รายการอ้างอิง

ภาษาไทย

เกศสุชา พูลคำ. การกำจัดโลหะหนักโดยการใช้เรซินแลกเปลี่ยนไอออนที่ทำจากชานอ้อยและผักตบชวา. วิทยานิพนธ์มหาบัณฑิต คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย, 2537.

ทิพย์ ชัยวิริยกุล. การนำโลหะนิคเกิลในน้ำเสียจากการชุบโลหะกลับมาใช้ใหม่โดยใช้เรซินแลกเปลี่ยนไอออน. วิทยานิพนธ์มหาบัณฑิต คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย, 2537.

นันทนา อิทธิพรโกวิท. การกำจัดโลหะหนักของเรซินแลกเปลี่ยนไอออนชนิดซัลโฟเอทีลและครอสลิ้งค์-แซนเทตที่ทำจากผักตบชวา. วิทยานิพนธ์มหาบัณฑิต คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย, 2538.

ปราณี สถิรพิพัฒน์กุล. การผลิตอาซีโตน-บิวทานอล จากผักตบชวาที่ถูกย่อยสลายด้วยเอมไซน์. วิทยานิพนธ์มหาบัณฑิต คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย, 2532.

พิชิต เลี่ยมพิพัฒน์. ชุบทอง. กรุงเทพมหานคร : มิตรนราการพิมพ์, 2525.

มั่นสิน ตัณฑุลเวศม์. วิศวกรรมประป่า เล่ม2. กรุงเทพมหานคร : โรงพิมพ์จุฬาลงกรณ์มหาวิทยาลัย, 2527.

โมะโตะกิ มัทซึโอะ. เทคนิคการประหยัดพลังงานภาคไฟฟ้า. กรุงเทพมหานคร : ห้างหุ้นส่วนจำกัด สีทองกิจพิศาล (แผนกการพิมพ์),2525.

ศุภโชค วิริยโกศล. กระบวนการขัดและแต่งผิวโลหะ. สงขลา : โรงพิมพ์มหาวิทยาลัยสงขลานครินทร์, 2530.

อนันต์ ทองมอญ. ชุบโครเมียม-ชุบทอง. กรุงเทพมหานคร : โรงพิมพ์เรือนแก้วการพิมพ์, 2527.

อรุณี อริยประยูร, จรุงค์ ยงศิริ, และ นพคุณ เพชรเครือ. การประยุกต์ใช้เรซินแลกเปลี่ยนไอออนในการนำโลหะกลับมาใช้ใหม่. โครงงานทางวิศวกรรมสิ่งแวดล้อม คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย, 2536.

ภาษาอังกฤษ

Bailey, J.E., and Ollis, D.F. Biochemical engineering fundamentals. 2nd ed. New York : Mc Graw-Hill Book Co., 1986.

Brown, C.J. Standard handbook of Hazard waste treatment and disposal. USA : Mc Graw-Hill Book Company, 2532.

Dofner, K. Ion exchange properties and application. 3th. ed. Michigan : Ann Arbor Science Publisher Inc., 1977.

Freeman, H.M. Standard handbook of Hazard waste treatment and disposal. USA : Mc Graw-Hill Book Company, 2532.

Lee, C.K. and Low, K.S. Removal of copper from solution using moss. Environmental Technology letters ,10 (1989) : 395-404

Larry, D.B., Joseph, F.J., and Barron, L.W. Process Chemistry for Water and Wastewater Treatment. New Jersey : Prentice-Hall, Inc., 1982

Macchi, G., Marani, D., and Tiravanti, G., Uptake of mercury by exhausted coffee grounds. Environmental Technology letters, 7 (1986) : 431-444

Maranon, E., and Sastre, H. Preconcentration and removal of trace metals from water by apple waste. Bioresource Technology, 40 (1992) : 73-76

_____. and Sastre, H. Heavy metal removal in packed beds using apple wastes. Bioresource Technology, 30 (1991) : 39-43

Nakajima, A., and Sakaguchi, T. Recovery and removal of uranium by using plant wastes. Biomass, 21 (1990) : 55-63

Nguyen Thi Lien Ha. Application of clean technology in the small scale electroplating. Master's Thesis AIT, 1993.

Odozi, T.O., Okeke, S., and Lartey, R.B. Studies on binding metal ions with polymerized corn cob and a composite resin with sawdust and onion skin. Agricultural Wastes, 12 (1985) : 13-21

Pinner, W.L., Knapp, B.B., Diggen, M.B. 'Nickel' Modern electroplating. USA : Mc Graw-Hill Book Company, 1964.

Srivastava, H.C.P., Mathur, R.P., and Mehrotra, I. Removal of chromium from industrial effluents by adsorption on sawdust. Environmental Technology letters, 7 (1986) : 55-63

Tan, W. T., Ooi, S.T., and Lee, C.K. Removal of chromium (VI) from solution by coconut husk and palm pressed fibres. Environmental Technology, 14 (1993) : 227-282

_____. Abd. Rahman Majid Khan., Removal of lead cadmium and zinc by waste tea leaves. Environmental Technology letters, 9 (1988) : 1223-1232

ภาคผนวก

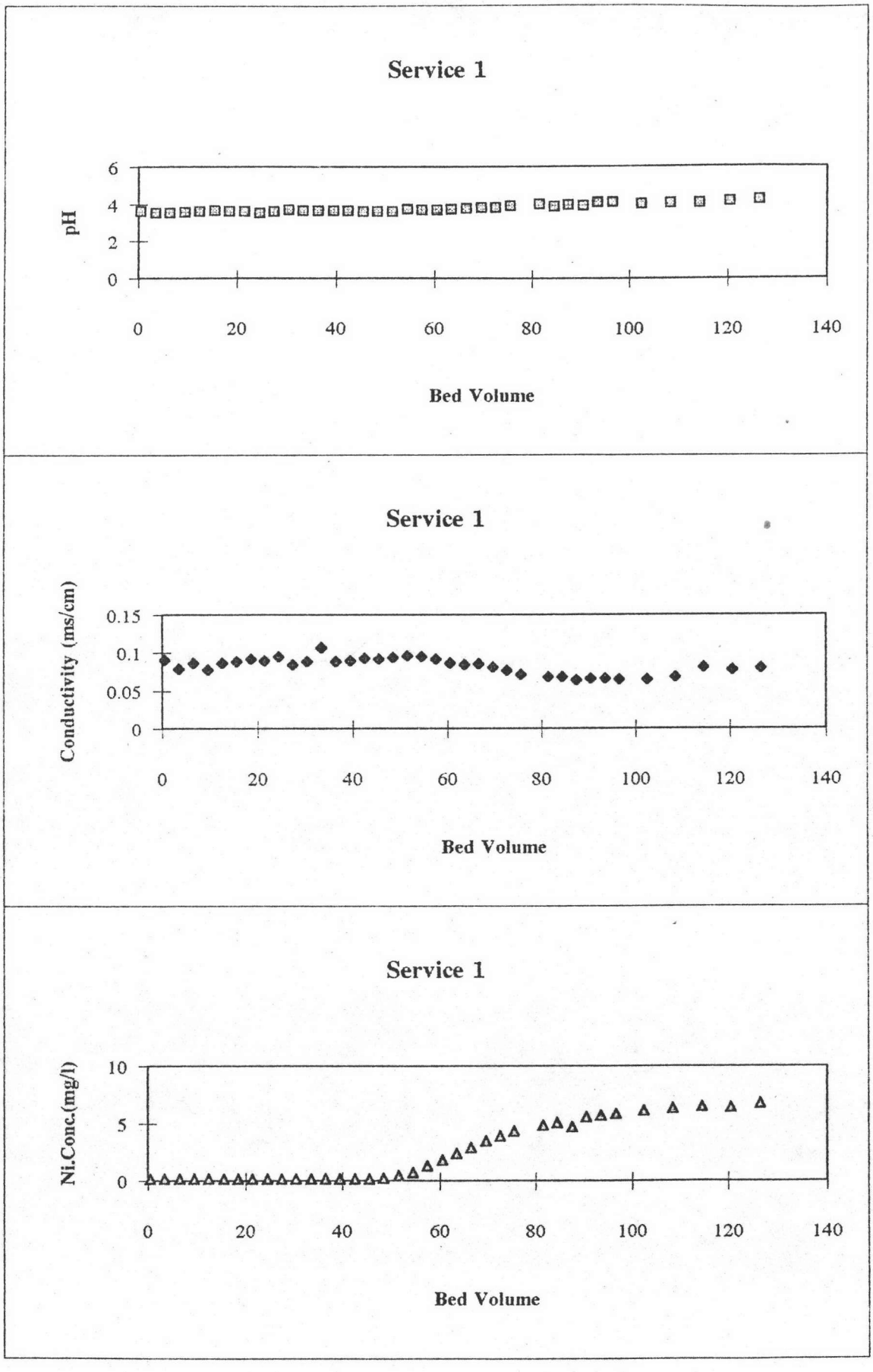
ตารางข้อมูลที่ได้จากการทดลอง

EXPERIMENT 1 Service

Column Size 2*50 cm

Influent Waste	flow BV/Hr	pH	Conductivity ms/cm.	Ni.in conc mg/l
synthetic	3	7.09	0.0461	10.44

