park adjacent to metropolitan Vancouver British Columbia.



1.2. ROADWAY CHARACTERISTICS

The roadway is of asphalt construction with numerous parking lots. The agency jurisdiction includes the parking lots and spur roads to some of the facilities.

The grade is an average of 5.5% for the length of the road, which is roughly 14.3 kilometers long and consists of 48.2 lane kilometers of treated roadway.

1.3. CLIMATE.

The general climate is Pacific Maritime Mountain, similar to the Oregon and Washington Cascade Mountains, with relatively moderate winter temperatures and, at times, fairly heavy snowfall. At LOT 1, with a base elevation 980m, the annual average snowfall is 622 cm (244 in.). The snow is generally heavy and relatively wet.

2.0 OPERATIONS

The winter season lasts from November 1 to April 1 and there are up to 5 supervisory / lead people providing 24 hour a day/ 7 days a week coverage. The target level of service for the section is "bare and wet" pavement conditions.

Pavement Temperatures are measured using a hand-held radiometer. This unit costs about $500 (Cdn). The particular unit is a Snap On Enhance® Model 30 PB. It measures temperature from – 32 to + 545 degrees Celsius with a +/- 1 degree accuracy and costs about $500 (Cdn).

Also, the winter of 2000 – 2001 was the first season for the use of liquid chemicals

2.1. PROCEDURE 1999 –2000

The general procedure for a winter storm in 1999 – 2000 was:

a) The Environment Canada weather forecast is received and reviewed by the supervisor/lead person to determine if there is a threat.

b) If a storm or icing condition is expected, the workers are given an advanced warning.

c) The supervisor/lead person will call out the workers if the storm or icing conditions materialize.

d) The workers will plow and apply a 50/50-sand/salt mix (by volume) until the "bare and wet" pavement condition is achieved. Roadway surface temperatures are measured and logged using the hand-held radiometer

e) On frost days, the crews patrol with 2 trucks loaded with a 50/50-sand/salt mix looking for ice until the end of the shift.

2.2. PROCEDURE 2000-2001

The general procedure for a winter storm in 2000-2001 was:

a) The Environment Canada weather forecast is received and reviewed by the supervisor/lead person to determine if there is a threat.

b) If a storm or icing condition is expected, the workers are given an advanced warning.

c) The supervisor/lead person will call out the workers if the storm or icing conditions materialize.

d) The workers will plow and apply prewetted salt until the "bare and wet" pavement condition is achieved. Sand is used only of needed. The sand is also prewetted.

e) On frost days, after an initial application of liquid magnesium chloride with 1 truck, the crews will patrol for a short time and, if no further problems are noted, go home.

2.3. EQUIPMENT

The equipment used in snow and ice operations (Pictures and details are in Appendix A) consists of:

a) A grader with a 3, or 4-m. moldboard and a 3-m. wing plow is used about 20% of the time on the roadways. The John Deere and rental graders used in 1999-2000 have been replaced with a Champion in 2000 – 2001.

b) A large loader with a snow bucket is used about 10% of the time on the roadways. The Trojan and rental loaders used in 1999-2000 have been replaced with a Volvo loader in 2000 – 2001.

c) A Case #480 loader is used to load sand and salt,

d) 2 Sicard 5150 snow blowers are used about 10% of the time on the roadways,

e) 2 International and 1 Freightliner trucks with snowplow, 5 cu m. dump box, and spreader were used in the winter of 1999-2000. For the winter of 2000 – 2001, one of the Internationals and Freightliner were fitted with prewet systems. The other International was fitted with a liquid application system, but retaining the plow. These units spend 95% of their time on the roadways.

3.0 WEATHER - MARCH 1999-2000 vs. MARCH 2000-2001

For the purposes of this study, the month of March in both 2000 and 2001was selected for comparison as it provided the most complete data and the most comparable weather conditions. This data is recorded at the Lot 1 site.

3.1. WEATHER STATISTICS.

The following table shows that the month of March 2001 was only slightly milder from a conventional standpoint.

