URS
AN INTERNATIONAL PROFESSIONAL SERVICES ORGANIZATION

August 31, 1994

URS CONSULTANTS, INC.
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Mr. Joe Yavondetti, Project Manager
Division of Hazardous Waste Remediation
New York State Department of Environmental Conservation
50 Wolf Road
Albany, New York 12233-7010

RE: RAMAPO LANDFILL REMEDIATION
RESULTS OF SECOND QUARTER MONITORING FOR 1994

Dear Ms. McCue:

Attached are two (2) copies the results of the second quarter monitoring event for 1994. This sampling is the second round of sampling included as part of the Remedial Action phase of the Ramapo Landfill Remediation Project. This document provides the validated analytical data for the second of eight sampling rounds included during this phase of the project and historical analytical data tables for the four target compounds, i.e., benzene, chromium, iron and manganese. Locations sampled are shown in Figure 1. The samples for this monitoring event, which was conducted the week of June 20, 1994, were analyzed for routine and site-related parameters.

In addition to the usual sampling, a tap water sample from the faucet in the Torne Brook Farm office (identified as PW-3) was analyzed to determine the Langlier Corrosivity Index of the water. The Langlier Index for PW-3 was found to be -2.8, indicating that the water is corrosive.

As you know, the third quarter monitoring event for 1994 is planned for the week of September 19. Please feel free to call if you have any questions or if you wish to discuss.

Sincerely,
URS CONSULTANTS, INC.

James Lanzo
Project Manager

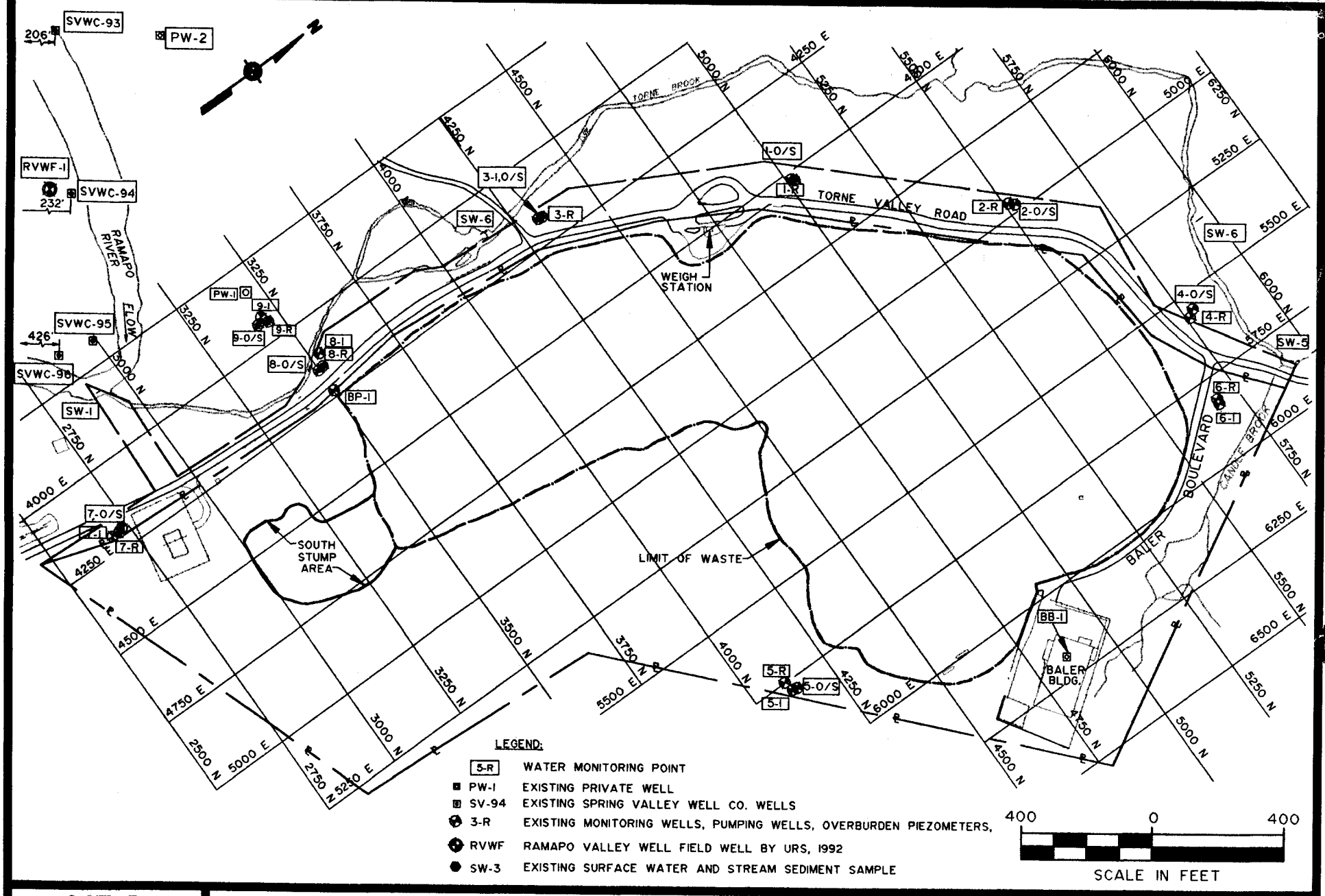
Enc.

cc: Supervisor Reisman - Town of Ramapo
Mr. Gene Ostertag - Town of Ramapo
Mr. Alan Simon - Town of Ramapo
Mr. Robert Nunes - USEPA
Mr. Thomas Micelli - Rockland County Department of Health
Ms. Judy Hunderfund - Rockland County Department of Health
Mr. John Olm - NYSDOH
Ms. Arlene Lapidos - Ramapo Land Company, Inc.
Mr. George Demas - Torne Brook Farm
Mr. Raymond Cywinski - Hackensack Water Company
Mr. Tanyo Parashkevov - Hackensack Water Company
Mr. Michael Barnes, Director of Operations - Spring Valley Water Company
Mr. Craig Flanagan
File: 35314 (VI-C and XII-C)

J\35314\WP\COR\8-31-94M.KMC\yg

AC-5904

1=400 5/19/94-1 FAO



URS CONSULTANTS, INC.