Effluent NO	Bed Volume	pH	Conductivity (ms/cm)	Ni.eff Conc (mg/l)	Effluent Nickel / Influent Nickel		Total Exchanging Ni / Influent Nickel		Total Ni. Exchanging (mg/l resin)
					Value	Average	Value	Cumulation	
1	0.5	3.57	0.0902	0.12	0.01	0.01	0.50	0.50	5.19
2	3.5	3.49	0.0787	0.12	0.01	0.01	2.97	3.46	36.15
3	6.5	3.52	0.0868	0.12	0.01	0.01	2.97	6.43	67.11
4	9.5	3.55	0.078	0.12	0.01	0.01	2.97	9.39	98.07
5	12.5	3.59	0.0866	0.15	0.01	0.01	2.96	12.35	128.99
6	15.5	3.63	0.089	0.12	0.01	0.01	2.96	15.32	159.90
7	18.5	3.6	0.0919	0.12	0.01	0.01	2.97	18.28	190.86
8	21.5	3.58	0.0893	0.12	0.01	0.01	2.97	21.25	221.82
9	24.5	3.52	0.0945	0.12	0.01	0.01	2.97	24.21	252.78
10	27.5	3.58	0.0839	0.12	0.01	0.01	2.97	27.18	283.74
11	30.5	3.66	0.0886	0.12	0.01	0.01	2.97	30.14	314.70
12	33.5	3.64	0.107	0.13	0.01	0.01	2.96	33.11	345.65
13	36.5	3.64	0.0886	0.13	0.01	0.01	2.96	36.07	376.58
14	39.5	3.65	0.0897	0.14	0.01	0.01	2.96	39.03	407.49
15	42.5	3.64	0.0925	0.12	0.01	0.01	2.96	41.99	438.42
16	45.5	3.59	0.0916	0.14	0.01	0.01	2.96	44.96	469.35
17	48.5	3.58	0.094	0.22	0.02	0.02	2.95	47.91	500.13
18	51.5	3.6	0.0961	0.41	0.04	0.03	2.91	50.81	530.51
19	54.5	3.71	0.0947	0.74	0.07	0.06	2.83	53.65	560.10
20	57.5	3.67	0.0914	1.29	0.12	0.10	2.71	56.36	588.38
21	60.5	3.7	0.0867	1.78	0.17	0.15	2.56	58.92	615.09
22	63.5	3.74	0.0842	2.37	0.23	0.20	2.40	61.32	640.19
23	66.5	3.76	0.0855	2.89	0.28	0.25	2.24	63.56	663.62
24	69.5	3.79	0.0807	3.48	0.33	0.31	2.08	65.65	685.38
25	72.5	3.83	0.0771	3.87	0.37	0.35	1.94	67.59	705.68
26	75.5	3.88	0.0717	4.29	0.41	0.39	1.83	69.42	724.76
27	81.5	3.97	0.0684	4.81	0.46	0.44	3.39	72.81	760.10
28	84.5	3.85	0.0682	5.04	0.48	0.47	1.58	74.39	776.64
29	87.5	3.92	0.0634	4.71	0.45	0.47	1.60	75.99	793.34
30	90.5	3.9	0.0661	5.53	0.53	0.49	1.53	77.52	809.30
31	93.5	4.06	0.0653	5.71	0.55	0.54	1.39	78.90	823.76
32	96.5	4.08	0.065	5.84	0.56	0.55	1.34	80.24	837.75
33	102.5	3.99	0.0647	6.09	0.58	0.57	2.57	82.82	864.60
34	108.5	4.02	0.0677	6.36	0.61	0.60	2.42	85.24	889.89
35	114.5	4.02	0.0807	6.46	0.62	0.61	2.32	87.55	914.07
36	120.5	4.11	0.0781	6.41	0.61	0.62	2.30	89.86	938.10
37	126.5	4.2	0.0802	6.75	0.65	0.63	2.22	92.07	961.26

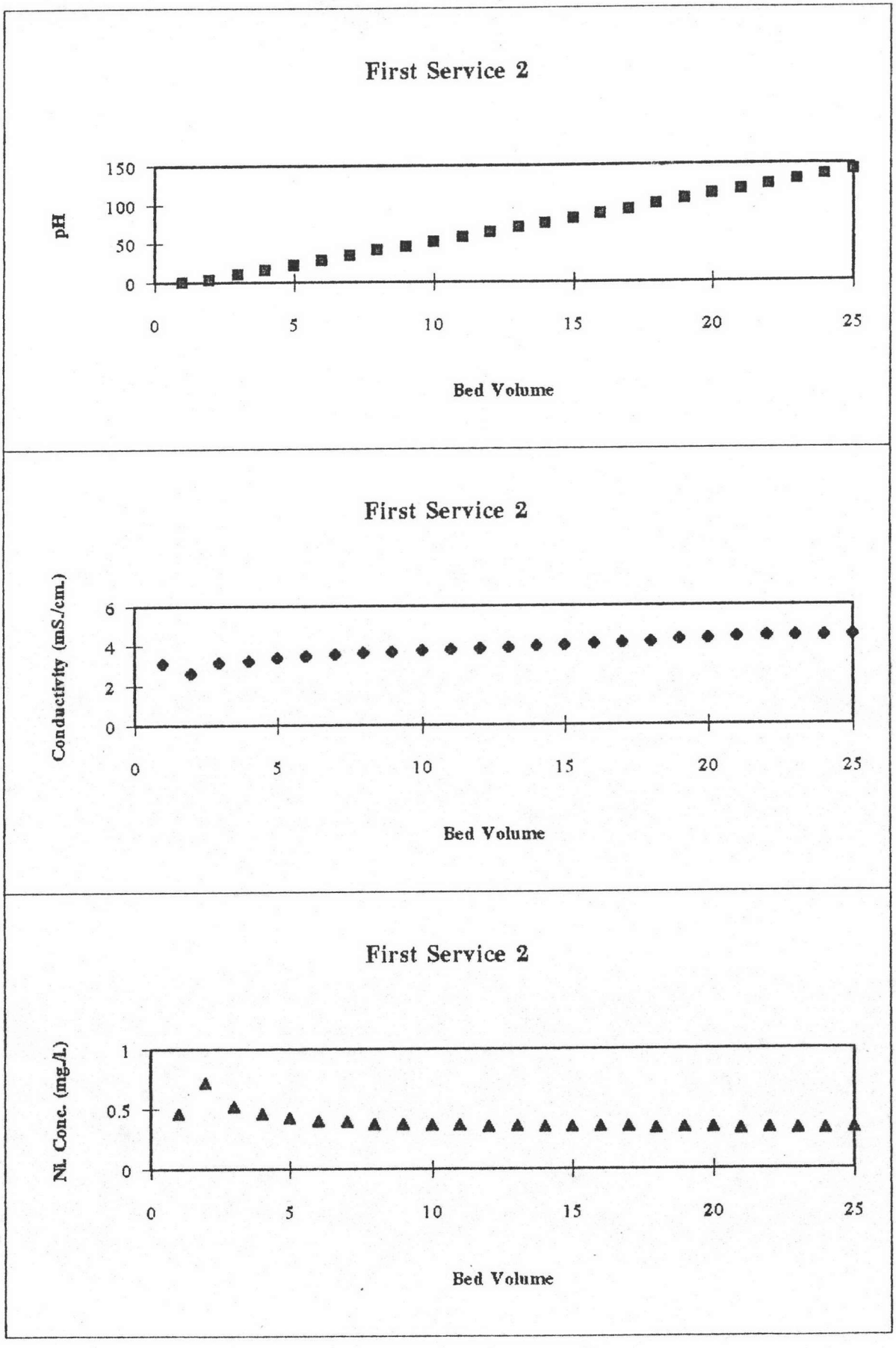

Service 1
pH
6
4
2
0
0
20
40
60
80
100
120
140
Bed Volume
Service 1
Conductivity (ms/cm)
0.15
0.1
0.05
0
0
20
40
60
80
100
120
140
Bed Volume
Service 1
Ni.Conc.(mg/l)
10
5
0
0
20
40
60
80
100
120
140
Bed Volume

EXPERIMENT 2 First Service

Column Size ∅ 2*50 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni.in.conc. (mg./l.)
synthetic	3	5.02	0.329	104.2