WEATHER SUMMARY – MARCH 2000 vs. MARCH 2001

WEATHER ELEMENT	UNIT	WINTER MARCH 2000	MARCH 2001	CRITERIA
SNOW	**DAY**	18	14	Trace or more of SNOW
RAIN	**DAY**	2	5	Trace or more of RAIN
NONE	**DAY**	11	12	No Measurable Precipitation
FREEZING	**DAY**	28	24	The low temperature is below freezing
FROST	**DAY**	10	10	The low Temperature is below freezing and there is no precipitation
TOTAL SNOW	**CM**	122.04	115.53	Total snow fall
MAXIMUM SNOW	**CM**	30	25	Maximum Daily snow fall
AVERAGE SNOW	**CM**	3.94	3.73	Average daily snow fall
WEATHER INDEX		-12.30	-11.26	WSDOT Weather Index Calculation

WEATHER INDEX - WSDOT weather index is derived from the original SHRP weather index. It should be noted that the winter index values are not linear in nature and one can not draw any inferences except that the two months were relatively equal in regards to weather severity. The range is from -50 (severe) to 50 (mild).

3.2. DISCUSSION OF WEATHER.

The most significant difference in the two winters is the rainfall, one day of which was freezing rain. The study area received almost as much snow in 2001 as it did in 2000 and, while the maximum daily snow was slightly lower, the average daily snowfall was about the same.

It should also be noted that the total number of freezing days was almost equal and the number of frost days was the same.

4.0 MATERIALS - March 1999-2000 vs. March 2000-2001

Materials used at Cypress bowl include sand (Gradation shown in Appendix B), salt, and in the winter of 2000-2001, 30% magnesium chloride liquid.

4.1. COSTS.

The costs, in Canadian Dollars, reflect all fixed charges and taxes, for materials delivered to the maintenance yard. It should be noted that there is a $0.25 environmental tax per metric tonne of sanding material (Abrasives). Note, also, that there was a $5.00 increase in the purchase price of salt in the winter of 2000 –2001.

MATERIALS UNIT COST

TYPE	UNIT	PURCHASE	SHIPPING	PST TAXES	GST TAXES	ENV TAXES	TOTAL UNIT COST
SAND	Metric Tonne	$ 5.650	$ 9.60	$1.070	$0.400	$ 0.25	$ 16.97
SALT (99-00)	Metric Tonne	$ 50.000	$ 8.00	$4.060	$3.500	*	$ 65.56
SALT (00-01)	Metric Tonne	$ 55.000	$ 8.00	$4.410	$3.850	*	$ 71.26
MgCl	Liter	$ 0.179	*	$0.013	$0.013	*	$ 0.205

4.2. SUMMARY OF MATERIALS USED.

The following materials use and costs are for the month of March for each winter.

MATERIALS SUMMARY

MATERIAL	UNIT	AMOUNT March 2000	AMOUNT MARCH 2001	COST March 2000	COST MARCH 2001	% CHANGE
SAND	**Tonne**	254.01	92.06	$ 4,310.55	$ 1,562.26	-64%
SALT	**Tonne**	452.69	89.54	$ 29,678.36	$ 6,380.62	-79%
MgCl	**Liter**	-	61,800		$ 12,669.00	+100%
TOTAL MATERIALS COST =➔				**$ 33,988.91**	**$ 20,611.88**	**-39%**

4.3. DISCUSSION OF MATERIALS COSTS.

The 39% reduction in materials cost use can be attributed to a more efficient operation with less wastage due to the use of liquid chemicals, directly applied, or as a prewet for sand and salt. The 64% reduction in the use of sand is due to the prewetting process. The 80% reduction in the use of salt is partly due to its replacement with magnesium chloride as well as the prewetting process.

5.0 EQUIPMENT & MANPOWER – March 2000 vs. March 2001.

The manpower costs reflected in the total hourly rates for the equipment. This is excluding peripheral supervisory and support costs.

5.1. COSTS AND USAGE.

The total hourly equipment costs are for operated equipment. The details are in Appendix A.

