Summary of Wallace Laboratories Report on Cal-CM

Provided to PACE Turf by Art Wilson Company

To test the theory in which Pace Consulting has stated that Cal-CM Plus calcium sulfate is not soluble therefore it is not effective in reducing sodicity in soil. The Wallace Laboratories LLC was commissioned to study and prove or disprove this theory.

A sandy loam soil was obtained from Number 17 Fairway, North Course at Pelican Hill Golf Course, Newport Beach, California. Untreated soil had a pH of 7.65. Salinity was 2.74 dS/m. SAR was 9.1. Exchangeable sodium was 10%. Exchangeable calcium was 57%. Soil organic matter was 2.82%. Water permeability was 0.05 inches per hour.

Samples of the soil were amended with anhydrite, gypsum or Art Wilson Cal-CM Plus. Gypsum was reagent grade calcium sulfate dihydrate.

All calcium products were applied at the equivalent rate of 50 pounds per 1,000 square feet, 6 inches deep. The leaching water was site irrigation water with a pH of 8.22. Salinity was 1.26 dS/m. SAR was 4.2. Adjusted SAR was 8.0. Sodium was 159 parts per million. Bicarbonate was 245 parts per million. Eighteen inches of water was applied to each column of soil containing 6 inches of treated soil.

The three products were equally effective in reducing exchangeable sodium. After leaching, the treated soils had 5% exchangeable sodium compared to the untreated soil at 10% exchangeable sodium. SAR was reduced to 3.9 for the reagent grade gypsum treatment and sodicity was further reduced to 3.7 by the anhydrite and for the Art Wilson Cal-CM Plus treatments. Exchangeable calcium in the soil was increased to 59% for both the reagent grade gypsum and for Art Wilson Cal-CM Plus and to 57% for anhydrite. The percent of applied calcium that did not remain in the soil but was leached from the soil and recovered in the leachate was 59% for the reagent grade gypsum, 56% for Art Wilson Cal-CM Plus, and 23% for anhydrite.

Conclusion – All three products were nearly equal in effectiveness in reducing sodicity. Additional applications of the calcium containing products are recommended for added reduction in sodicity.

The use of a simple water solubility test to determine rate of dissolution of anhydrite and gypsum as determined by these results is not a reliable predictor for determining the efficacy of lowering exchangeable sodium levels in soil when using these calcium sulfate containing products.

A complete and detailed description of the above test is available upon request from the Art Wilson Co.

WALLACE LABORATORIES, LLC
365 Coral Circle
El Segundo, CA 90245
phone (310) 615-0116 fax (310) 640-6863

August 7, 2010

Art Wilson Company
Richard Taylor, rtaylor@calcmplus.com
PO Box 20160
Carson City, NV 89721

RE: rate of dissolution
of gypsum and gypsum equivalent products
soil reclamation
Pelican Hill Golf Course

Dear Dick,

Two soils were provided to us from the Pelican Hill Golf Course for evaluation. Reduction in sodicity and rate of release of gypsum and anhydrite were evaluated.

Soil Number 1

The first soil was received June 9, 2010. The soil texture was sandy loam. Based on the non-gravel fraction, it contained 67.8% sand, 15.7% silt and 16.5% clay. The gravel fraction was 1.4%. The soil organic matter was 2.59% on a dry weight basis.

The SAR was 9.1.

Exchangeable cations

Potassium	5%
Sodium	13%
Calcium	55%
Magnesium	26%
Hydrogen	2%

A sodic soil is defined as having at least 15% exchangeable sodium or SAR in excess of 13.

The rate of water percolation was very low at 0.002 inch per hour. Due to the slow rate of permeability, it was not feasible to measure the rate of release of surface applied gypsum and anhydrite materials. Soil samples were amended with three materials: (A) Art Wilson Cal-CM Plus, (B) Ludwig anhydrite and (C) Mallinckrodt reagent grade gypsum. The application rate was equivalent to 50 pounds of gypsum per 1,000 square feet homogeneously incorporated to a depth of 6 inches.

The amended soil samples were placed in individual columns 2 inches wide to a depth of 6 inches. Irrigation water supplied by the golf course was applied at 6 inches per column, applied water equal to the depth of soil. After leaching, the individual soil samples were evaluated for comparison to the initial conditions.