RAMAPO LANDFILL SAMPLE LOCATIONS

FIGURE 1

TABLE 1
RAMAPO LANDFILL - JUNE 1994 SAMPLING

ANALYTE	CONCENTRATION (µg/l)								
	1-OS	1-R	2-OS	2-R	3-OS/I	3-R	4-OS	4-R	5-I
Dichlorofluoromethane	--	--	--	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	--	--	--	--	--	--	--
1,1-Dichloroethane	1	--	--	--	--	--	--	1	--
Chlorobenzene	--	--	--	--	--	--	--	--	--
Chloroethane	--	--	--	--	--	--	--	--	--
Benzene	--	--	--	--	--	--	--	--	--
Toluene	--	--	--	--	--	--	--	--	--
Vinyl Chloride	--	--	--	--	--	--	--	--	--
Hexachlorobenzene	--	--	--	--	--	--	--	--	--
Di-n-octylphthalate	--	--	--	--	--	--	--	--	--
Diethylphthalate	--	--	--	--	--	--	--	--	--
bis(2-Ethylhexyl)phthalate	--	--	--	--	--	--	--	--	--
Dibenzofuran	--	--	--	--	--	--	--	--	--
Di-n-octylphthalate	--	--	--	--	--	--	--	--	--
gamma BHC	--	--	--	--	--	--	--	--	--
delta-BHC	--	--	--	--	--	--	--	--	--
alpha-BHC	--	--	--	--	--	--	--	--	--
Aluminum	--	--	--	--	--	--	--	--	--
Antimony	--	--	--	--	--	--	--	--	--
Arsenic	--	2.7 []	--	--	--	--	2 []	0.8 []	3.4 []
Barium	--	--	--	--	--	--	--	--	--
Beryllium	--	--	--	--	--	--	--	--	--
Boron	--	--	--	--	--	--	--	--	--
Cadmium	--	--	--	--	--	--	--	--	--
Calcium	82,100	82,900	79,000	57,700	71,900	73,100	53,800	51,500	8,030
Chromium	7.2 []	148	89.3	5.1 []	304	17.8	25.4	--	7.2 []
Cobalt	--	--	--	--	--	--	--	--	--
Copper	--	103	10.4 []	--	20.4 []	4.8 []	17.8 []	--	6.9 []
Iron	69.6 []	70,600	5,080	83.1 []	29,900	2,090	17,600	4,020	2,380
Lead	--	11.1	5.1	--	3.8	--	4.4	--	3
Magnesium	16,100	32,800	16,400	11,800	22,500	24,500	21,500	20,100	5,610
Manganese	26.8	6,020	985	91.1	10,300	11,200	2,850	1,350	215
Mercury	--	0.13 []	0.10 []	0.14 []	0.13 []	--	0.11 []	0.13 []	0.13 []
Nickel	13.6 []	234	33 []	--	263	116	25.8 []	--	9.3 []
Potassium	1,800 []	10,100	1,660 []	1,000 []	7,700	1,410 []	2,810 []	1,400 []	1,110 []
Silver	--	--	--	--	--	--	--	--	--
Sodium	15,900	48,800	8,900	6,670	71,500	47,000	30,700	15,200	4,220 []
Thallium	--	--	--	--	--	--	--	--	--
Vanadium	--	--	--	--	--	--	--	--	--
Zinc	24.5	12.3	21.2	17.5 []	40.4	40.5	39.9	28.4	43.1

Only detected results reported.

[] - The reported value is less than CRDL but greater than the IDL.

TABLE 1
RAMAPO LANDFILL - JUNE 1994 SAMPLING

ANALYTE	CONCENTRATION (µg/l)								
	5-R	6-I	6-R	7-OS	7-R	8-I	8-OS	8-R	9-I
Dichlorofluoromethane	--	--	--	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	--	--	--	--	--	--	--
1,1-Dichloroethane	--	--	--	--	--	--	--	--	--
Chlorobenzene	--	--	--	--	--	4	2	--	--
Chloroethane	--	--	--	--	--	--	--	--	--
Benzene	--	--	--	--	--	1	--	--	--
Toluene	--	--	--	--	--	--	--	--	--
Vinyl Chloride	--	--	--	--	--	--	--	--	--
Hexachlorobenzene	--	--	--	--	--	--	--	--	--
Di-n-octylphthalate	--	--	--	--	--	--	--	--	--
Diethylphthalate	--	--	--	--	--	--	--	--	--
bis(2-Ethylhexyl)phthalate	--	--	--	--	--	--	--	--	--
Dibenzofuran	--	--	--	--	--	--	--	--	--
Di-n-octylphthalate	--	--	--	--	--	--	--	--	--
gamma BHC	--	--	--	--	--	--	--	--	--
delta-BHC	--	--	--	--	--	--	--	--	--
alpha-BHC	--	--	--	--	--	--	--	--	--
Aluminum	--	--	--	--	--	--	--	--	--
Antimony	--	--	--	--	--	--	--	--	--
Arsenic	--	--	--	1.4 []	--	3.4 []	1.2 []	4.4 []	--
Barium	--	--	--	--	--	--	--	--	--
Beryllium	--	--	--	--	--	--	--	--	--
Boron	--	--	--	--	--	--	--	--	--
Cadmium	--	--	--	--	--	--	--	--	3.7 []
Calcium	12,700	17,700	23,200	39,800	54,400	69,100	42,400	132,000	8,240
Chromium	6.3 []	9.5 []	27.1	210	5.3 []	17	28.7	17	--
Cobalt	--	--	--	--	--	--	--	--	--
Copper	--	--	--	31.1	3.4 []	3.2 []	7.5 []	4.3 []	--
Iron	71.2 []	1,360	379	15,600 E	226 E	41,200	6,240	11,100 E	62.3 []
Lead	--	--	--	5.7	--	2.3 []	--	--	--
Magnesium	4,580 []	4,780 []	5,890	12,800	17,800	24,500	14,300	36,700	2,080 []
Manganese	2.5 []	275	72.6	1,580	186	1180	1,790	1,890	3.2 []
Mercury	0.12 []	0.11 []	0.10 []	--	--	--	--	--	--
Nickel	--	9.2 []	11.1 []	47.1	14.6 []	30.2 []	27.8 []	37.1 []	--
Potassium	700 []	925 []	1,100 []	15,400	1,620 []	35,000	26,700	30,000	462 []
Silver	--	--	--	--	--	--	--	--	--
Sodium	3,940 []	5,060	5,660	37,700	25,100	158,000	92,700	118,000	2,480 []
Thallium	--	--	--	--	--	--	--	--	--
Vanadium	--	--	--	--	--	--	--	--	--
Zinc	15.7 []	16.6 []	14.5 []	62.6	13.8 []	25.6	19.4 []	24.5	20.7

Only detected results reported.

[] - The reported value is less than CRDL but greater than the IDL.
E - The reported value is estimated because of the presence of interference.