MONTHLY EQUIPMENT USE

NUMBER NEW/OLD	TYPE	HRS MARCH 2000	HRS MARCH 2001	TOTAL HOURLY RATE	% RDWY USE
LO99/RENT	**VOLVO LOADER**	230	138.7	$ 34	10%
GR99/RENT	**CHAMPION GRADER**	151.4	105.0	$ 38	20%
SB74/CB74	**SICARD BLOWER**	86.8	-	$ 49	10%
SB73/CB76	**SICARD BLOWER**	36.8	53.2	$ 51	10%
PT99/CB49	**INTERNATIONAL TRUCK**	168.3	99.1	$ 37	95%
PT96/CB48	**FREIGHTLINER TRUCK**	140.2	151.1	$ 45	95%
PT89/CB46	**INTERNATIONAL TRUCK**	180.9	110.9	$ 62	95%
LO92/CB15	**CASE LOADER**	34.7	31.2	$ 33	100%
____/CB14	**TROJAN LOADER**	0		$ 39	10%
____/CB12	**JOHN DEERE GRADER**	10		$ 35	20%

The percent of roadway use is the portion of equipment hours used on the roadways only. The remainder of the time reflects the work in parking lots. The figures in this table have been adjusted to reflect only the roadway-related use.

MONTHLY EQUIPMENT COST FOR ROADWAY ACTIVITIES

NUMBER NEW/OLD	TYPE	MARCH 2000	MARCH 2001	% CHANGE
LO99/RENT	VOLVO LOADER	$ 782.00	$ 471.58	-40%
GR99/RENT	CHAMPION GRADER	$ 1,150.64	$ 798.00	-31%
SB74/CB74	SICARD BLOWER	$ 425.32	$ -	-100%
SB73/CB76	SICARD BLOWER	$ 187.68	$ 271.32	45%
PT99/CB49	INTERNATIONAL TRUCK	$ 5,915.75	$ 3,483.37	-41%
PT96/CB48	FREIGHTLINER TRUCK	$ 5,993.55	$ 6,459.53	8%
PT89/CB46	INTERNATIONAL TRUCK	$ 10,655.01	$ 6,532.01	-39%
LO92/CB15	CASE LOADER	$ 1,145.10	$ 1,029.60	-10%
____/CB14	TROJAN LOADER	$ -	$ -	
____/CB12	JOHN DEERE GRADER	$ 70.00	$ -	-100%
TOTAL MONTHLY COST		**$ 26,325.05**	**$ 19,045.40**	**-28%**

5.2. DISCUSSION OF EQUIPMENT COSTS

The 27% reduction in costs for the two study periods can be attributed to several factors:

a) Replacement of older equipment (Grader & Loader) with newer, more efficient and less maintenance cost equipment.

b) Lesser patrol time, and reduced equipment use, due to liquid chemical use, both directly applied and as a prewet for salt and sand.

6.0 EQUIPMENT CORROSION ISSUES

The corrosion of equipment is always a concern as it is an added cost over and above the normal materials, labor and equipment.

The annual corrosion-related equipment maintenance for the agency's fleet is as follows:

CORROSION RELATED MAINTENANCE COSTS

EQUIPMENT TYPE	#	MAINTENANCE PROCEDURE(s)	BASE COST (Cdn)
TRUCKS	2	Sandblast & Paint Hoppers	$ 1,750
LOADERS	2	Sandblast & Paint	$ 1,250
GRADER	1	Chipping & Painting	$ 1,250
BUSES	5	Chipping & Painting	$ 4,000

6.1. SNOW & ICE CONTROL EQUIPMENT

In the past, the corrosion-related maintenance for the snow and ice control equipment has been carried out on an annual basis costing approximately $7250 (Cdn) per year. This work consisted of sandblasting truck hoppers and frames along with loader buckets and frames followed by spray painting. Grader frames were chipped and painted. Based on inspection of the equipment, it is expected that this process will, in the future, be done every three years for an annualized cost of approximately $ 2420 (Cdn) representing annual savings of $4830(Cdn) per year.