	Cal-CM Plus	Ludwig anhydrite	reagent grade gypsum	untreated
Percolation In/Hr	0.026	0.037	0.511	0.002
pH	7.53	7.47	7.54	7.38
Salinity dS/m	1.20	1.49	0.81	2.45
SAR	4.2	4.0	3.6	9.1
	Exchangeable Cations in Percent			
Potassium	4	5	4	5
Sodium	6	7	6	13
Calcium	60	60	62	55
Magnesium	25	26	23	26
Hydrogen	4	3	5	2

All three products increased the rate of water percolation. Reagent grade gypsum was most effective. SAR values were reduced from 9.1 to the range of 3.6 for reagent grade gypsum and 4.2 for Cal-CM Plus. Exchangeable sodium was reduced from 13% to 7% for Ludwig anhydrite and to 6% for Cal-CM Plus and reagent grade gypsum.

All three products were effective in reducing sodicity and in increasing the rate of water percolation.

The irrigation water had a pH of 7.95. Salinity was 1.30 millimho/cm. SAR was 4.15. Adjusted SAR was 7.75. Sodium was 151 parts per million. Bicarbonate was 230 parts per million.

Soil Number 2

Due to the low rate of water percolation, a second soil sample was provided from the Pelican Hill Golf Course Number 17 Fairway, North Course.

The second soil was received June 28, 2010. The soil texture was sandy loam. Based on the non-gravel fraction, it contained 63.5% sand, 16.7% silt and 19.8% clay. The gravel fraction was 1.2%. The soil organic matter was 2.82% on a dry weight basis.

The SAR was 9.1.

Exchangeable cations

Potassium	6%
Sodium	10%
Calcium	57%
Magnesium	27%
Hydrogen	1%

The rate of water percolation was 0.050 inch per hour.

Soil was placed into three 2-inch wide columns to a depth of 6 inches. One of each columns was treated with (A) Art Wilson Cal-CM Plus, (B) Ludwig anhydrite and (C) Mallinckrodt reagent grade gypsum at the equivalent to 50 pounds of gypsum per 1,000 square feet surface applied.

One inch of new irrigation water provided by Pelican Hill Golf Course was applied daily to each column. The leachate was collected and analyzed for the concentration of calcium, the concentrations of other minerals, salinity, and pH.

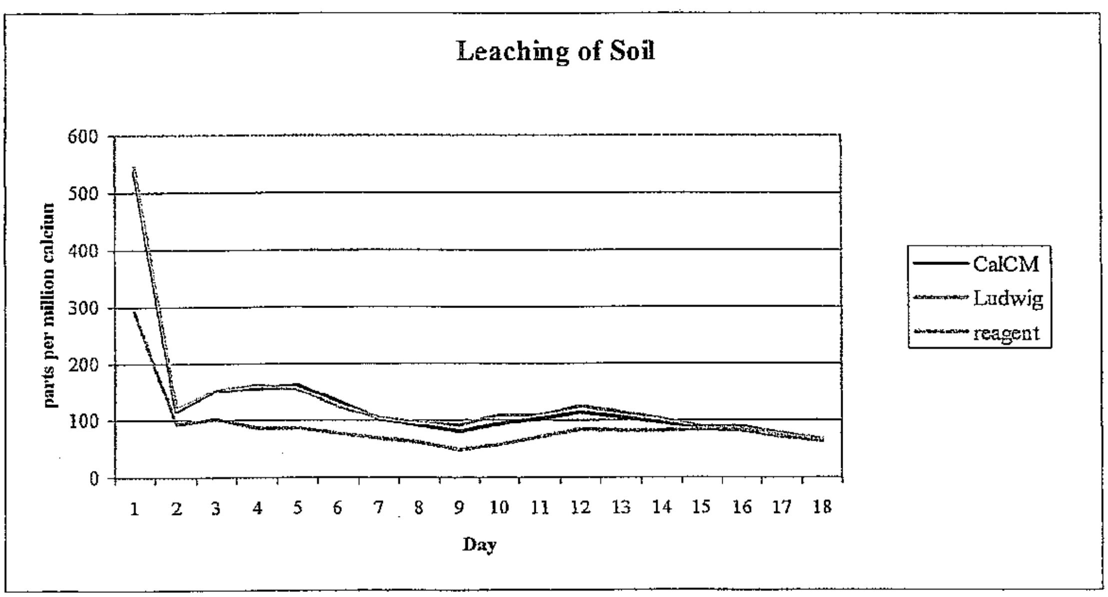
The irrigation water had a pH 8.22. Salinity was 1.26 millimho/cm. SAR was 4.19. Adjusted SAR was 8.01. Sodium was 159 parts per million. Bicarbonate was 245 parts per million.