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni.eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	0.5	3.14	0.458	0.38	0.00	0.00	0.50	0.50	52.01
2	3.5	2.62	0.716	42.2	0.40	0.20	2.39	2.89	300.74
3	10.5	3.18	0.518	83.2	0.80	0.60	2.79	5.67	591.24
4	15.5	3.26	0.46	89.9	0.86	0.83	0.85	6.52	679.49
5	21.5	3.39	0.429	94.9	0.91	0.89	0.68	7.20	750.29
6	27.5	3.49	0.399	96.5	0.93	0.92	0.49	7.69	801.29
7	33.5	3.56	0.392	97.8	0.94	0.93	0.41	8.10	843.59
8	41	3.64	0.372	98.7	0.95	0.94	0.43	8.52	888.21
9	45.5	3.68	0.369	99.6	0.96	0.95	0.22	8.74	910.94
10	51.5	3.76	0.362	100.3	0.96	0.96	0.24	8.99	936.44
11	57.5	3.82	0.362	101.2	0.97	0.97	0.20	9.19	957.14
12	63.5	3.84	0.354	102.1	0.98	0.98	0.15	9.33	972.44
13	69.5	3.9	0.357	104.3	1.00	0.99	0.06	9.39	978.44
14	75.5	3.96	0.35	103.9	1.00	1.00	0.01	9.40	979.04
15	81.5	4.03	0.351	103.6	0.99	1.00	0.03	9.42	981.74
16	87.5	4.08	0.35	103.2	0.99	0.99	0.05	9.47	986.54
17	92.5	4.13	0.349	103.7	1.00	0.99	0.04	9.50	990.29
18	99.5	4.19	0.34	103.5	0.99	0.99	0.04	9.54	994.49
19	105.5	4.28	0.344	104.10	1.00	1.00	0.02	9.57	996.89
20	111.5	4.32	0.342	103.50	0.99	1.00	0.02	9.59	999.29
21	117.5	4.4	0.331	104.8	1.01	1.00	0.00	9.59	999.59
22	123.5	4.44	0.339	105.6	1.01	1.01	-0.06	9.54	993.59
23	129.5	4.46	0.328	105.7	1.01	1.01	-0.08	9.45	984.89
24	135.5	4.44	0.331	105.5	1.01	1.01	-0.08	9.37	976.49
25	141.5	4.5	0.336	105.3	1.01	1.01	-0.07	9.30	969.29

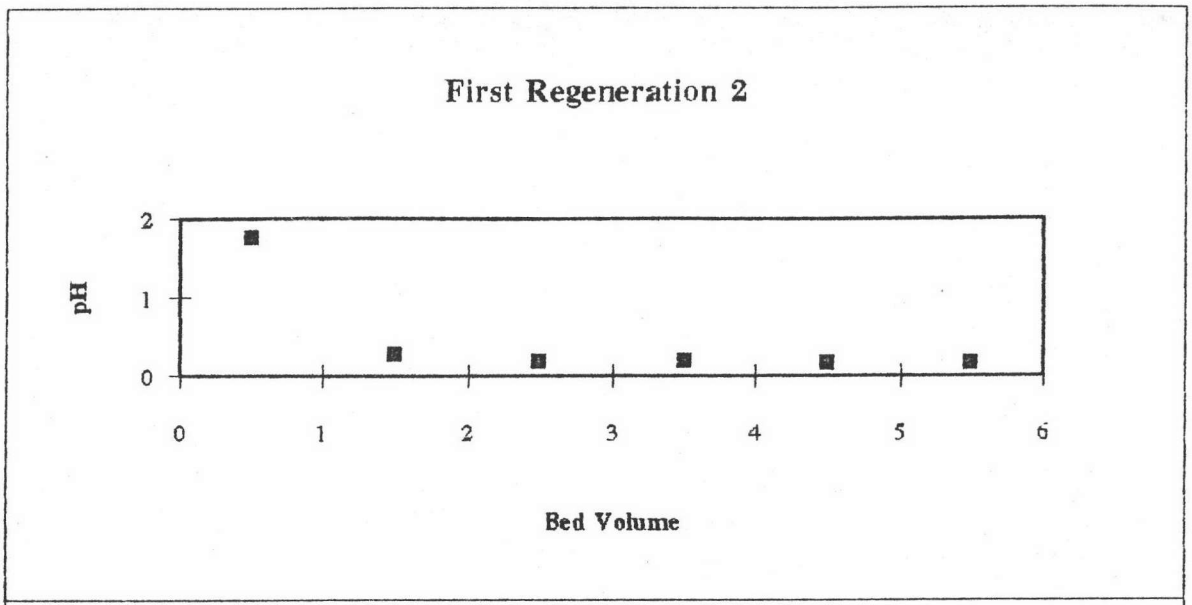

First Service 2
pH
150
100
50
0
0
5
10
15
20
25
Bed Volume
First Service 2
Conductivity (mS./cm.)
6
4
2
0
0
5
10
15
20
25
Bed Volume
First Service 2
NL Conc. (mg./L)
1
0.5
0
0
5
10
15
20
25
Bed Volume

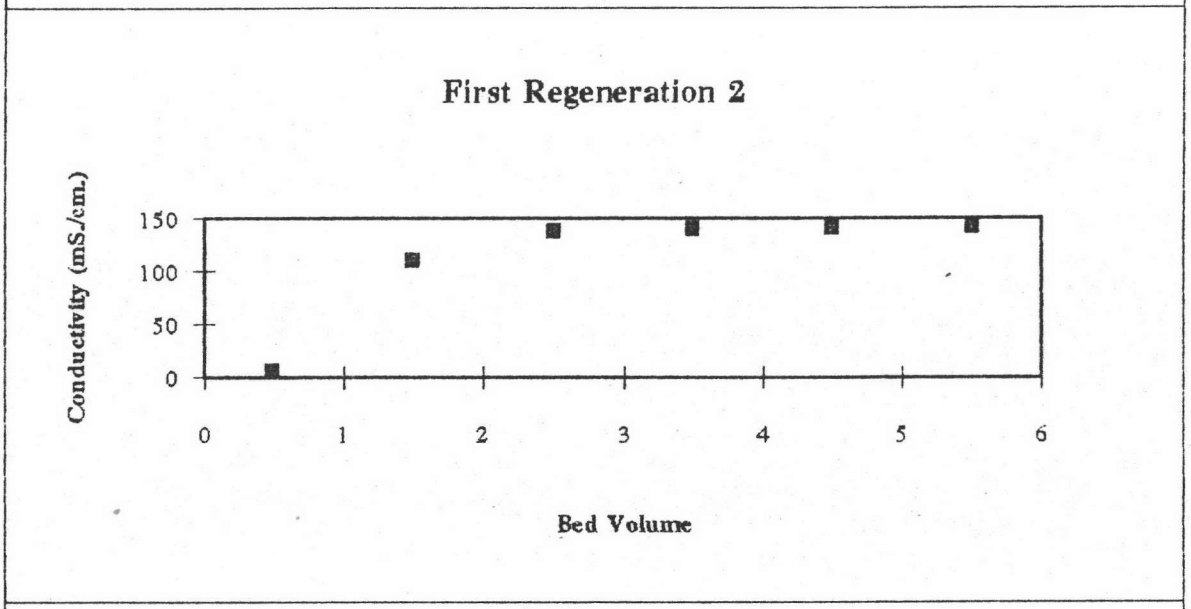
EXPERIMENT 2 First regeneration

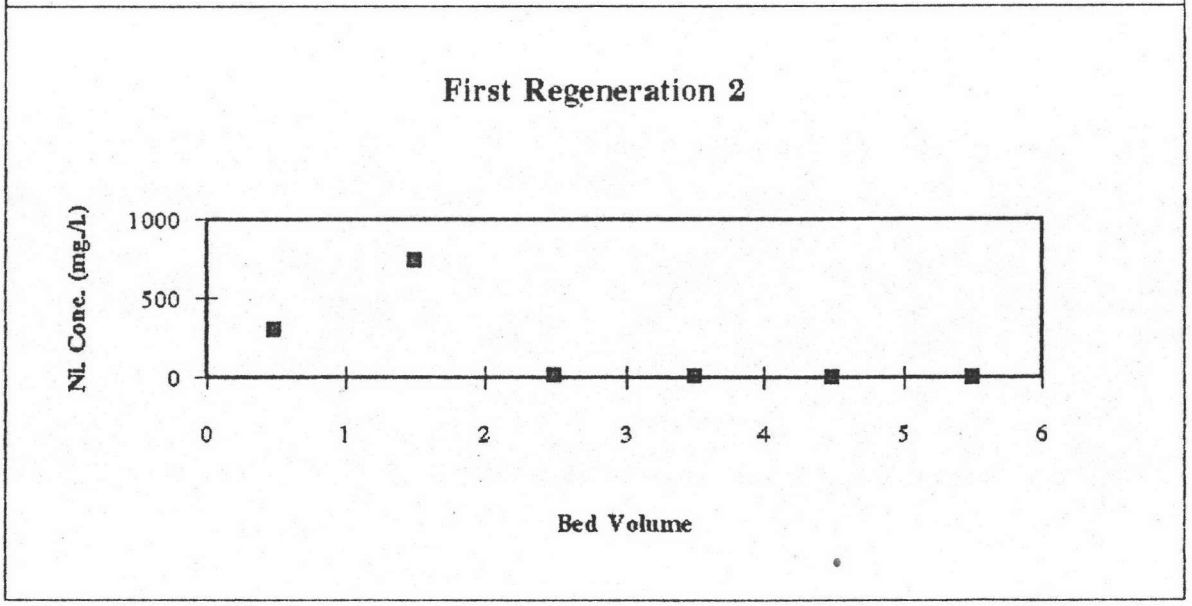
Column Size ∅ 2*50 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	10	0.19	139.6	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	1.75	6.54	300.4	0.31	0.31	0.31	300.40	300.40	300.40
2	1.5	0.28	110.1	738.4	0.76	0.76	1.07	738.4	1038.8	519.40
3	2.5	0.18	137.4	13.8	0.01	0.01	1.09	13.8	1052.6	350.87
4	3.5	0.19	140.3	4.24	0.00	0.00	1.09	4.2	1056.8	264.21
5	4.5	0.17	141.3	1.78	0.00	0.00	1.09	1.8	1058.6	211.72
6	5.5	0.16	141.4	1.19	0.00	0.00	1.09	1.2	1059.8	176.64