6.2. BUSES

As shown above, the agency is responsible for the operation of 5 shuttle busses that shuttle between Vancouver destinations and the resort area. Last season, 4 busses required chipping and repainting. The cost for this process is about $4000 (Cdn). Since this assessment, the shuttle busses have been discontinued.

6.3. BRAKES.

The brakes on the trucks and buses had, in the past, show scoring from sanding material and significant rust from the chemicals. For this reason, the brakes were replaced annually.

This year the brakes were inspected and showed significantly less rust than in previous years, and a reduced amount of scoring. The brakes will not be replaced this year. The savings in this area would primarily be in the cost of parts, as the annual inspection already requires a complete teardown of the brakes. The estimated annualized savings for the 3 truck and 5 buses would be about $1200 (Cdn).

7.0 VEHICLE CRASH DATA

The crew reports that there were 24 snow-related crashes during the winter of 1999 –2000 and they reported no crashes during the winter of 2000 –2001.

In March of 2000, there were 2 accidents reported, one of which cites a slippery roadway as involved. In March of 2001, there were 3 accidents reported, none of which were related to a slippery roadway.

MOTOR VEHICLE CRASH DATA			
MONTH	**INCIDENTS COUNT**	**RELATED TO SLIPPERY ROADWAY**	**OTHER CAUSES**
MARCH 2000	2	1	1
MARCH 2001	3	0	3

Due to the low number of accidents, one can not draw any significant conclusions as to accident reduction.

The Insurance Corporation of British Columbia reports the following:

Incident Counts by Season	**Incidents Count**	**Fatal**	**Injury**	**MD only > $1,000**	**MD only =< $1,000**
Winter 1996-1997-Nov. 01 to March 31 =	31	0	8	14	9
Winter 1997-1998-Nov. 01 to March 31 =	28	0	5	17	6
Winter 1998-1999-Nov. 01 to March 31 =	24	0	6	14	4
Winter 1999-2000-Nov. 01 to March 31 =	21	0	5	11	5
Winter 2000-2001-Nov. 01 to March 31 =	17	0	7	6	4
Totals =	**121**	**0**	**31**	**62**	**28**

As there was a significant difference in the overall winter index for 1999-2000 and 2000-2001, and the relatively low number of accidents, no reliable conclusions can be drawn as to accident reduction.

8.0 CONCLUSIONS

This case study illustrates that, even in the initial stages, the use of liquid chemicals can yield significant savings for the winter maintenance community. The results can be shown as follows:

8.1. MONTHLY OPERATIONAL SAVINGS

Given the relatively equal weather conditions between March of 2000 and March of 2001, the following table illustrates the advantages of a liquid chemical based operation.

OPERATIONAL COST SUMMARY
MARCH 2000 vs. MARCH 2001

ITEM	COST		%
	MARCH 2000	MARCH 2001	CHANGE
LABOR & EQUIPMENT	$ 26,325.05	$ 19,045.40	-28%
MATERIALS	$ 33,988.91	$ 20,611.88	-39%
TOTAL COST =	**$ 60,313.95**	**$ 39,657.28**	**-34%**

Along with the $20,746.67 (–34%) monthly savings in operational costs, an additional $4,830 in annual savings can be expected from reduce corrosion on the equipment.

8.2. MONTHLY REDUCTION IN CHLORIDE RELEASE.

Given the reduced amounts of chemicals used, the monthly reduction in the release of chlorides into the environment can be calculated as shown below.