Summary Data

	Cal-CM Plus	Ludwig anhydrite	reagent grade gypsum	untreated
pH	7.79	7.81	7.82	7.65
salinity dS/m	0.81	0.89	0.88	2.74
SAR	3.7	3.7	3.9	9.1
	Exchangeable Cations in Percent			
Potassium	5	5	5	6
Sodium	5	5	5	10
Calcium	59	57	59	57
Magnesium	23	25	23	27
Hydrogen	8	8	8	1

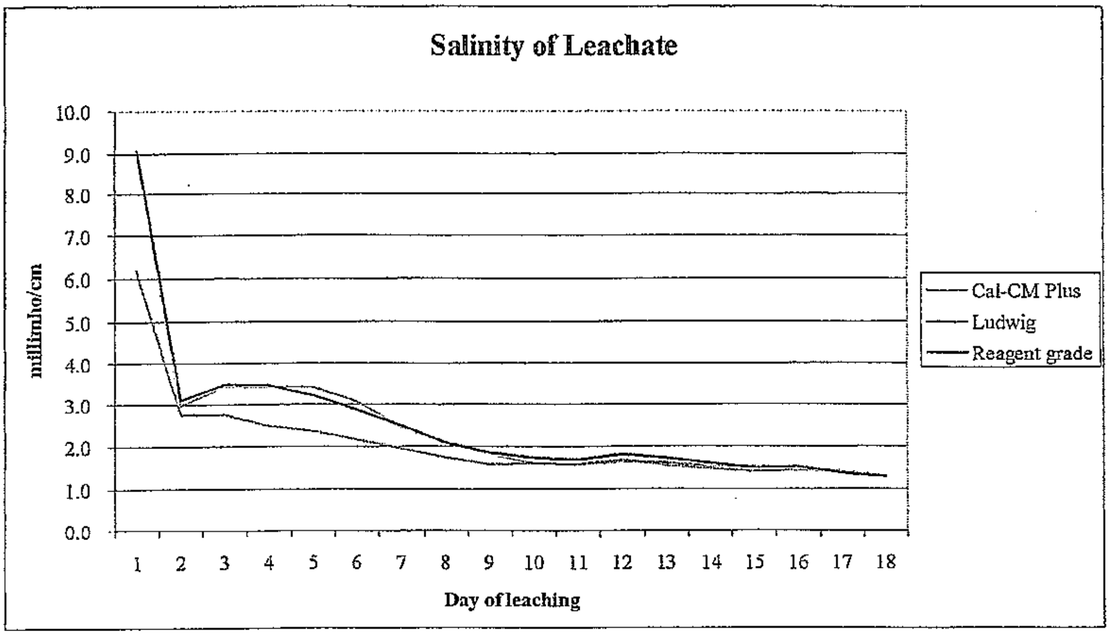
Each of the three gypsum/anhydrite materials were approximately equal in efficacy to reclaim the soil.

Concentration of calcium in leachate



The concentration of calcium form Ludwig was lower than the concentrations of calcium from Cal-CM Plus and reagent grade gypsum. The rate of release of calcium from Cal-CM Plus appears to be approximately equivalent to reagent grade gypsum.

Salinity of Leachate



Percent of applied calcium recovered in leachate

Cal-CM Plus	56%
Ludwig anhydrite	23%
Reagent Grade gypsum	59%

Conclusions

Art Wilson Cal-CM Plus, Ludwig anhydrite and Reagent Grade gypsum have equality efficacy in reclaiming soil containing an excess of sodium.

Ludwig anhydrite releases calcium slower than Cal-CM Plus and Reagent Grade.