TABLE 1
RAMAPO LANDFILL - JUNE 1994 SAMPLING

ANALYTE	CONCENTRATION (µg/l)						
	9-OS	9-R	BB-1	PW-1	PW-2	PW-3	RVWF-1
Dichlorofluoromethane	--	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	--	--	--	--	--
1,1-Dichloroethane	--	--	--	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--
Chloroethane	--	--	--	--	--	--	--
Benzene	--	--	--	--	--	--	--
Toluene	--	--	--	--	--	--	--
Vinyl Chloride	--	--	--	--	--	--	--
Hexachlorobenzene	--	--	--	--	--	--	--
Di-n-octylphthalate	--	--	--	--	--	--	--
Diethylphthalate	--	--	--	--	--	--	--
bis(2-Ethylhexyl)phthalate	--	--	--	--	--	--	--
Dibenzofuran	--	--	--	--	--	--	--
Di-n-octylphthalate	--	--	--	--	--	--	--
gamma BHC	--	--	--	--	--	--	--
delta-BHC	--	--	--	--	--	--	--
alpha-BHC	--	--	--	--	--	--	--
Aluminum	--	--	--	--	--	--	--
Antimony	--	--	--	--	--	--	--
Arsenic	--	4.1 []	--	--	--	--	--
Barium	--	--	--	--	--	--	--
Beryllium	--	--	--	--	--	--	--
Boron	--	--	--	--	--	--	--
Cadmium	--	5	--	--	--	--	--
Calcium	8,330	319,000	18,000	10,800	39,400	10,600	22,100
Chromium	27.1	48.2	--	--	--	--	--
Cobalt	--	--	--	--	--	--	--
Copper	2.7 []	9.7 []	46.8	62.4	19.4 []	156	5.4 []
Iron	1,040 E	19,400 E	282 E	11.2 []E	--	6.4 []E	50.9 []E
Lead	1 []	2.5 []	1.2 []	1.2 []	4.2	--	--
Magnesium	2,190 []	10,700	3,880 []	3,060 []	4,450 []	3,030 []	5,970
Manganese	34.7	1,830	12.5 []	--	2.4 []	--	767
Mercury	--	--	0.15 []	--	--	--	--
Nickel	18.6 []	40.7	--	--	--	--	10.7 []
Potassium	757 []	15,800	654 []	809 []	1,040 []	747 []	2,220 []
Silver	--	--	--	--	--	--	--
Sodium	3,330 []	65,100	5,540	4,470 []	8,800	4,430 []	30,900
Thallium	--	--	--	--	--	--	--
Vanadium	--	--	--	--	--	--	--
Zinc	22.9	33.5	251	14.1 []	76.3	17.8 []	12.6 []

Only detected results reported.

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E - The reported value is estimated because of the presence of interference.

TABLE 1
RAMAPO LANDFILL - JUNE 1994 SAMPLING

ANALYTE	CONCENTRATION (µg/l)				
	SVWC-93	SVWC-94	SVWC-95	SVWC-96	ARARs @
Dichlorofluoromethane	--	--	--	--	--
1,4-Dichlorobenzene	--	--	--	--	4.7
1,1-Dichloroethane	--	--	--	--	5
Chlorobenzene	--	--	--	--	5 §
Chloroethane	--	--	--	--	5
Benzene	--	--	--	--	0.7 @
Toluene	--	--	--	--	--
Vinyl Chloride	--	--	--	--	2
Hexachlorobenzene	--	--	--	--	0.35
Di-n-octylphthalate	--	--	--	--	--
Diethylphthalate	--	--	--	--	50
bis(2-Ethylhexyl)phthalate	--	--	--	--	50
Dibenzofuran	--	--	--	--	50 ¤
Di-n-octylphthalate	--	--	--	--	50
gamma BHC	--	--	--	--	ND
delta-BHC	--	--	--	--	ND
alpha-BHC	--	--	--	--	ND
Aluminum	--	--	--	--	--
Antimony	--	--	--	--	3
Arsenic	--	--	--	--	25
Barium	--	--	--	--	1,000
Beryllium	--	--	--	--	3
Boron	--	--	--	--	1,000
Cadmium	--	--	--	--	10
Calcium	24,300	31,700	22,700	19,600	--
Chromium	--	--	--	--	50
Cobalt	--	--	--	--	--
Copper	3.7 []	2.9 []	35	2.3 []	200
Iron	--	--	42.8 []E	--	300
Lead	4.2	--	2.9 []	--	15 ¥
Magnesium	5,970	8,040	5,790	5,420	35,000
Manganese	--	--	108	--	300
Mercury	--	--	--	--	2
Nickel	--	--	--	--	--
Potassium	1,360 []	1,340 []	1,530 []	1,230 []	--
Silver	--	--	--	--	50
Sodium	41,300	45,600	36,800	32,500	20,000
Thallium	--	--	--	--	4
Vanadium	--	--	--	--	--
Zinc	7.2 []	4.5 []	34.7	6.7 []	300

@ - Values obtained from Water Quality Regulations for Surface Waters and Groundwaters 6 NYCRR Parts 700-705, September 1, 1991, unless otherwise indicated.

§ - Values obtained from Chapter I - New York State Sanitary Code, Subpart 5-1, Principle Organic Contaminants.

¤ - Value obtained from Chapter I - New York State Sanitary Code, Subpart 5-1, Unspecified Organic Contaminants.

¥ - USEPA action level

Only detected results reported.

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E - The reported value is estimated because of the presence of interference.

TABLE 1
RAMAPO LANDFILL - JUNE 1994 SAMPLING

ANALYTE	CONCENTRATION (µg/l)					
	SW-1	SW-5	SW-6	SW-8	ARARs @	
Dichlorofluoromethane	--	--	--	--	--	
1,4-Dichlorobenzene	--	--	--	--	4.7	
1,1-Dichloroethane	--	--	--	--	0.07	
Chlorobenzene	--	--	--	--	20	
Chloroethane	--	--	--	--	5	
Benzene	--	--	--	--	0.7	
Toluene	--	--	--	--	--	
Vinyl Chloride	--	--	--	--	0.3	
Hexachlorobenzene	--	--	--	--	0.02	
Di-n-octylphthalate	--	--	--	--	--	
Diethylphthalate	--	--	--	--	50	
bis(2-Ethylhexyl)phthalate	--	--	--	--	0.6	£
Dibenzofuran	--	--	--	--	50	
Di-n-octylphthalate	--	--	--	--	50	
gamma BHC	--	--	--	--	0.01	
delta-BHC	--	--	--	--	0.01	
alpha-BHC	--	--	--	--	0.01	
Aluminum	--	--	--	--	--	
Antimony	--	--	--	--	3	
Arsenic	--	--	--	--	50	
Barium	--	--	--	--	1,000	
Beryllium	--	--	--	--	3	
Boron	--	--	--	--	1,000	
Cadmium	--	--	--	--	10	ç
Calcium	24,200	6,940	5,990	6,090	--	
Chromium	--	--	--	--	50	ç
Cobalt	--	--	--	--	--	
Copper	6.3 []	4 []	2.2 []	2.7 []	200	ç
Iron	287 E	291 E	159 E	187 E	300	
Lead	--	--	--	--	50	ç
Magnesium	6,100	1,710 []	1,500 []	1,470 []	35,000	
Manganese	83.8	50.3	23.5	64.3	300	
Mercury	0.13 []	0.15 []	0.13 []	0.12 []	0.012	£
Nickel	11.4 []	9.7 []	--	11.5 []	1.30E-07	£
Potassium	1,780 []	408 []	380 []	369 []	--	
Silver	--	--	--	--	50	
Sodium	39,200	3,620 []	3,300 []	3,290 []	--	
Thallium	--	--	--	--	4	
Vanadium	--	--	--	--	--	
Zinc	17.9 []	15.6 []	8.8 []	10.3 []	30	

æ - Values obtained from Water Quality Regulations for Surface Waters and Groundwaters 6 NYCRR Parts 700-705, September 1, 1991, unless otherwise indicated.

£ - Clean Water Act

ç - ARAR value must be calculated; see next page.

Only detected results reported.

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E - The reported value is estimated because of the presence of interference.