MOLECULAR WEIGHT CALCULATION

ELEMENT	ATOMIC WEIGHT	COMPOUND	MOLECULAR WEIGHT	% Chloride
CHLORINE	35.4527	ROAD SALT (Na Cl)	58.44247	60.66 %
SODIUM	22.98977	MAG CHLORIDE ($Mg Cl_2$)	95.2104	74.47 %
MAGNESIUM	24.3050			

MOISTURE ADJUSTMENT & CHLORIDE CONTENT

COMPOUND	UNIT	% Water	Sp. Gr.	Kg Cl per Unit
ROAD SALT (Na Cl)	Tonne	5%		576.27
30% MAG CHLORIDE ($Mg Cl_2$)	Liter	70 %	1.285	0.28708185

COMBINED RELEASE CALCULATION

COMPOUND	FACTOR	MARCH 2000		MARCH 2001	
		Quantity	Kg Cl	Quantity	Kg Cl
ROAD SALT (Na Cl)	576.27/tonne	452.69	260,872	89.54	51,599
30% MAG CHLORIDE ($Mg Cl_2$)	0.28708185/L	00		61,800	17,742
TOTAL CHLORIDE RELEASE ==========➔			**260,872 Kg**		**69,341 Kg**

8.3. MONTHLY REDUCTION IN SAND RELEASE

The 64% reduction of sand or abrasive consumption (254.01 tonnes in March of 2000 to 92.06 tonnes in March of 2001) was also very significant. This translates into monthly savings of $2748.29 (Cdn). While Cypress Bowls has no roadway-sweeping program, others who are required to sweep would realize additional saving.

9.0 LONG RANGE IMPACT

There are a number of long range impacts that can be estimated from the monthly results. This is because the analysis of six months of weather over two years shows the months of March in both 2000 and 2001 appear to be relatively close to "average" or "typical" (See Appendix C).

9.1. ESTIMATED ANNUAL SAVINGS

One can estimate the annual savings by the following:

MONTHLY SAVINGS	$ 20,746.67
# of winter months	X 5
TOTAL ANNUAL SAVINGS	**$103,733.35**

Depending on the fleet maintenance requirements, another $6030 (Cdn) could be added to this figure representing the savings in corrosion and sand-related damage to the fleet.

9.2. ESTIMATED ANNUAL REDUCTION IN CHLORIDE RELEASE

One can estimate the annual reduction in chloride release by the following:

MONTHLY REDUCTION	191,531Kg
# of winter months	X 5
TOTAL ANNUAL REDUCTION	**957,655 Kilograms**

9.3. ESTIMATED ANNUAL REDUCTION IN SAND USAGE

One can also estimate the annual reduction in sand use.

MONTHLY REDUCTION	161.95 Tonnes
# of winter months	X 5
TOTAL ANNUAL REDUCTION	**810 Tonnes**

The annual savings for sand purchase amounts to $ 13,741.45. Using the figure of $12 per tonne for urban pickup (City of Kamloops 1996) further savings of up to $ 9,720 would be realized by those agencies required to sweep.

9.4. ESTIMATED ANNUAL RETURN ON INVESTMENT

The annual return on investment can be calculated by using the following method:

CAPITAL INVESTMENT FOR LIQUID CHEMICAL APPLICATION

ITEM DESCRIPTION	#	UNIT COST	TOTAL COST
PREWETTING KITS FOR SPREADERS	2	$ 10,000	$ 20,000.00
LIQUID APPLICATION TRUCK	1	$ 30,000	$ 30,000.00
STORAGE TANKS & Misc. Fittings	1	$ 10,000	$ 10,000.00
TOTAL CAPITAL INVESTMENT ==========➔			**$60,000.00**

Given the above information, one can reasonably calculate the following:

ANNUAL SAVINGS	$103,733.35	
LESS CAPITAL INVESTMENT	- $60,000.00	
FIRST YEAR NET BENEFIT	**$43,733.35**	
FIRST YEAR NET BENEFIT	$ 43,733.35	= **72.89%**
÷ ORIGINAL INVESTMENT	$ 60,000.00	

9.5. ESTIMATED 4 YEAR BENEFIT COST RATIO

Using a conservative 4-year life cycle for the equipment, a benefit/cost (B/C) ratio can be calculated.