Sincerely,

Garn A. Wallace, Ph. D.
GAW:n

Copy: Gary Gilliland, gmigary@cox.net

WALLACE LABS	SOILS REPORT	Print Date	Aug. 4, 2010	Receive Date	8/4/10
365 Coral Circle	Location	Leaching Study, Post Leaching			
El Segundo, CA 90245	Requester	Richard Taylor, Art Wilson Company			
(310) 615-0116	graphic interpretation: * very low, ** low, *** moderate				
~~mmonium bicarbonate/DTPA		**** high, ***** very high			

ıctable - mg/kg soil	Sample ID Number	10-216-10		10-216-11		10-216-12	
ınterpretation of data	Sample Description	#1 Cal-CM Plus		#2 Ludwig		#3 Reagent Grade	
low medium high	elements		graphic		graphic		graphic
0 - 7 8-15 over 15	phosphorus	36.21	*****	32.65	*****	35.48	*****
0-60 60 -120 121-180	potassium	215.68	*****	238.12	*****	219.52	*****
0 - 3 3 - 5 over 5	iron	108.11	*****	114.38	*****	114.46	*****
0- 0.5 0.6- 1 over 1	manganese	40.09	*****	46.59	*****	49.22	*****
0 - 1 1 - 1.5 over 1.5	zinc	1.89	****	1.91	****	1.77	****
0- 0.2 0.3- 0.5 over 0.5	copper	3.35	*****	3.51	*****	3.36	*****
0- 0.2 0.2- 0.5 over 1	boron	0.18	**	0.19	**	0.17	**
ratio of calcium to magnesium	calcium	225.90	***	233.64	***	219.70	***
needs to be more than 2 or 3	magnesium	275.89	*****	320.19	*****	280.36	*****
should be less than potassium	sodium	142.98	***	169.42	***	148.59	***
	sulfur	36.20	**	32.66	**	22.37	*
	molybdenum	0.15	****	0.16	****	0.17	****
	nickel	2.52	**	2.61	**	2.56	**
The following trace	aluminum	0.78	**	0.26	*	0.30	*
elements may be toxic	arsenic	0.33	*	0.28	*	0.34	*
The degree of toxicity	barium	0.25	*	0.27	*	0.27	*
depends upon the pH of	cadmium	0.19	*	0.18	*	0.16	*
the soil, soil texture,	chromium	0.08	*	0.09	*	0.09	*
organic matter, and the	cobalt	0.66	**	0.76	**	0.73	**
concentrations of the	lead	1.31	**	1.41	**	1.50	**
individual elements as well	lithium	0.08	*	0.09	*	0.13	*
as to their interactions.	mercury	n d	*	n d	*	n d	*
	selenium	n d	*	n d	*	n d	*
The pH optimum depends	silver	n d	*	n d	*	n d	*
upon soil organic	strontium	1.52	*	1.84	*	1.48	*
·ter and clay content-	tin	n d	*	n d	*	n d	*
clay and loam soils:	vanadium	3.06	****	3.29	****	3.20	****
under 5.2 is too acidic							
6.5 to 7 is ideal	Saturation Extract						
over 9 is too alkaline	pH value	7.79	****	7.81	****	7.82	****
The ECe is a measure of	ECe (milli-mho/cm)	0.81	***	0.89	***	0.88	***
the soil salinity:			millieq/l		millieq/l		millieq/l
1-2 affects a few plants	calcium	30.4	1.5	35.3	1.8	31.3	1.6
2-4 affects some plants,	magnesium	11.6	1.0	13.4	1.1	11.9	1.0
> 4 affects many plants.	sodium	94.0	4.1	102.7	4.5	100.3	4.4
	potassium	9.9	0.3	18.1	0.5	9.5	0.2
	cation sum		6.8		7.8		7.2
problems over 150 ppm	chloride	54	1.5	61	1.7	67	1.9
	nitrate as N	2	0.1	1	0.1	2	0.1
	phosphorus as P	0.5	0.0	0.4	0.0	0.4	0.0
toxic over 800	sulfate as S	47.6	3.0	57.4	3.6	43.8	2.7
	anion sum		4.7		5.4		4.8
toxic over 1 for many plants	boron as B	0.12	*	0.12	*	0.15	*
increasing problems start at 6	SAR	3.7	***	3.7	***	3.9	***
lbs of nitrate as nitrogen in top 12 inches/acre	Na/Mg	3		3		3	
est. gypsum requirement-lbs. per 1,000 square feet		33		52		35	
	relative infiltration rate	slow		slow		slow	
	estimated soil texture	clay loam		clay loam		clay loam	
	lime (calcium carbonate)	no		no		yes	
	organic matter	low/fair		low/fair		low/fair	
	moisture content of soil	5.0%		5.1%		4.7%	
	half saturation percentage	21.8%		22.6%		21.3%	