TABLE 2
RAMAPO LANDFILL - JUNE 1994 SAMPLING

INDICATOR	CONCENTRATION (mg/l)*											
	1-OS	1-R	2-OS	2-R	3-OS/I	3-R	4-OS	4-R	5-I	5-R	6-I	6-R
Biochemical Oxygen Demand	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloride	31	32	6	17	105	58	93	33	5	6	20	19
COD	<15	45	15	<15	55	30	NA	25	25	30	<15	<15
Color (units)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hexavalent Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Hardness	271	342	265	193	272	283	223	211	43.1	50.4	63.8	82.1
Ammonia	0.03	0.08	<0.02	<0.02	0.17	<0.02	NA	0.04	<0.02	<0.02	<0.02	<0.02
Nitrate	0.6	0.1	0.2	<0.1	1.1	0.7	NA	<0.1	0.3	0.3	<0.1	<0.1
Total Phenols (ug/l)	<1	<1	<1	<1	<1	<1	<1	4.5	<1	<1	<1	<5
Sulfate	28.9	38.1	18.4	20.9	10.7	20.7	34.5	19.8	9.9	11.5	12.6	57.6
Total Alkalinity	240	306	250	164	265	318	126	184	35	44.8	39.6	151
Total Dissolved Solids	362	410	306	237	478	446	411	329	79	85	132	83
Total Kjeldahl Nitrogen	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	<1	<1	<1	<1	1.1	3.6	NA	<1	<1	<1	1.2	1.4
Turbidity (units)	1	53	1.5	5	64	9.5	65	29	46	1.2	5	3.5

* - All concentrations given in mg/l unless otherwise noted.
NA - Not analyzed

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TABLE 2
RAMAPO LANDFILL - JUNE 1994 SAMPLING

INDICATOR	CONCENTRATION (mg/l)*												
	7-OS	7-R	8-I	8-OS	8-R	9-I	9-OS	9-R	BB-1	PW-1	PW-2	PW-3	RVWF-1
Biochemical Oxygen Demand	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloride	28	47	260	116	232	4	5	66	10	13	30	12	42
COD	25	15	70	40	70	15	15	45	<15	<15	<15	<15	<15
Color (units)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hexavalent Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Hardness	152	209	273	165	480	29.1	30	124	68	39.4	117	39	80
Ammonia	<0.02	<0.02	30.5	27	30	<0.02	<0.02	16	<0.02	<0.02	<0.02	<0.02	0.62
Nitrate	5.5	2.3	<0.1	3.2	<0.1	0.2	1.0	0.4	<0.1	0.5	0.9	0.4	1.5
Total Phenols (ug/l)	<1	3.0	<1	<1	5.2	<1	<1	<1	<1	<1	<1	<1	<1
Sulfate	21.3	32.8	33.1	21.7	22.5	9.2	7.0	9.8	10.8	8.1	18.3	7.5	11
Total Alkalinity	147	168	466	302	536	21.6	16.1	206	52.2	22.1	69	22.4	81.7
Total Dissolved Solids	277	360	860	493	948	53	59	335	92	88	222	91	187
Total Kjeldahl Nitrogen	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	<1	4.0	27.7	7.2	15.4	<2	<1	11.2	<1	1.4	1.6	1	3.1
Turbidity (units)	43	<1	55	12	48	2.5	3.8	42	2.2	<1	<1	<1	<1

* - All concentrations given in mg/l unless otherwise noted.
NA - Not analyzed

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TABLE 2
RAMAPO LANDFILL - JUNE 1994 SAMPLING

INDICATOR	CONCENTRATION (mg/l)*				
	SVWC-93	SVWC-94	SVWC-95	SVWC-96	ARARs @ (ug/l)
Biochemical Oxygen Demand	NA	NA	NA	NA	--
Chloride	95	105	69	61	250,000
COD	<15	<15	<15	25	--
Color (units)	NA	NA	NA	NA	--
Hexavalent Chromium	NA	NA	NA	NA	--
Total Hardness	85.2	112	81.0	71.3	--
Ammonia	<0.02	<0.02	<0.02	<0.02	2,000
Nitrate	1	1.3	0.9	0.9	10,000
Total Phenols (ug/l)	<1	<1	<1	<1	--
Sulfate	17.5	17.2	14.3	16.1	250,000
Total Alkalinity	34.5	50.4	51.2	43.7	--
Total Dissolved Solids	289	340	213	182	500,000
Total Kjeldahl Nitrogen	NA	NA	NA	NA	--
Total Organic Carbon	1.5	2.2	2.2	1.5	--
Turbidity (units)	<1	<1	<1	<1	--

* - All concentrations given in mg/l unless otherwise noted.
NA - Not analyzed

@ NYSDEC Water Quality Standards and Guidance Values, TOGS 1.1.1, October 1993, Table 1

TABLE 2
RAMAPO LANDFILL - JUNE 1994 SAMPLING

INDICATOR	CONCENTRATION (mg/l)*				
	SW-1	SW-5	SW-6	SW-8	ARARs @ (ug/l)
Biochemical Oxygen Demand	NA	NA	NA	NA	--
Chloride	90	13	10	6	250,000
COD	30	40	<15	<15	--
Color (units)	NA	NA	NA	NA	--
Hexavalent Chromium	NA	NA	NA	NA	--
Total Hardness	86	17.4	21.1	21.2	--
Ammonia	0.02	<0.02	<0.02	<0.02	2,000
Nitrate	0.09	0.3	0.1	0.1	10,000
Total Phenols (ug/l)	<1	<1	<1	<1	--
Sulfate	13.5	6.7	<5	10.3	250,000
Total Alkalinity	51.4	15.5	13.6	13.1	--
Total Dissolved Solids	239	44	51	51	500,000
Total Kjeldahl Nitrogen	NA	NA	NA	NA	--
Total Organic Carbon	2.7	2.2	2.1	1.4	--
Turbidity (units)	1.5	<1	<1	<1	--

@ NYSDEC Water Quality Standards and Guidance Values, TOGS 1.1.1, October 1993, Table 1