First Regeneration 2
pH
2
1
0
0
1
2
3
4
5
6
Bed Volume


First Regeneration 2
Conductivity (mS./cm.)
150
100
50
0
0
1
2
3
4
5
6
Bed Volume

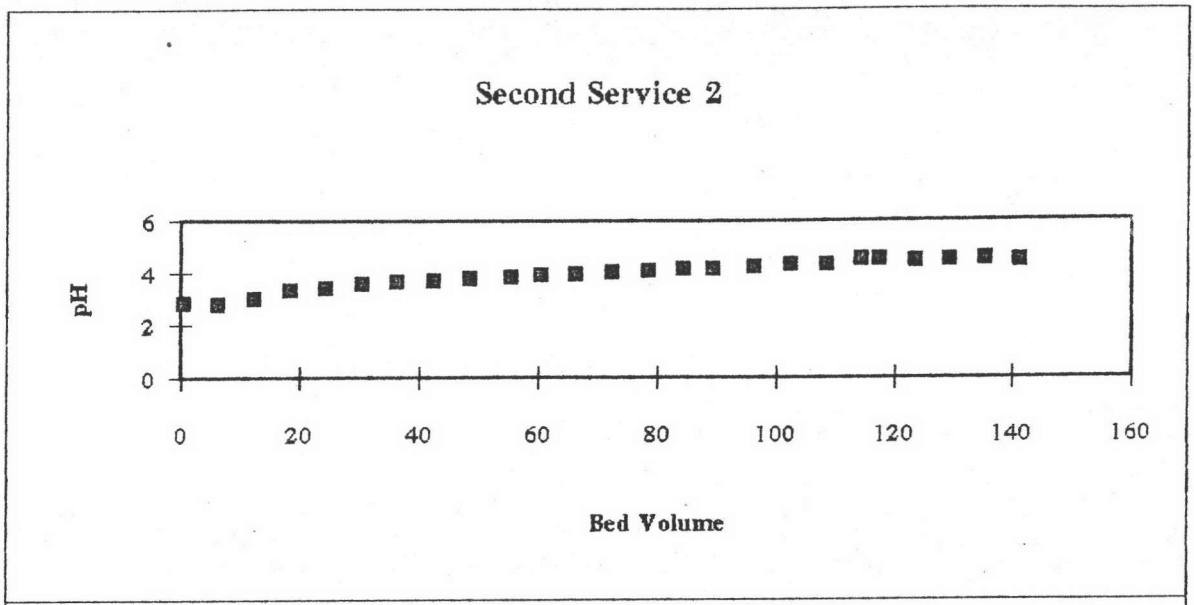

First Regeneration 2
NL Conc. (mg./L)
1000
500
0
0
1
2
3
4
5
6
Bed Volume

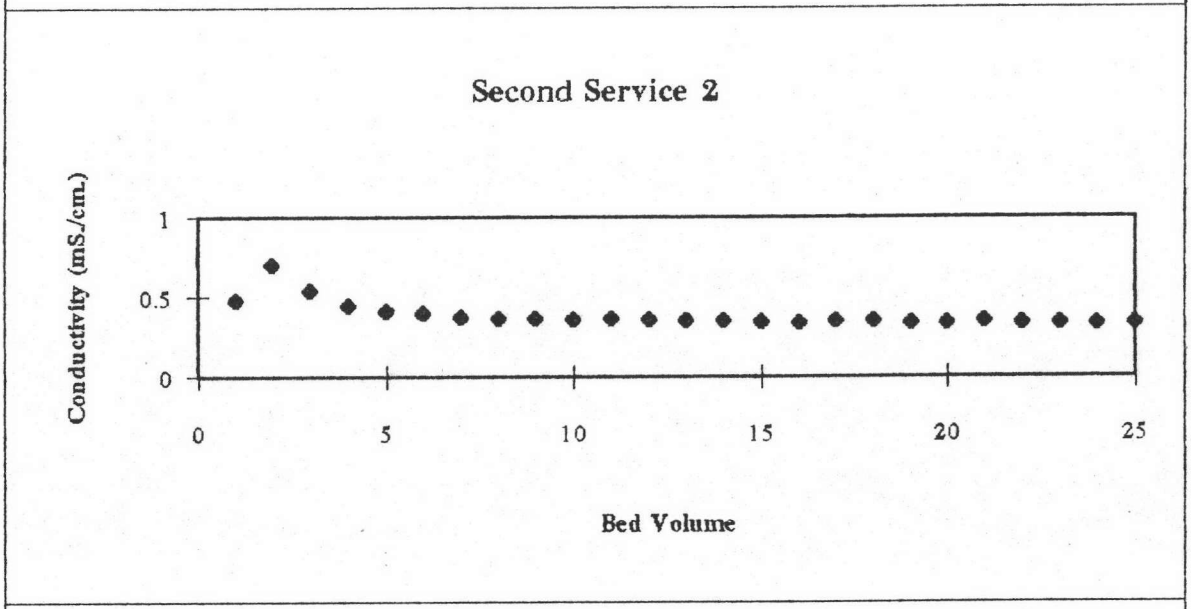
EXPERIMENT 2 Second Service

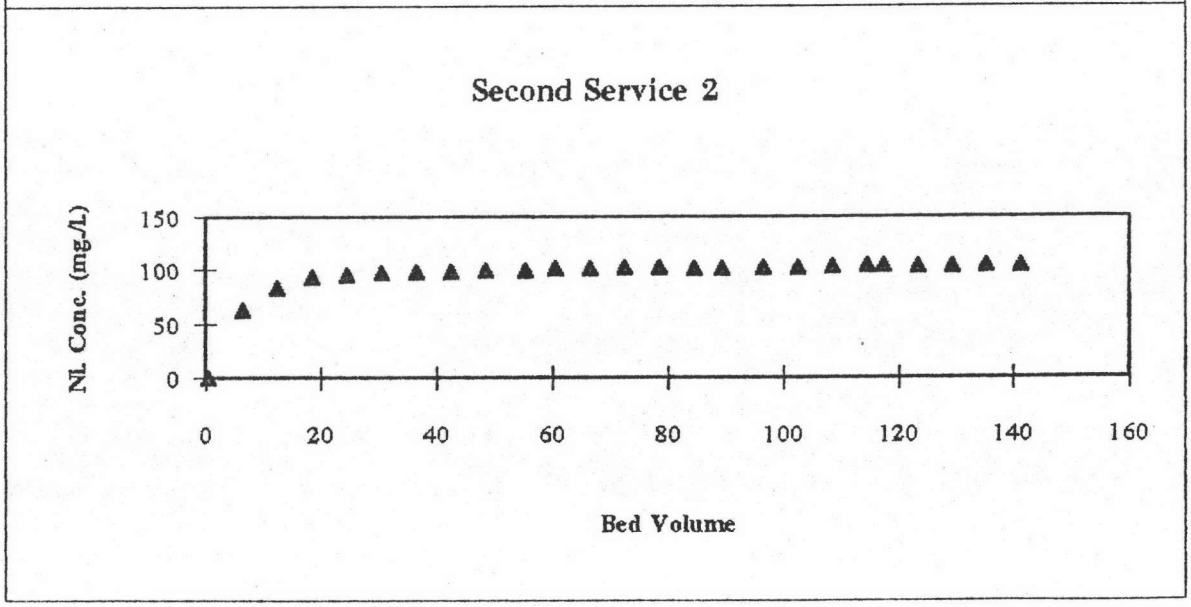
Column Size ∅ 2*50 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	3	4.97	0.332	103.4