ideal percentages of cations				% saturation		% saturation		% saturation
2% - 5 %	potassium	millieq K	0.66	5%	0.67	5%	0.69	5%
< 3%	sodium	millieq Na	0.65	5%	0.71	5%	0.76	5%
~ 70%	calcium	millieq Ca	8.38	59%	8.37	57%	8.77	59%
15%	magnesium	millieq Mg	3.34	23%	3.63	25%	3.50	23%
10 - 15%	hydrogen	Millieq H	1.20	8%	1.20	8%	1.20	8%
		total millieq/100 grams	14.23		14.59		14.92	

Elements are expressed as mg/kg dry soil or mg/l for saturation extract.

pH and ECe are measured in a saturation paste extract. nd means not detected.

Analytical data determined on soil fraction passing a 2 mm sieve.

WALLACE LABS
365 Coral Circle
El Segundo, CA 90245
(310) 615-0116

SOILS REPORT Print Date Jun. 10, 2010 Receive Date 6/9/10

Location

Requester Dick Taylor, Art Wilson Co.

graphic interpretation: * very low, ** low, *** moderate, **** high, ***** very high

ammonium bicarbonate/DTPA

ιotable - mg/kg soil	Sample ID Number	10-161-27	
.erpretation of data	Sample Description	Pelican Hills Soils	
low medium high	elements		graphic
0 - 7 8-15 over 15	phosphorus	41.18	*****
0-60 60 -120 121-180	potassium	246.36	*****
0 - 4 4 - 10 over 10	iron	51.63	*****
0- 0.5 0.6- 1 over 1	manganese	1.78	****
0 - 1 1 - 1.5 over 1.5	zinc	6.61	****
0- 0.2 0.3- 0.5 over 0.5	copper	4.29	*****
0- 0.2 0.2- 0.5 over 1	boron	0.55	****
ratio of calcium to magnesium	calcium	327.29	***
needs to be more than 2 or 3	magnesium	320.28	*****
should be less than potassium	sodium	507.17	*****
	sulfur	83.88	**
	molybdenum	0.36	****
	nickel	1.95	**
The following trace	aluminum	1.07	***
elements may be toxic	arsenic	0.26	*
The degree of toxicity	barium	0.27	*
depends upon the pH of	cadmium	1.67	**
the soil, soil texture,	chromium	n d	*
organic matter, and the	cobalt	0.02	*
concentrations of the	lead	1.00	**
individual elements as	lithium	0.21	*
well as to their interactions.	mercury	n d	*
	selenium	0.34	*
The pH optimum depends	silver	n d	*
upon soil organic	strontium	2.27	*
matter and clay content-	tin	n d	*
for clay and loam soils:	vanadium	1.76	**
under 5.2 is too acidic			

to 7 is ideal	**Saturation Extract**			
over 9 is too alkaline	pH value	7.38	***	
The ECe is a measure of	ECe (milli-	2.45	****	
the soil salinity:	mho/cm)			millieq/l
1-2 affects a few plants	calcium	68.4		3.4
2-4 affects some plants,	magnesium	28.1		2.3
> 4 affects many plants.	sodium	355.5		15.5
	potassium	28.3		0.7
	cation sum			21.9
problems over 150 ppm	chloride	270		7.6
	nitrate as N	2		0.2
	phosphorus as P	2.3		0.1
toxic over 800	sulfate as S	168.3		10.5
	anion sum			18.4
toxic over 1 for many plants	boron as B	0.63	***	
increasing problems start at 6	SAR	9.1	*****	
est. gypsum requirement-lbs./1,000 square feet		109		

infiltration rate inches/hour	0.002	
soil texture	sandy loam	gravel > 2 mm
sand	67.8%	1.4%
silt	15.7%	
clay	16.5%	
lime (calcium carbonate)	no	
Total nitrogen	0.142%	
Total carbon	1.295%	
carbon:nitrogen ratio	9.1	
organic matter based on carbon	2.59%	
moisture content of soil	12.5%	
half saturation percentage	26.5%	

ideal percentages of cations				% saturation
abt 5 %	potassium	millieq K	0.70	5%
< 3%	sodium	millieq Na	1.76	13%
·70%	calcium	millieq Ca	7.61	55%
20%	magnesium	millieq Mg	3.61	26%
5-10%	hydrogen	millieq H	0.24	2%
		total millieq/100 grams	13.92	

Elements are expressed as mg/kg dry soil or mg/l for saturation extract.
pH and ECe are measured in a saturation paste extract. nd means not detected.
Sand, silt, clay and mineral content based on fraction passing a 2 mm screen.