* - All concentrations given in mg/l unless otherwise noted.
NA - Not analyzed

TABLE 3

RAMAPO LANDFILL
GROUNDWATER AND SURFACE WATER
MONITORING DATA
COMPOUND: Benzene

Sample ID	Date of Sampling Event							
	1/90	9/90	1/93	4/93	9/93	12/93	3/94	6/94
1 O/S	ND	ND	ND	ND	ND	ND	ND	ND
1 R	ND	ND	ND	ND	ND	ND	ND	ND
2 O/S	ND	ND	NA	ND	ND	ND	ND	ND
2R	ND	ND	NA	ND	ND	ND	ND	ND
3 O/S/I	ND	ND	ND	ND	ND	ND	ND	ND
3 R	ND	ND	ND	ND	ND	ND	ND	ND
4 O/S	ND	0.3	ND	ND	ND	ND	ND	ND
4 R	1.0	1.0	ND	0.7	ND	ND	ND	ND
5I	NA	NA	NA	NA	NA	ND	ND	ND
5 O/S	2.0	ND	ND	ND	NA	NA	NA	ND
5 R	ND	ND	ND	ND	ND	ND	ND	ND
6 I	NA	0.2	ND	ND	ND	ND	ND	ND
6 R	NA	ND	ND	ND	ND	ND	ND	ND
7 O/S	ND	ND	ND	ND	ND	ND	ND	ND
7 R	ND	ND	ND	ND	ND	ND	ND	ND
8 I	2.0	2.9	NA	ND	ND	ND	ND	ND
8 O/S	2.0	0.3	ND	ND	ND	ND	ND	ND
8 R	3.0	0.4	ND	0.9	ND	ND	ND	ND
9I	NA	0.2	NA	NA	NA	NA	ND	ND
9 O/S	NA	ND	ND	ND	ND	NA	ND	ND
9 R	NA	0.9	ND	ND	ND	NA	ND	ND
PW-1	NA	ND	ND	ND	ND	NA	ND	ND
PW-2	NA	NA *	ND	ND	ND	NA	NA	NA
PW-3	NA	NA	NA	NA	NA	NA	NA	ND
BP-1	NA	NA	ND	NA	NA	NA	NA	NA
BB-1	NA	NA	ND	ND	ND	NA	ND	ND
RVWF-1	NA	NA	ND	ND	ND	NA	ND	ND
SVWC-93	NA	NA	ND	ND	NA	NA	ND	ND
SVWC-94	NA	NA	ND	ND	NA	NA	ND	ND
SVWC-95	NA	NA	ND	ND	ND	NA	ND	ND
SVWC-96	NA	NA	ND	ND	NA	NA	ND	ND
Surface Water	**Date of Sampling Event**							
Sample ID	**10/89**	**7/90**	**1/93**	**4/93**	**9/93**	**12/93**	**3/94**	**6/94**
SW-1	ND	NA	ND	ND	ND	ND	ND	ND
SW-5	ND	ND	ND	ND	ND	ND	ND	ND
SW-6	NA	ND	ND	ND	ND	ND	ND	ND
SW-8	NA	ND	ND	ND	ND	ND	ND	ND

Notes: Concentration reported in µg/L (ppb).

ND - Not detected

NA - Not applicable (e.g. well not installed by this date or if installed, not sampled)

* NYSDOH results from 3/92 sampling.

- Exceeded ARAR value of 0.7 ppb for groundwater.

TABLE 4

RAMAPO LANDFILL
GROUNDWATER AND SURFACE WATER
MONITORING DATA
COMPOUND: Chromium

Sample ID	Date of Sampling Event							
	1/90	9/90	1/93	4/93	9/93	12/93	3/94	6/94
1 O/S	153	57.3	8	ND	60.0	257.0	65.5	7.2
1 R	39.7	17.5	ND	ND	84.9	46.8	10.3	ND
2 O/S	180	141	NA	ND	50.2	95.9	11.8	89.3
2R	16.1	5.5	NA	ND	14.8	6.1	ND	5.1
3 O/S/I	587	1290	807	40.4	1350	1100	784	304
3 R	28	11.4	ND	ND	ND	14.7	10.5	17.8
4 O/S	139	40.1	5.8	ND	10.8	11.2	15.1	25.4
4 R	35.5	13.1	ND	8.8	ND	5.9	4.4	ND
5I	NA	NA	NA	NA	NA	80	30.2	7.2
5 O/S	90	35.6	48.8	ND	NA	NA	NA	NA
5 R	27.4	29.3	6.8	ND	ND	8.6	13.8	6.3
6 I	NA	28.7	ND	ND	13.4	17.0	32.7	9.5
6 R	NA	31.1	24	34.8	27.7	67.4	71.3	27.1
7 O/S	33.5	40.1	24.2	13.0	1890	218	31	210
7 R	16.2	16.8	ND	ND	ND	ND	ND	5.3
8 I	215	32.5	NA	ND	ND	ND	29	17
8 O/S	34.8	16.7	ND	ND	ND	7.6	86.6	28.7
8 R	20	23.1	9.9	ND	17.7	18.2	7.5	17.0
9 I	NA	8.1	NA	NA	NA	NA	28	ND
9 O/S	NA	6.8	ND	ND	ND	ND	22.9	27.1
9 R	NA	8.8	3.9	16.4	16.7	11.6	35.4	48.2
PW-1	NA	ND	ND	ND	ND	ND	ND	ND
PW-2	NA	ND *	ND	ND	ND	4.9	NA	ND
PW-3	NA	NA	NA	NA	NA	NA	NA	ND
BP-1	NA	NA	ND	NA	NA	NA	NA	NA
BB-1	NA	NA	ND	ND	ND	ND	ND	ND
RVWF-1	NA	NA	25.2	14.7	13.2	20.5	8.4	ND
SVWC-93	NA	NA	ND	ND	NA	ND	ND	ND
SVWC-94	NA	NA	ND	ND	NA	NA	ND	ND
SVWC-95	NA	NA	ND	ND	ND	NA	ND	ND
SVWC-96	NA	NA	ND	ND	NA	ND	ND	ND
Surface Water	**Date of Sampling Event**							
Sample ID	**10/89**	**7/90**	**1/93**	**4/93**	**9/93**	**12/93**	**3/94**	**6/94**
SW-1	ND	NA	ND	ND	ND	ND	ND	ND
SW-5	ND	ND	ND	ND	ND	ND	ND	ND
SW-6	NA	ND	ND	ND	ND	5.1	ND	ND
SW-8	NA	ND	ND	ND	ND	ND	ND	ND

Notes: Concentration reported in µg/L (ppb).

ND - Not detected

NA - Not applicable (e.g. well not installed by this date or if installed, not sampled)

* NYSDOH results from 3/92 sampling.

- Exceeded ARAR value of 50 ppb for groundwater.

- Exceeded ARAR value of 50 ppb for surface water.

The ARAR for SW-1 (Class A water body) is 50 ppb.

TABLE 5

RAMAPO LANDFILL
GROUNDWATER AND SURFACE WATER
MONITORING DATA
COMPOUND: Iron

Sample ID	Date of Sampling Event							
	1/90	9/90	1/93	4/93	9/93	12/93	3/94	6/94
1 O/S	45000	17500	1870	884	32300	162000	12200	69.6
1 R	1180	2650	395	197	1940	1210	186	70600
2 O/S	912	41800	NA	186	11800	9800	946	5080
2R	409	602	NA	674	1120	1450	187	83.1
3 O/S	6830	9750	5110	333	21300	37900	19400	29900
3 R	1930	1370	11500	2940	3280	4800	1970	2090
4 O/S	15600	12400	529	520	5560	10600	5720	17600
4 R	8230	5290	3520	4920	3100	5290	4790	4020
5I	NA	NA	NA	NA	NA	2030	2080	2380
5 O/S	27000	11200	11100	4700	NA	NA	NA	NA
5 R	658	368	620	2310	751	243	742	71.2
6 I	NA	486	953	17.3	332	2860	4020	1360
6 R	NA	683	1220	715	662	1710	698	379
7 O/S	981	24500	1250	521	619000	2200	2340	15600
7 R	ND	1940	31.5	56.6	989	600	762	226
8 I	15700	30500	NA	ND	ND	ND	22300	41200
8 O/S	229000	43800	3230	2080	6180	12000	20300	6240
8 R	1360	2940	11600	2590	9160	4710	2510	11100
9 I	NA	145	NA	NA	NA	NA	2040	62.3
9 O/S	NA	249	50.7	1200	383	393	2210	1040
9 R	NA	20200	2680	8250	11500	10800	8850	19400
PW-1	NA	64	186	130	1260	916	85.3	11.2
PW-2	NA	11 *	41.8	49.5	ND	22.7	NA	ND
PW-3	NA	NA	NA	NA	NA	NA	NA	6.4
BP-1	NA	NA	274	NA	NA	NA	NA	NA
BB-1	NA	NA	NA	297	247	225	263	282
RVWF-1	NA	NA	362	207	202	294	221	ND
SVWC-93	NA	NA	32.6	10.6	NA	553	179	ND
SVWC-94	NA	NA	40.3	19.1	NA	NA	49.4	ND
SVWC-95	NA	NA	51.7	74.4	ND	NA	45.5	ND
SVWC-96	NA	NA	22.3	17.3	NA	22.6	14.9	ND
Surface Water	**Date of Sampling Event**							
Sample ID	**10/89**	**7/90**	**1/93**	**4/93**	**9/93**	**12/93**	**3/94**	**6/94**
SW-1	2630	NA	141	1670	170	119	367	287
SW-5	93	163	194	204	168	71.7	41.9	291
SW-6	NA	177	82.5	245	76.7	55.2	55	159
SW-8	NA	1290	109	341	ND	26.7	66.2	187