Effluent No	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	0.5	2.82	0.483	0.32	0.00	0.00	0.50	0.50	51.62
2	6.5	2.79	0.704	62.6	0.61	0.30	4.17	4.67	483.26
3	12.5	3.01	0.542	83.1	0.80	0.70	1.77	6.45	666.56
4	18.5	3.32	0.443	93.2	0.90	0.85	0.88	7.33	758.06
5	24.5	3.42	0.41	95.7	0.93	0.91	0.52	7.85	811.76
6	30.5	3.56	0.396	97.4	0.94	0.93	0.40	8.25	852.86
7	36.5	3.64	0.373	97.9	0.95	0.94	0.33	8.58	887.36
8	42.5	3.71	0.368	98.8	0.96	0.95	0.29	8.87	917.66
9	48.5	3.78	0.365	99.4	0.96	0.96	0.25	9.12	943.46
10	55.5	3.84	0.361	99.7	0.96	0.96	0.26	9.39	970.41
11	60.5	3.9	0.363	101.3	0.98	0.97	0.14	9.53	984.91
12	66.5	3.95	0.358	101.6	0.98	0.98	0.11	9.64	996.61
13	72.5	4.01	0.352	102.2	0.99	0.99	0.09	9.73	1005.61
14	78.5	4.06	0.351	102	0.99	0.99	0.08	9.80	1013.41
15	84.5	4.17	0.345	101.4	0.98	0.98	0.10	9.90	1023.61
16	89.5	4.17	0.341	101	0.98	0.98	0.11	10.01	1034.61
17	96.5	4.25	0.348	102	0.99	0.98	0.13	10.13	1047.91
18	102.5	4.32	0.348	102	0.99	0.99	0.08	10.22	1056.31
19	108.5	4.33	0.339	102.9	1.00	0.99	0.06	10.27	1062.01
20	114.5	4.53	0.336	104.1	1.01	1.00	-0.01	10.27	1061.41
21	117.5	4.53	0.348	104.2	1.01	1.01	-0.02	10.24	1059.16
22	123.5	4.42	0.341	103.7	1.00	1.01	-0.03	10.21	1055.86
23	129.5	4.46	0.339	103.5	1.00	1.00	-0.01	10.20	1054.66
24	135.5	4.52	0.328	104.3	1.01	1.00	-0.03	10.17	1051.66
25	141.5	4.43	0.341	103.9	1.00	1.01	-0.04	10.13	1047.46


Second Service 2
pH
6
4
2
0
0
20
40
60
80
100
120
140
160
Bed Volume


Second Service 2
Conductivity (mS/cm)
1
0.5
0
0
5
10
15
20
25
Bed Volume

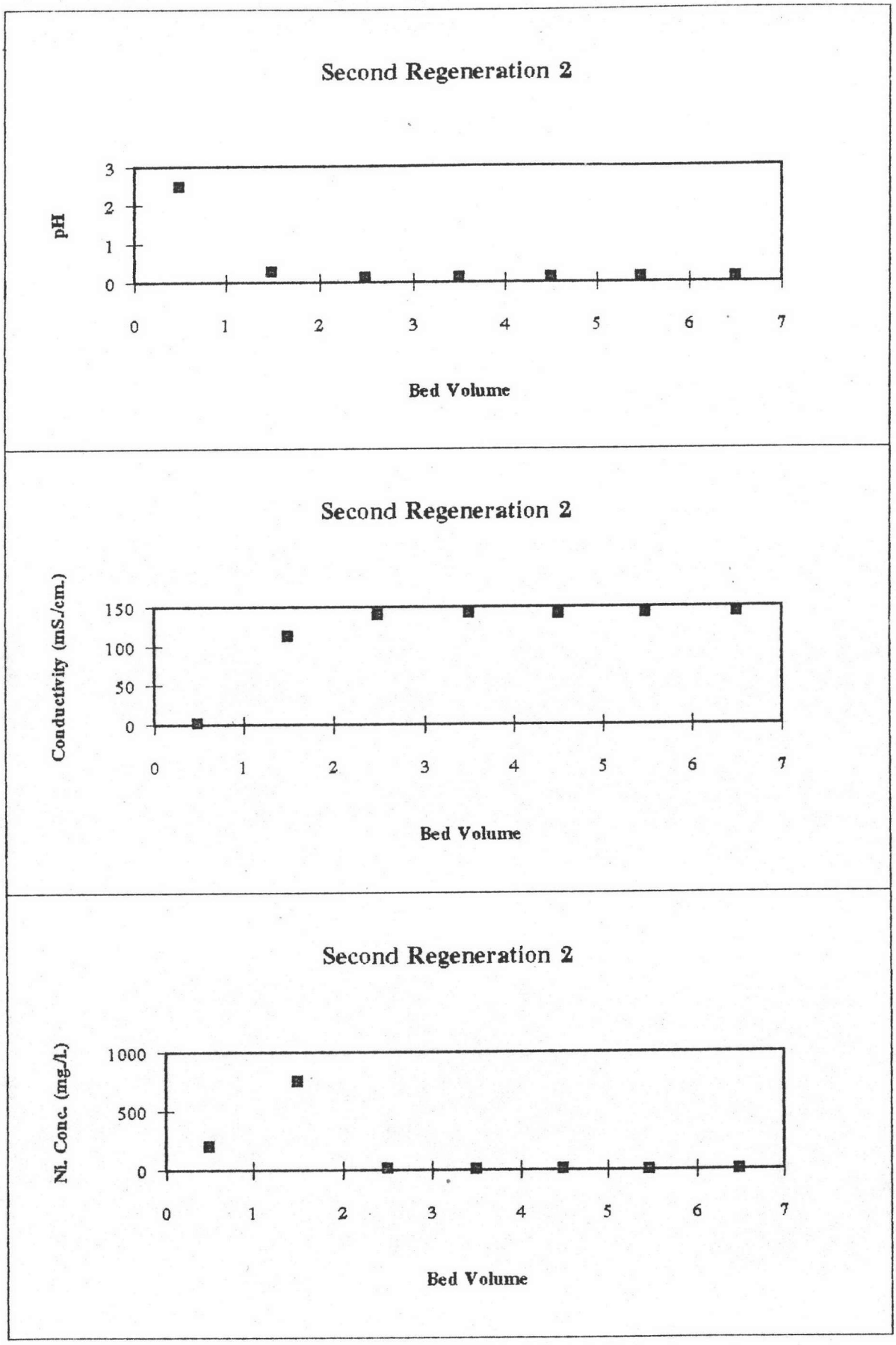

Second Service 2
Ni. Conc. (mg/L)
150
100
50
0
0
20
40
60
80
100
120
140
160
Bed Volume

EXPERIMENT 2 Second regeneration

Column Size ∅ 2*50 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	10	0.12	138.6	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	2.49	2.24	200.8	0.19	0.19	0.19	200.80	200.80	200.80
2	1.5	0.26	113.4	751.8	0.72	0.72	0.91	751.8	952.6	476.30
3	2.5	0.13	139.8	12.45	0.01	0.01	0.92	12.5	965.1	321.68
4	3.5	0.13	141.5	3.64	0.00	0.00	0.92	3.6	968.7	242.17
5	4.5	0.13	141.2	3.76	0.00	0.00	0.93	3.8	972.5	194.49
6	5.48	0.12	141.9	2.67	0.00	0.00	0.93	2.6	975.1	163.05
7	6.5	0.12	142.3	2.64	0.00	0.00	0.93	2.7	977.8	139.68