WALLACE LABS
365 Coral Circle
El Segundo, CA 90245
(310) 615-0116

WATER ANALYSES June 10, 2010

Location Pelican Hill Golf Course water
Requester Dick Taylor
Irrigation water

elements	10-161W-01 mg/liter	milliequivalent/liter cation	anion	maximum concentrations for agronomic uses FAO & UC
phosphorus	0.837		0.03	
potassium	14.431	0.37		
iron	0.009	0.00		1
manganese	0.022	0.00		0.2
zinc	0.016	0.00		2
copper	< 0.0006	0.00		0.2
boron	0.308		0.03	0.5 to 10
calcium	57.816	2.89		
magnesium	25.365	2.10		
sodium	151.111	6.57		70 foliar
sulfur	52.919		3.31	
molybdenum	0.050			0.01
aluminum	< 0.0067			5
arsenic	< 0.0066			0.1
barium	0.014			
cadmium	< 0.0015			0.01
chromium	< 0.0021			0.1
cobalt	0.004			0.01
lead	0.018			5
lithium	0.052	0.01		2.5
mercury	0.002			
nickel	< 0.0032	0.00		0.2
selenium	< 0.0246			0.02
silicon	7.325			
silver	< 0.0008			
strontium	0.483	0.01		
tin	< 0.0140			
titanium	0.004			
vanadium	0.003			0.1
pH	7.95			6.5- 8.4
ECw (dS/m)	1.30			3
bicarbonate	230		3.77	100 foliar
carbonate	nd		0.00	
nitrate as N	6.4		0.46	
ammonium as N	5.1	0.36		
chloride	164		4.61	105 foliar, 150
SAR	4.15			6
Adjusted SAR	7.75			
ion sum		12.31	12.20	

Gypsum requirement in pounds per acre foot of water (234 pounds equals 1 me/l)

for sodium control	112	recommended rate of gypsum
for total bicarbonate and sodium control	1,253	
for magnesium control	303	

Units are milligrams per liter (parts per million) except as noted.