Notes: Concentration reported in µg/L (ppb).

ND - Not detected

NA - Not applicable (e.g. well not installed by this date or if installed, not sampled)

* NYSDOH results from 3/92 sampling.

- Exceeded ARAR value of 300 ppb for groundwater.

- Exceeded ARAR value of 300 ppb for surface water.

TABLE 6

RAMAPO LANDFILL
GROUNDWATER AND SURFACE WATER
MONITORING DATA
COMPOUND: Manganese

Sample ID	Date of Sampling Event							
	1/90	9/90	1/93	4/93	9/93	12/93	3/94	6/94
1 O/S	3790	3700	809	1410	4010	5590	3510	26.8
1 R	144	98.5	61.4	38.7	143	62	29.3	6020
2 O/S	298	4770	NA	27.0	4850	1580	92.5	985
2R	197	135	NA	118	126	116	99.5	91.1
3 O/S/I	8700	18100	3450	1690	9590	8780	5640	10300
3 R	7230	12400	10700	12900	11000	12000	11800	112800
4 O/S	4210	5020	547	506	2080	995	598	2850
4 R	1730	1520	1660	1890	1160	1230	1460	1350
5I	NA	NA	NA	NA	NA	52.8	40.6	215
5 O/S	981	530	192	43.2	NA	NA	NA	NA
5 R	22.3	9.3	9.6	21.9	11.4	8.2	9.6	2.5
6 I	NA	33.1	151	1.3	34.4	84.7	1060	275
6 R	NA	14.3	100	57.5	60.7	195	59.8	72.6
7 O/S	1240	3260	48.3	46.1	45100	122	67.4	1580
7 R	51.9	102	46.1	51.8	114	81.6	99.8	186
8 I	4230	1110	NA	ND	ND	ND	877	1180
8 O/S	2830	2750	1680	1640	3330	1910	4090	1790
8 R	872	181	1660	2600	2440	2650	2220	1890
9 I	NA	377	NA	NA	NA	NA	40.6	3.2
9 O/S	NA	14.6	ND	21.1	9.6	8.7	74.8	34.7
9 R	NA	3270	2320	2280	2540	1890	1660	1830
PW-1	NA	ND	1.2	1.8	ND	3.6	5.4	ND
PW-2	NA	ND *	4.7	7.5	6.3	6.6	NA	2.4
PW-3	NA	NA	NA	NA	NA	NA	NA	ND
BP-1	NA	NA	4630	NA	NA	NA	NA	NA
BB-1	NA	NA	7.9	11.7	11.1	10.3	8.9	12.5
RVWF-1	NA	NA	839	40.2	1710	111	46.5	767
SVWC-93	NA	NA	ND	1.7	NA	72.2	ND	ND
SVWC-94	NA	NA	7.3	ND	NA	NA	6.3	ND
SVWC-95	NA	NA	56.4	1.8	ND	NA	91.6	108
SVWC-96	NA	NA	ND	ND	NA	ND	ND	ND
Surface Water	**Date of Sampling Event**							
Sample ID	**1/90**	**9/90**	**1/93**	**4/93**	**9/93**	**12/93**	**3/94**	**6/94**
SW-1	1120	NA	16.6	107	50.4	29.6	63	83.8
SW-5	19.5	44.5	19.3	27.9	70.8	20.5	23	50.3
SW-6	NA	31.9	14.5	23.9	14.4	16.9	19.6	23.5
SW-8	NA	153	10.9	28.5	8.6	9.9	17.6	64.3

Notes: Concentration reported in µg/L (ppb).

ND - Not detected

NA - Not applicable (e.g. well not installed by this date or if installed, not sampled)

* NYSDOH results from 3/92 sampling.

- Exceeded ARAR value of 300 ppb for groundwater.

Designation: D 3739 – 88

Standard Practice for Calculation and Adjustment of the Langelier Saturation Index for Reverse Osmosis[1]

This standard is issued under the fixed designation D 3739; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the calculation and adjustment of the Langelier saturation index for the concentrate stream of a reverse osmosis device. This index is used to determine the need for calcium carbonate scale control in the operation and design of reverse osmosis installations. This practice is applicable for concentrate streams containing up to 10 000 mg/L of total dissolved solids.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 511 Test Methods for Calcium and Magnesium in Water[2]

D 1067 Test Methods for Acidity or Alkalinity of Water[2]

D 1129 Definitions of Terms Relating to Water[2]

D 1293 Test Method for pH of Water[2]

D 1888 Test Methods for Particulate and Dissolved Matter in Water[2]

D 4194 Test Methods for Operating Characteristics of Reverse Osmosis Devices[3]

3. Terminology

3.1 For definitions of terms used in this practice, refer to Definitions D 1129.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 For descriptions of terms relating to reverse osmosis, refer to Test Methods D 4194.

3.2.2 *Langelier saturation index*—an index calculated from total dissolved solids, calcium concentration, total alkalinity, pH, and solution temperature that shows the tendency of a water solution to precipitate or dissolve calcium carbonate.

4. Summary of Practice

4.1 This practice consists of calculating the Langelier saturation index for a reverse osmosis concentrate stream from the total dissolved solids, calcium ion content, total alkalinity, pH, and temperature of the feed solution, and the recovery of the reverse osmosis system.

4.2 This practice also presents techniques to lower the Langelier saturation index by decreasing the recovery, by decreasing the calcium content of the feedwater, or by changing the ratio of total alkalinity to free carbon dioxide in the feedwater.

5. Significance and Use

5.1 In the design and operation of reverse osmosis installations, it is important to predict the calcium carbonate scaling properties of the concentrate stream. Because of the increase in total dissolved solids in the concentrate stream and the difference in passages for calcium ion, bicarbonate ion, and free CO_2, the calcium carbonate scaling properties of the concentrate stream will generally be quite different from those of the feed solution. This practice permits the calculation of the Langelier saturation index for the concentrate stream from the feed water analyses and the reverse osmosis operating parameters.