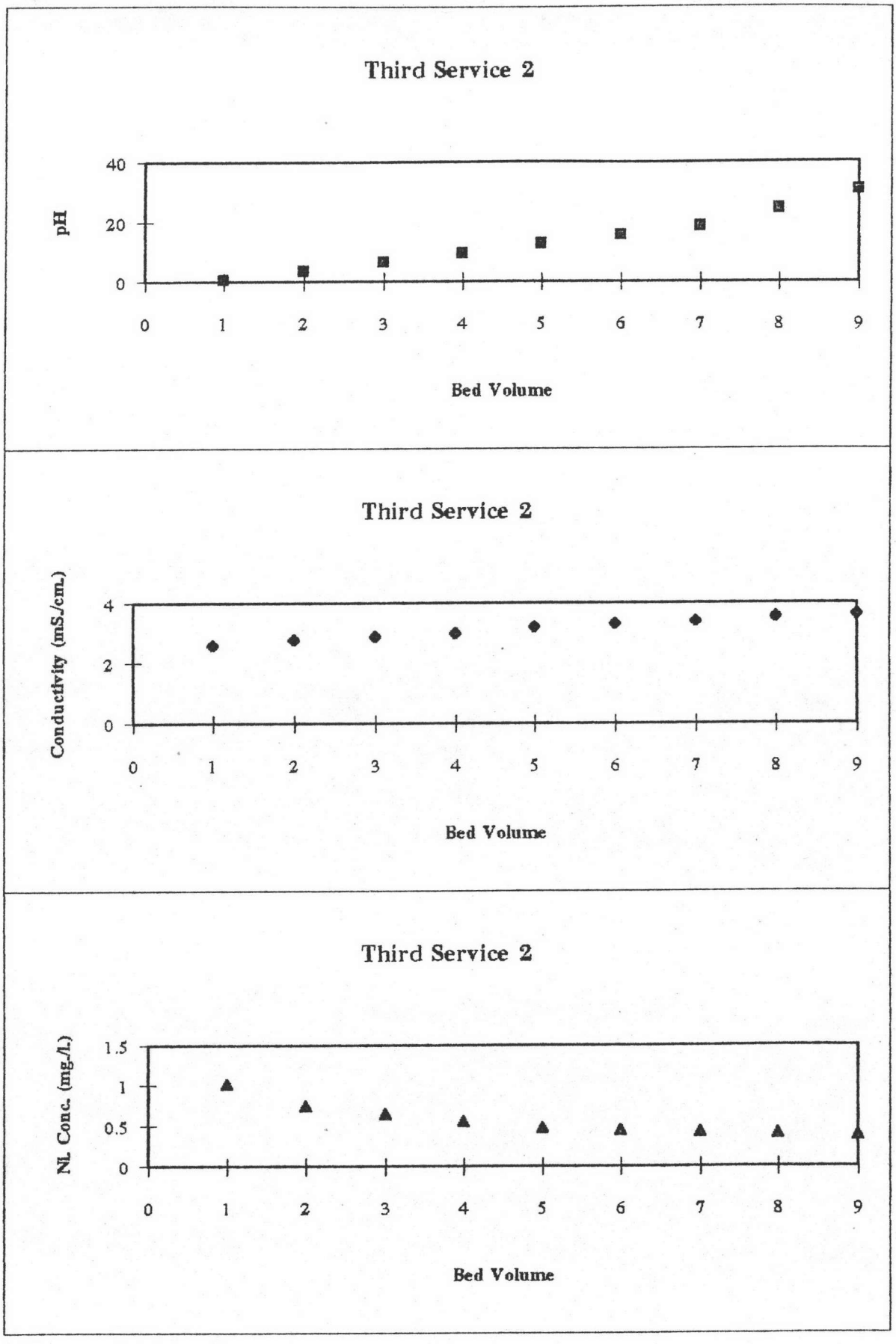

Second Regeneration 2
pH
3
2
1
0
0
1
2
3
4
5
6
7
Bed Volume
Second Regeneration 2
Conductivity (mS./cm.)
150
100
50
0
0
1
2
3
4
5
6
7
Bed Volume
Second Regeneration 2
NL Conc. (mg./L)
1000
500
0
0
1
2
3
4
5
6
7
Bed Volume

EXPERIMENT 2 Third Service

Column Size ∅ 2*50 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	3	5	0.34	103.1

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Total Exchanging Ni / Influent Nickel		Total Exchanging (mg./l resin)
					Value	Average	Value	Cumulation	
1	0.5	2.58	1.01	5.07	0.05	0.02	0.49	0.49	50.29
2	3.5	2.77	0.743	51.8	0.50	0.28	2.17	2.66	274.35
3	6.5	2.87	0.648	64.7	0.63	0.56	1.31	3.97	408.99
4	9.5	2.99	0.561	75.6	0.73	0.68	0.96	4.93	507.99
5	12.5	3.2	0.478	85.3	0.83	0.78	0.66	5.59	576.13
6	15.5	3.3	0.443	91.6	0.89	0.86	0.43	6.01	620.19
7	18.5	3.39	0.427	95.9	0.93	0.91	0.27	6.29	648.24
8	24.5	3.55	0.404	99.2	0.96	0.95	0.32	6.61	681.57
9	30.5	3.63	0.389	103.3	1.00	0.98	0.11	6.72	692.79

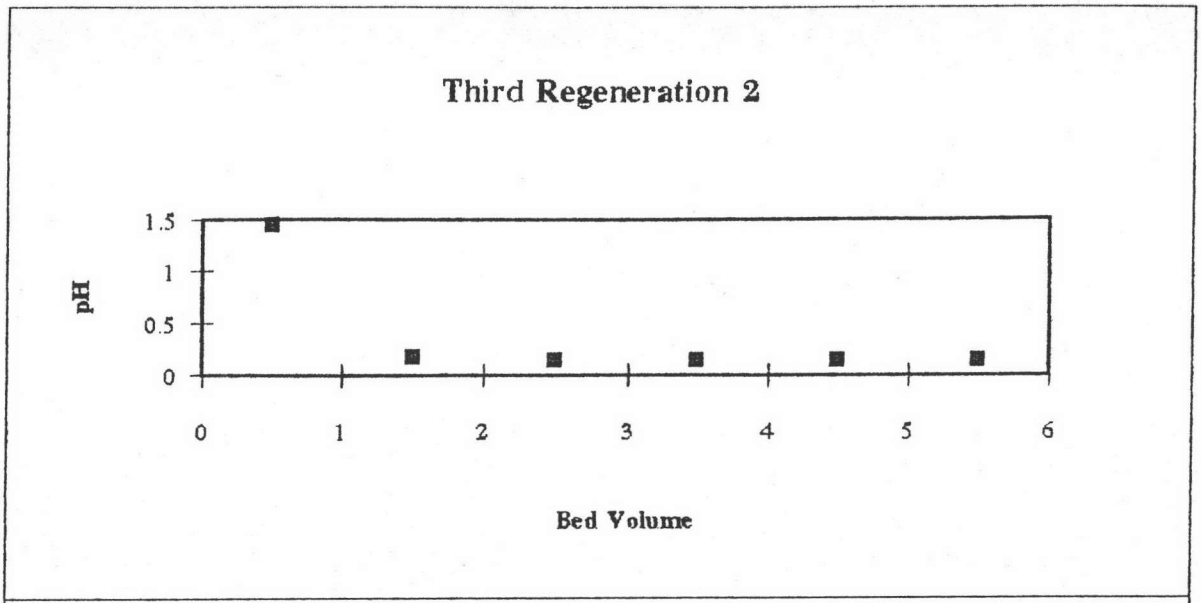

Third Service 2
pH
40
20
0
0 1 2 3 4 5 6 7 8 9
Bed Volume
Third Service 2
Conductivity (mS/cm)
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume
Third Service 2
NL Conc. (mg/L)
1.5
1
0.5
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