ANNUAL SAVINGS	$103,733.35	
X YEARS	4	
YEAR BENEFIT	**$414,933.40**	
FOUR YEAR BENEFIT	$414,933.40	= **6.92 : 1**
÷ ORIGINAL INVESTMENT	$ 60,000.00	

APPENDIX A – EQUIPMENT

NUMBER NEW (*OLD)*	TYPE	RATE	WAGES	TOTAL HOURLY RATE	% RDWY USAGE	DESCRIPTION
LO99(*RENTAL)*	VOLVO LOADER	$ 15	$ 19	$ 34	10	L120C with Snow Bucket
GR99(*RENTAL)*	CHAMPION GRADER	$ 19	$ 19	$ 38	20	740 VHP , 4 Meter Blade, 3 Meter Wing
SB74(*CB74)*	SICARD BLOWER	$ 30	$ 19	$ 49	10	Sicard 5150
SB73(*CB76)*	SICARD BLOWER	$ 32	$ 19	$ 51	10	Sicard 5150
PT99(*CB49)*	INTERNATIONAL TRUCK	$ 18	$ 19	$ 37	95	Plow, 5 Cu M. Box, Sander, & Prewet
PT96(*CB48)*	FREIGHTLINER TRUCK	$ 26	$ 19	$ 45	95	Plow, 5 Cu M. Box, Sander, & Prewet
PT89(*CB46)*	INTERNATIONAL TRUCK	$ 43	$ 19	$ 62	95	Plow, Anti Icing Tank & Spray
LO92(*CB15)*	CASE LOADER	$ 14	$ 19	$ 33	100	#480 F FWD
____(*CB14)*	TROJAN LOADER	$ 20	$ 19	$ 39	10	Snow Bucket
____(*CB12)*	JOHN DEERE GRADER	$ 16	$ 19	$ 35	20	6 Wheel Drive, 5 Meter Blade, 3 Meter Wing

Volvo L120C Loader (LO99)

Champion 740 VHP Grader (GR99)

SICARD 5150 Blower (SB73/SB74)

Case #480 FWD Loader (LO92)

Plow Truck (PT99/ PT96) Front View

Plow Truck (PT99/PT96) Rear View

Liquid Chemical Truck (PT89) Detail

Liquid Chemical Truck (PT89) Detail

APPENDIX B – MATERIALS

SANDING MATERIAL GRADATION

SIEVE SIZE		% Passing (CSA Standard)		
Metric	**English**	**Minimum**	**Maximum**	**CYPRESS SAMPLE**
5.00 mm	# 4	95 %	100 %	94.9 %
2.50 mm	# 8	80 %	100 %	59.7 %
1.25 mm	#16	50 %	90 %	20.1 %
630 µm	#30	25 %	85 %	4.3 %
315 µm	#50	10 %	35 %	1.1 %
160 µm	#100	2 %	10 %	0.6 %
80 µm	#200			0.6 %
PASS	PASS			0.6 %

APPENDIX C – WEATHER COMPARISON

WEATHER ELEMENT	DECEMBER 1999	JANUARY 2000	MARCH 2000	DECEMBER 2001	JANUARY 2001	MARCH 2001	AVERAGE
SNOW DAYS	7.00	21.00	18.00	8.00	9.00	14.00	**12.83**
RAIN DAYS	4.00	1.00	2.00	3.00	4.00	5.00	**3.17**
NONE	18.00	9.00	11.00	18.00	18.00	12.00	**14.33**
FREEZING DAY	22.00	30.00	28.00	23.00	26.00	24.00	**25.5**
FROST ONLY	12.00	9.00	10.00	16.00	14.00	10.00	**11.83**
CM Snow	67.21	188.02	122.04	54.12	52.10	115.53	**99.84**
MAX SNOW	24.00	22.00	30.00	25.00	16.00	25.00	**23.67**
MEAN SNOW	2.32	6.07	3.94	1.87	1.68	3.73	**3.27**
WINTER INDEX	**-7.2**	**-27.3**	**-12.30**	**-4.1**	**-4.4**	**-11.26**	**-11.09**

WEATHER INDEX - WSDOT weather index is derived from the original SHRP weather index. It should be noted that the winter index values are not linear in nature and one can not draw any inferences except that there can be similarities and differences between any two months. The range is from -50 (severe) to 50 (mild).