5.2 A positive Langelier saturation index indicates the tendency to form a calcium carbonate scale, which can be damaging to reverse osmosis performance. This practice gives various procedures for the adjustment of the Langelier saturation index.

6. Procedure

6.1 Determine the calcium concentration in the feed solution in accordance with Test Methods D 511 and express as $CaCO_3$.

6.2 Determine the total dissolved solids of the feed solution using Test Methods D 1888.

6.3 Determine the total alkalinity of the feed solution using Test Methods D 1067, and express as $CaCO_3$.

6.4 Measure the pH of the feed solution using Test Method D 1293.

6.5 Measure the temperature of the feed solution.

7. Calculation

7.1 Calculate the calcium concentration in the concentrate stream from the calcium concentration in the feed solution, the recovery of the reverse osmosis system, and the calcium ion passage as follows:

$$Ca_c = Ca_f \times \frac{1 - Y(SP_{Ca})}{1 - Y} \quad (1)$$

where:

Ca_c = calcium concentration in concentrate, as $CaCO_3$, mg/L,

[1] This practice is under the jurisdiction of ASTM Committee D-19 on Water and is the direct responsibility of Subcommittee D19.08 on Water Treatment Materials.

Current edition approved Sept. 30, 1988. Published November 1988. Originally published as D 3739 – 78. Last previous edition D 3739 – 83.

[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] *Annual Book of ASTM Standards*, Vol 11.02.

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LAB NO: 9419853

U.R.S. CONSULTANTS,INC.
282 DELAWARE AVE.
BUFFALO, NY 14202

TYPE..... GROUND WATER
SPECIAL

DATE COLLECTED. 06/21/94
DATE RECEIVED.. 06/22/94
COLLECTED BY... CL99
PROJECT NO..... 35314

POINT NO:
LOCATION: PW-3

REMARKS: RAMAPO LANDFILL

PARAMETER (S)	RESULTS	UNITS
CHLORIDE	12	mg/l
COD	<15.0	mg/l
TOTAL HARDNESS	30.0	mg/l
LANGLIER SATURATION INDEX	-2.8	
AMMONIA (AS N)	<0.02	mg/l
NITRATE (AS N)	0.4	mg/l
TOTAL PHENOLS	<1	ug/l
SULFATE	7.5	mg/l
TOTAL ALKALINITY	22.4	mg/l
TOTAL DISSOLVED SOLIDS	91	mg/l
TOTAL ORGANIC CARBON(TOC)	1.0	mg/l
TURBIDITY	<1	units

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DATE ISSUED 07/21/94

LABORATORY DIRECTOR

ORIGINAL

THE FOLLOWING FIVE (5) PAGES FROM HACH CO. LITERATURE
WERE PROVIDED BY H2M LABORATORY

HACH

ANALYTICAL PROCEDURE

LANGELIER AND AGGRESSIVE INDICES

LANGELIER SATURATION INDEX

The Langelier Saturation Index (LI), a measure of a solution's ability to dissolve or deposit calcium carbonate, often is used as an indicator of the corrosivity of water. The index is not related directly to corrosion, but is related to the deposition of a calcium carbonate film or scale which can insulate pipes, boilers and other components of a system from contact with water. When no protective scale is formed water is considered to be aggressive, and corrosion can occur if preventative measures are not taken. On the other hand, an excess of scale can damage water systems, necessitating repair or replacement.

In developing the LI, Langelier derived an equation for the pH at which water is saturated with calcium carbonate (pH_s). This equation is based on the equilibrium expressions for calcium carbonate solubility and bicarbonate disassociation. To approximate actual conditions more closely, pH_s calculations were modified to include the effects of temperature and ionic strength.

The Langelier Index is defined as the difference between actual pH (measured) and calculated pH_s. The magnitude and sign of the LI value show a water's tendency to form or dissolve scale and thus inhibit or encourage corrosion.

Although information obtained from the LI is not quantitative, it can be useful in estimating water treatment requirements for low pressure boilers, cooling towers and water treatment plants—as well as serving as a general indicator of the corrosivity of water.

Parameter Measurement

The Langelier Saturation Index can be calculated easily by using Hach products to determine the pH of calcium carbonate saturation (pH_s) and the actual pH of a solution. Using a simple formula, the pH_s is derived from the values for calcium hardness, total alkalinity, temperature and total filterable residue (total dissolved solids).

Total alkalinity: Total alkalinity is determined by titrating a water sample with standard acid to a brom cresol-methyl red end point. The value is expressed in mg/L $CaCO_3$.

Calcium hardness: An EDTA (ethylenediaminetetraacetic acid) titration with an appropriate indicator is used for the calcium hardness measurement. The value is expressed in mg/L $CaCO_3$.

Temperature: Temperature can be measured in degrees centigrade with a laboratory thermometer (Cat. No. 20959). If only a Fahrenheit thermometer is available, conversion to degrees Centigrade will be necessary. Refer to the appendix for a Fahrenheit to Centigrade conversion formula.

Total filterable residue: Total filtrable residue (total dissolved solids) refers to the amount of dissolved solids present in a sample. It is determined gravimetrically or can be estimated by using a conductivity meter (see appendix) and expressed in mg/L.

pH: The pH (referred to as pH_{actual}) can be measured by using Hach's Mini pH Meter (Cat. No. 17200-10), Digital pH Meter (Cat. No. 19000-00) with automatic temperature compensation, or one of Hach's other pH instruments.

*Hach procedures for these parameters are included in the LI package. These procedures can also be found in the Water Analysis Handbook.

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Table 1

Water Temp. °C	A
0	2.60
4	2.50
8	2.40
12	2.30
16	2.20
20	2.10
25	2.00
30	1.90
40	1.70
50	1.55
60	1.40
70	1.25
80	1.15

Table 2

TDS mg/L	B
0	9.70
100	9.77
200	9.83
400	9.86
600	9.89
1000	9.90

Table 3 and 4

Total Alkalinity in mg/L $CaCO_3$ / Ca Hardness in mg/L $CaCO_3$	D or C
10	1.00
20	1.30
30	1.48
40	1.60
50	1.70
60	1.78
70	1.84
80	1.90
100	2.00
200	2.30
300	2.48
400	2.60
500	2.70
600	2.78
700	2.84
800	2.90
900	2.95
1000	3.00

Note: Factors C and D are logarithms of concentrations expressed as mg/L $CaCO_3$.

Table 4

Calcium Hardness mg/L $CaCO_3$	D
10	0.60
20	0.90
30	1.08
40	1.20
50	1.30
60	1.38
70	1.44
80	1.50
100	1.60
200	1.90
300	2.08
400	2.20
500	2.30
600	2.38
700	2.44
800	2.50
900	2.55
1000	2.60

Use Combined Table to Your Left

Table 5

Corrosive characteristics	Langelier Index	Aggressive Index
Highly Aggressive	< 2.0	< 10.0
Moderately aggressive	-2.0 to 0.0	10.00 to 12.0
Nonaggressive	> 0.0	> 12.0

References

1. Langelier, W. F., 1936. "The Analytical Control of Anticorrosion Water Treatment." *J. Amer. Water Works Assn.* 28:1500
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Parameter Measurement*

Total alkalinity: Total alkalinity is determined by titrating a water sample with standard acid to a brom cresol-methyl red end point. The value is expressed in mg/L $CaCO_3$.