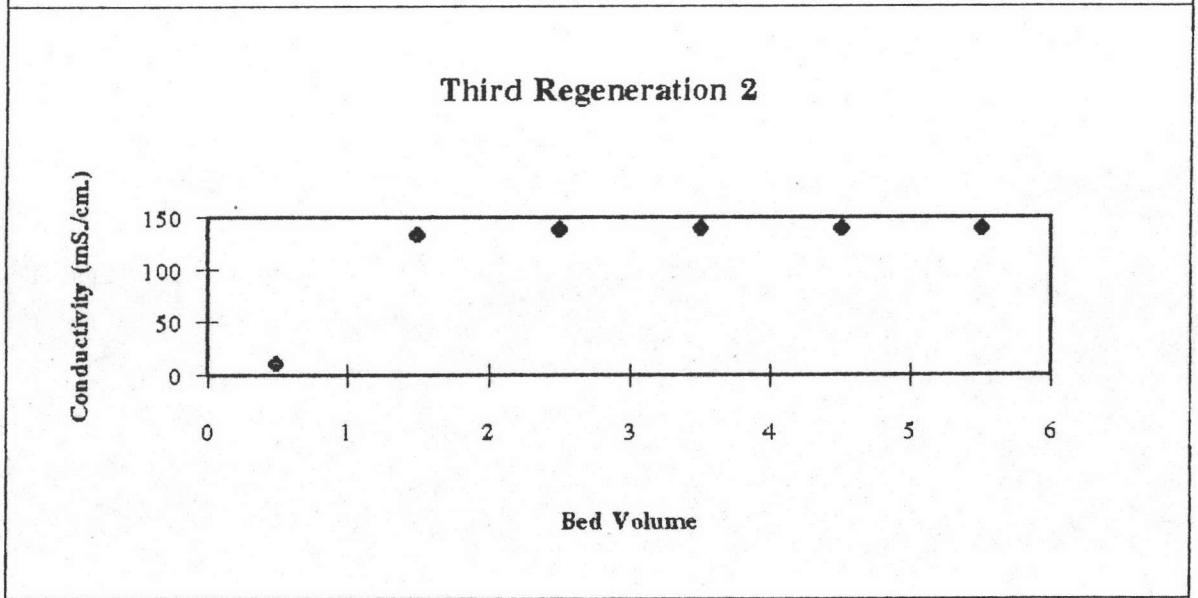
EXPERIMENT 2 Third regeneration

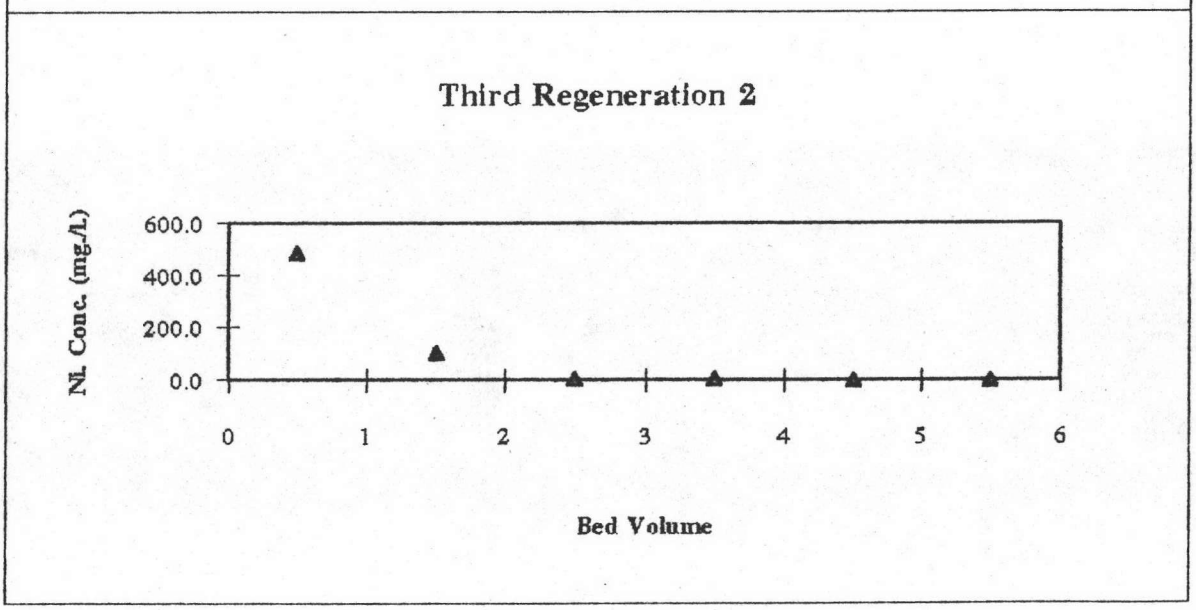
Column Size ∅ 2*50 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	10	0.15	139.8	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni.reg. Conc (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	1.45	11.53	483.7	0.70	0.70	0.70	483.73	483.73	483.73
2	1.5	0.18	133.6	103.7	0.15	0.15	0.85	103.7	587.4	293.70
3	2.5	0.15	139.1	2.35	0.00	0.00	0.85	2.4	589.8	196.58
4	3.5	0.15	139.4	2.12	0.00	0.00	0.85	2.1	591.9	147.97
5	4.5	0.15	139.5	1.80	0.00	0.00	0.86	1.8	593.7	118.74
6	5.5	0.15	140	1.10	0.00	0.00	0.86	1.1	594.8	99.13


Third Regeneration 2
pH
1.5
1
0.5
0
0
1
2
3
4
5
6
Bed Volume


Third Regeneration 2
Conductivity (mS/cm)
150
100
50
0
0
1
2
3
4
5
6
Bed Volume

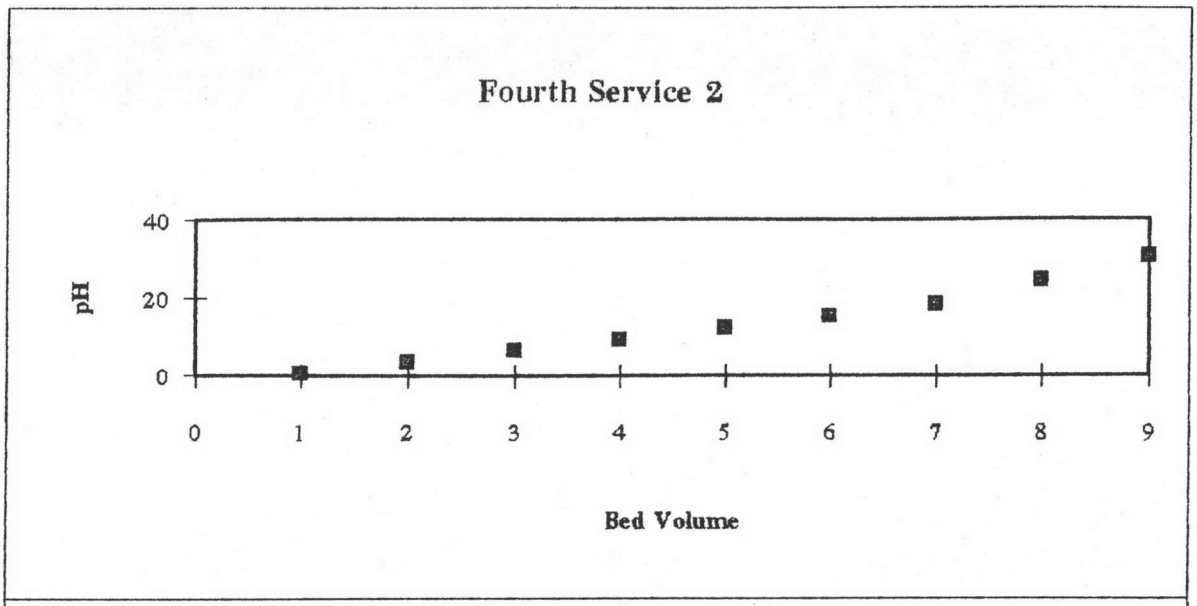

Third Regeneration 2
Ni Conc. (mg/L)
600.0
400.0
200.0
0.0
0
1
2
3
4
5
6
Bed Volume

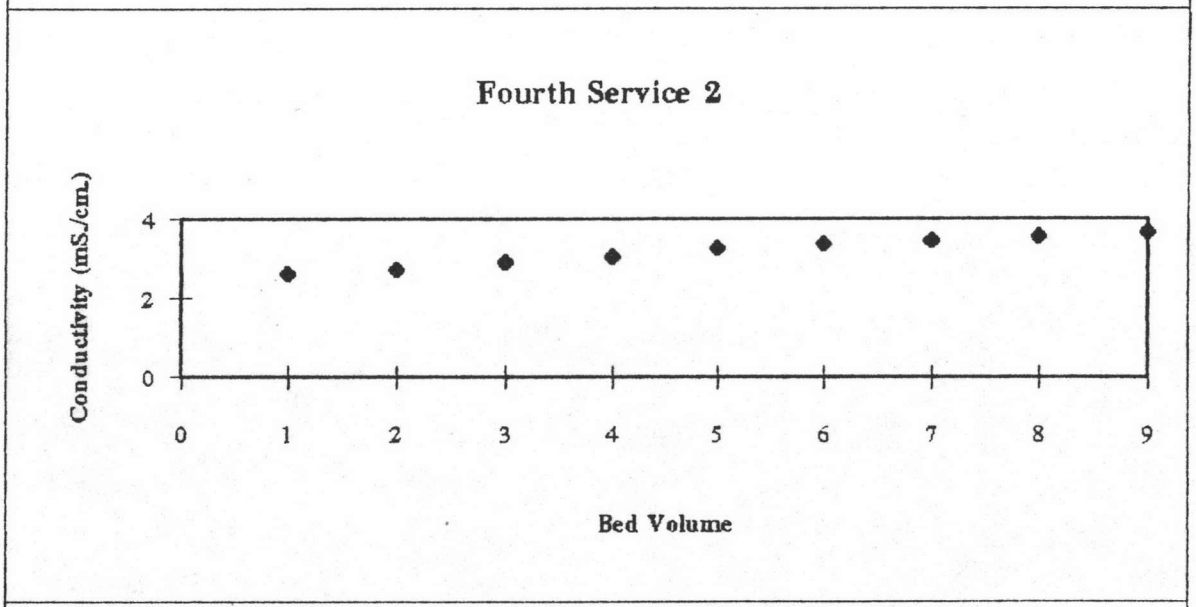
EXPERIMENT 2 Fourth Service

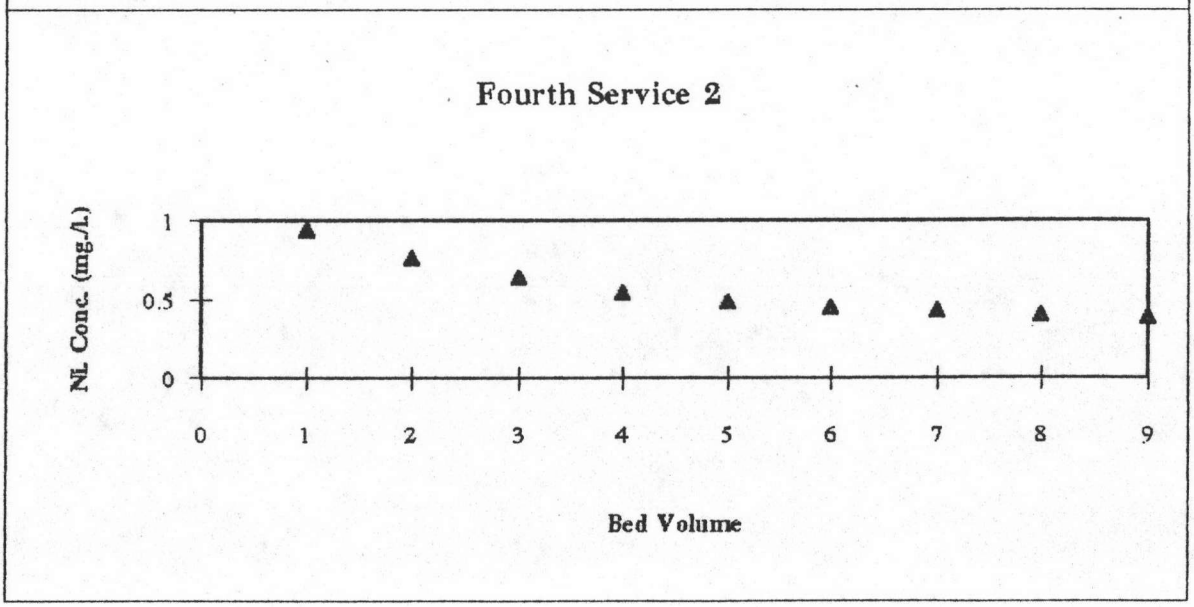
Column Size ∅ 2*50 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	3	4.97	0.337	100.6