WALLACE LABS
365 Coral Circle
El Segundo, CA 90245
(310) 615-0116

WATER ANALYSES June 30, 2010

Location #17 Fairway, Pelican Hill Golf Course

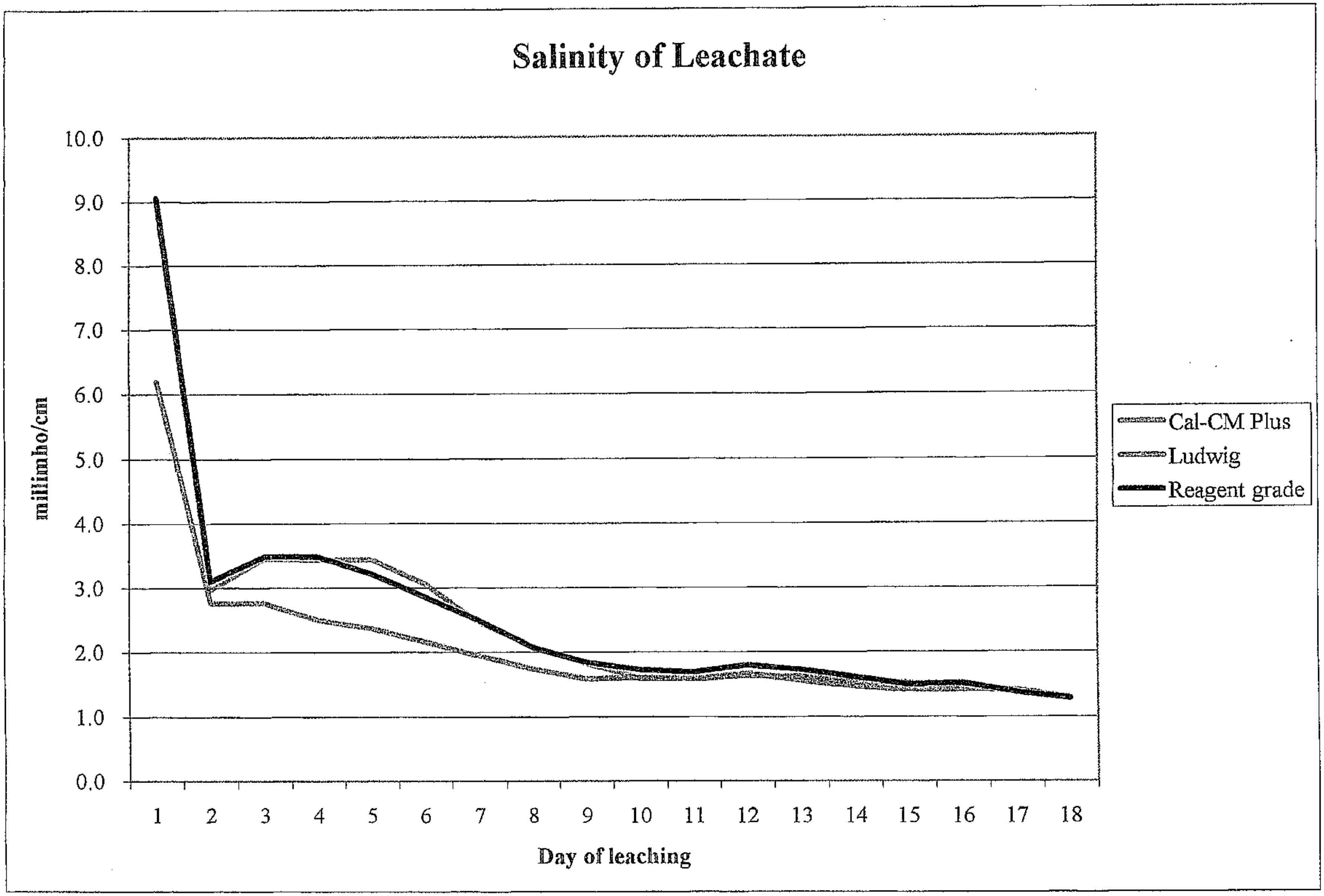
Requester Richard Taylor, Art Wilson Company

	10-181W-01	milliequivalent/liter		maximum concentrations for agronomic uses
		cation	anion	FAO & UC
elements	mg/liter			
phosphorus	0.704		0.02	
potassium	14.389	0.37		
iron	< 0.0014	0.00		1
manganese	0.000	0.00		0.2
zinc	0.015	0.00		2
copper	< 0.0006	0.00		0.2
boron	0.324		0.03	0.5 to 10
calcium	60.348	3.02		
magnesium	29.637	2.45		
sodium	159.471	6.93		70 foliar
sulfur	59.325		3.71	
molybdenum	0.022			0.01
aluminum	< 0.0067			5
arsenic	< 0.0066			0.1
barium	0.042			
cadmium	< 0.0015			0.01
chromium	< 0.0021			0.1
balt	0.006			0.01
ad	< 0.0155			5
lithium	0.057	0.01		2.5
mercury	< 0.0015			
nickel	0.006	0.00		0.2
selenium	< 0.0246			0.02
silicon	2.454			
silver	< 0.0008			
strontium	0.535	0.01		
tin	< 0.0140			
titanium	< 0.0003			
vanadium	0.006			0.1
pH	8.22			6.5 - 8.4
ECw (dS/m)	1.26			3
bicarbonate	245		4.02	100 foliar
carbonate	0		0.00	
nitrate as N	6.1		0.44	
ammonium as N	3.4	0.24		
chloride	179		5.04	105 foliar, 150
SAR	4.19			6
Adjusted SAR	8.01			
ion sum		13.03	13.25	

Gypsum requirement in pounds per acre foot of water (234 pounds equals 1 me/l)

sodium control	76
for total bicarbonate and sodium control	1,283
for magnesium control	438

Units are milligrams per liter (parts per million) except as noted.


Salinity of Leachate
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
millimho/cm
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Day of leaching
Cal-CM Plus
Ludwig
Reagent grade