Calcium hardness: An EDTA (ethylenediaminetetraacetic acid) titration with an appropriate indicator is used for the calcium hardness measurement. The value is expressed in mg/L $CaCO_3$.

pH: The pH (referred to as pH_{actual}) can be measured by using Hach's Mini pH Meter (Cat. No. 17200-10), The Hach Digital pH Meter (Cat. No. 19000-00) with automatic temperature compensation or one of Hach's other pH instruments.

*Hach procedures for these parameters are included in the LI package. These procedures can also be found in the Water Analysis Handbook.

Calculation

After obtaining the pH, total alkalinity, and calcium hardness, use the following formula to calculate the AI:

$$AI = pH_{actual} + C + D$$

Value C is obtained by using the measured value for calcium hardness in mg/L $CaCO_3$ and referring to Table 3.	Value D is obtained by using the measured value for total alkalinity in mg/L $CaCO_3$ and referring to Table 4.

Interpretation

As with LI, the AI is not a quantitative measure of corrosion but is a general indicator of the tendency for corrosion to occur and should be used with proper reservation. An AI of 12 or above indicates non-aggressive (not corrosive) water; AI values below 10 indicate extremely aggressive (corrosive) conditions. Values of 10-11.9 suggest that the water is moderately aggressive. Corrosivity characteristics of water as indicated by the LI and AI are compared in Table 5.

APPENDIX

Estimation of Dissolved Solids

Conductivity measurements can be used to estimate the amount of total dissolved solids (TDS) in a water sample using the following procedure.

1. Add four drops of phenolphthalein solution (Cat.No. 1897-36) to a 50 ml sample. If a pink color develops, add gallic acid solution (Cat. No. 14423-26) drop-wise until the color disappears.
2. Using a Hach Mini Conductivity Meter (Cat. No. 17250-00), a Hach Portable Conductivity Meter (Cat. No. 16300-00) or an equivalent instrument, measure the conductivity of the sample in micromhos/cm.
3. Multiply the sample conductivity by 0.9 (TDS/conductivity ratio) to obtain the approximate TDS in mg/L. For steam condensates, multiply the conductivity by 0.5 to 0.6 for the approximate TDS in mg/L.

Notes: Addition of gallic acid in the first step eliminates interference by hydroxide ions which have a high conductance relative to other common ions normally in water samples. An excess of gallic acid will not contribute significantly to the conductivity.

The ratio of the dissolved solids to conductivity is dependent on the type of substances that are in the sample and therefore differs with each plant or water system (the 0.9 and 0.5 TDS/conductivity ratios are approximations based on the average of many samples).

For more accurate results, the relationship between conductivity and TDS should be established for each plant or system individually. This relationship is determined by measuring the conductivity and TDS (using the gravimetric method) for a series of 10 representative samples. The average of the TDS/conductivity ratios for these samples then can be substituted for the constants 0.9 or 0.5 in estimating the TDS. If drastic changes in water composition occur, the TDS/conductivity ratio should be redetermined.

Fahrenheit To Centigrade Conversion: Degrees Centigrade = 5/9 x (Degrees Fahrenheit - 32)

Calculation

After the preceding parameters have been determined, calculate the pH_s from the following formula:

$$pH_s = A + B - C - D$$

Constant A, which takes into account the effect of temperature, is found by selecting the value from Table 1 that corresponds to the measured temperature in degrees centigrade.	Constant B helps compensate for the ionic strength of the sample. It is located in Table 2 by taking the value that corresponds to the measured total filtrable residue or the estimated TDS.
Value C is obtained by using the calcium hardness (in mg/L $CaCO_3$) of the sample and referring to Table 3.	Value D is obtained by using the total alkalinity (in mg/L $CaCO_3$) of the sample and referring to Table 4.

The Langelier Saturation Index is the difference between the pH_{actual} of the solution and the pH_s calculated above.

$$pH_{actual} - pH_s = LI$$

Interpretation

The LI is a gauge of whether a water will precipitate or dissolve calcium carbonate. If the pH_s is equal to the actual pH, the water is considered "balanced." This means that calcium carbonate will not be dissolved or precipitated. If the pH_s is less than the actual pH (the LI is a positive number), the water will tend to deposit calcium carbonate and is scale-forming (nonaggressive). If the pH_s is greater than the actual pH (the LI is a negative number), the water is not saturated and will dissolve calcium carbonate.

In summary:

$pH_s = pH_{actual}$, water is balanced

$pH_s < pH_{actual}$, water is scale forming (nonaggressive)

$pH_s > pH_{actual}$, water is not scale forming (aggressive)

It is important to remember that the LI value is not a quantitative measure of calcium carbonate saturation or corrosion.

Because the protective scale formation is dependent on pH, bicarbonate ion, calcium carbonate, dissolved solids and temperature, each may affect the water's corrosive tendencies independently. Soft, low alkalinity waters with either low or excessively high pH are corrosive even though this may not be predicted by the LI. This is because insufficient amounts of calcium carbonate and alkalinity are available to form a protective scale.

Waters having high pH values and sufficient hardness and alkalinity also may be corrosive even if the LI predicts the opposite. This is the result of calcium and magnesium complexes that can not actively participate in the scale forming process. Analytical procedures do not distinguish between these complexes and available calcium and magnesium, and so the LI value is not accurate in such situations.

Corrosive tendencies may be exhibited also by water containing sulfate, chloride and other ions in excess of 150 mg/L. These ions interfere with uniform carbonate film formation.

As a result of these and other problems, the LI is useful only for determining the corrosivity of waters containing more than 40 mg/L of alkalinity, sufficient calcium ion concentration and ranging between pH 6.5 and 9.5.

AGGRESSIVE INDEX

The Aggressive Index (AI), originally developed for monitoring water to be transported through asbestos pipe, is sometimes substituted for the Langelier Index as an indicator of corrosivity in water. The AI is derived from the actual pH, calcium hardness and total alkalinity. Where it is applicable, it is simpler and more convenient than the LI. Since the AI does not include the effects of temperature or dissolved solids, it is less accurate as an analytical tool than the LI.

Table for Constant A Water Temp (C)	A
0	2.60
4	2.50
8	2.40
12	2.30
16	2.20
20	2.10

Table for Constant B Total Dissolved Solids	B
0 mg/liter	9.70
100	9.77
200	9.83
400	9.86
800	9.89
1000	9.90

Table for log (Ca^{++}) and log (alkalinity)

Ca^{++} or Alkalinity expressed as mg/liter of $CaCO_3$	log
10	1.00
20	1.30
30	1.48
40	1.60
50	1.70
60	1.78
70	1.84
80	1.90
100	2.00
200	2.30
300	2.48
400	2.60
500	2.70
600	2.78
700	2.84
800	2.90
900	2.95
1000	3.00

Example: pH = 7.0; Water Temperature = 20 C: Total Dissolved Solids = 400 mg/liter; Calcium as $CaCO_3$ = 300 mg/liter and Alkalinity = 100 mg/liter

Langelier's Index = 7.0 - (2.10 + 9.86 - 2.48 - 2.00)
= 7.0 - (7.48) = -0.48

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