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Total Exchanging Ni / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	0.5	2.6	0.941	2.59	0.03	0.01	0.49	0.49	49.65
2	3.5	2.72	0.76	51.4	0.51	0.27	2.20	2.69	270.50
3	6.5	2.9	0.639	66.1	0.66	0.58	1.25	3.94	396.07
4	9.5	3.05	0.546	76.2	0.76	0.71	0.88	4.81	484.34
5	12.5	3.27	0.482	83.5	0.83	0.79	0.62	5.43	546.55
6	15.5	3.38	0.446	86.7	0.86	0.85	0.46	5.90	593.08
7	18.5	3.45	0.426	88.8	0.88	0.87	0.38	6.28	631.69
8	24.5	3.57	0.402	92.7	0.92	0.90	0.59	6.87	690.76
9	30.5	3.67	0.387	95.3	0.95	0.93	0.39	7.26	730.36


Fourth Service 2
pH
40
20
0
0 1 2 3 4 5 6 7 8 9
Bed Volume


Fourth Service 2
Conductivity (mS./cm.)
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

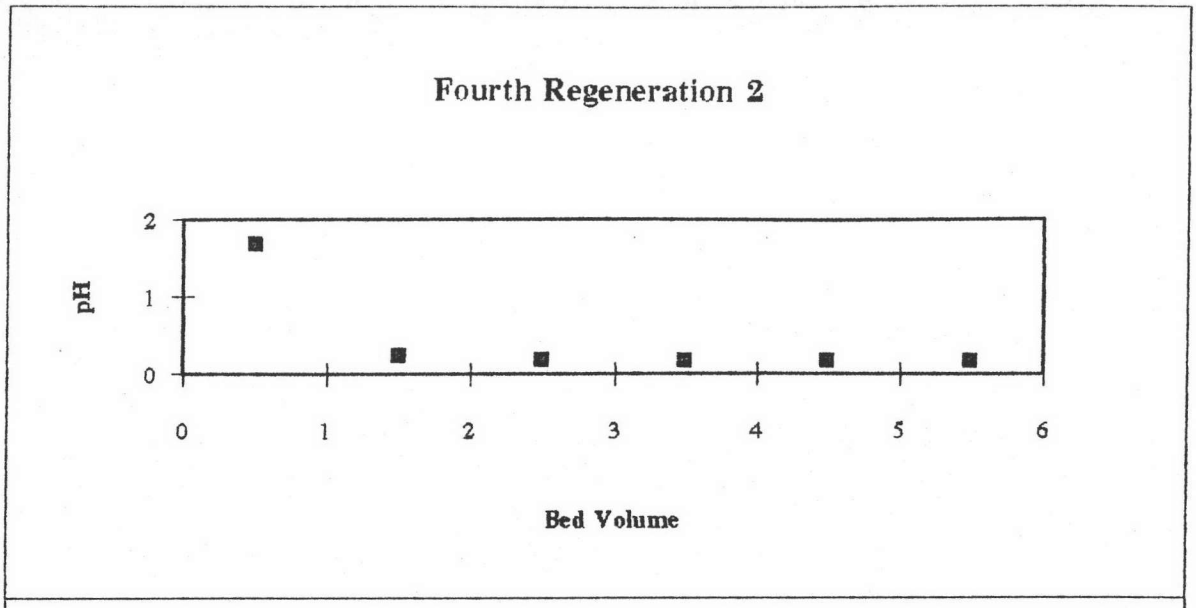

Fourth Service 2
NL Conc. (mg./L)
1
0.5
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

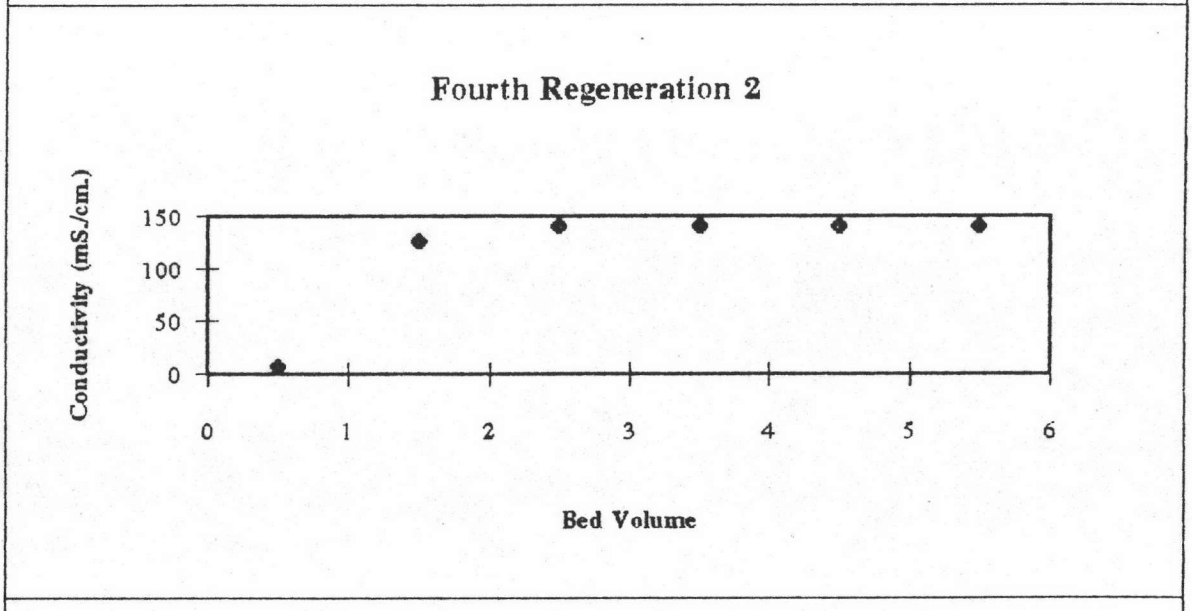
EXPERIMENT 2 Fourth regeneration

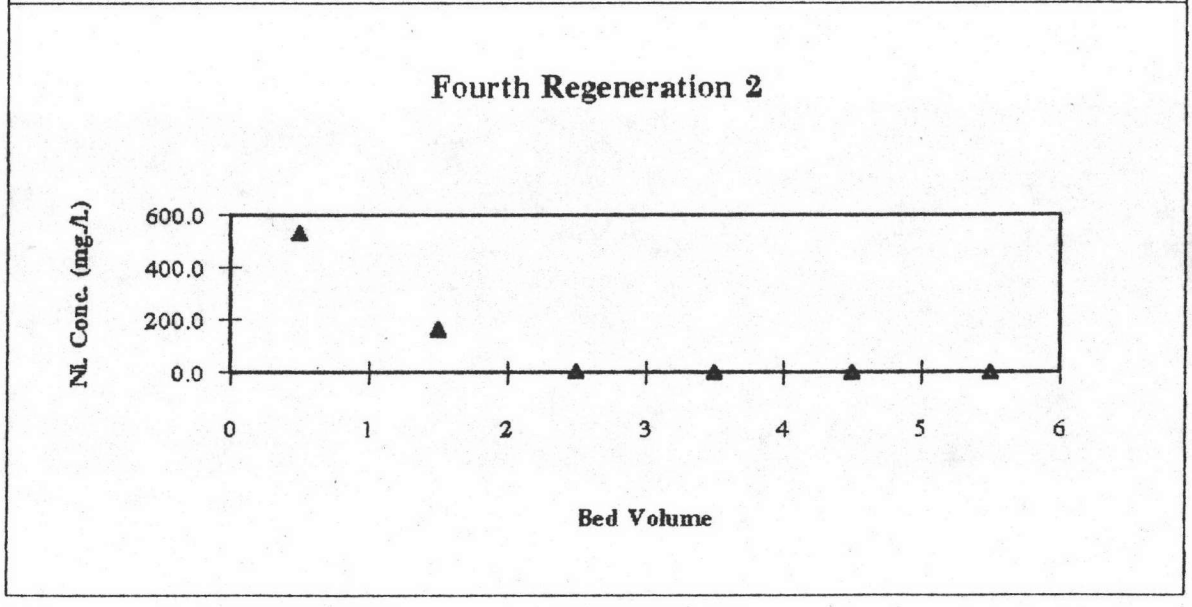
Column Size ∅ 2*50 cm

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	10	0.2	139.7	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	1.68	7.65	529.2	0.72	0.72	0.72	529.21	529.21	529.21
2	1.5	0.24	126.6	164.0	0.22	0.22	0.95	164.0	693.2	346.61
3	2.5	0.18	140.5	3.15	0.00	0.00	0.95	3.1	696.4	232.12
4	3.5	0.17	140.9	1.30	0.00	0.00	0.96	1.3	697.7	174.42
5	4.5	0.17	140.9	1.03	0.00	0.00	0.96	1.0	698.7	139.74
6	5.5	0.17	140.9	0.96	0.00	0.00	0.96	1.0	699.7	116.61


Fourth Regeneration 2
pH
2
1
0
0
1
2
3
4
5
6
Bed Volume


Fourth Regeneration 2
Conductivity (mS/cm.)
150
100
50
0
0
1
2
3
4
5
6
Bed Volume

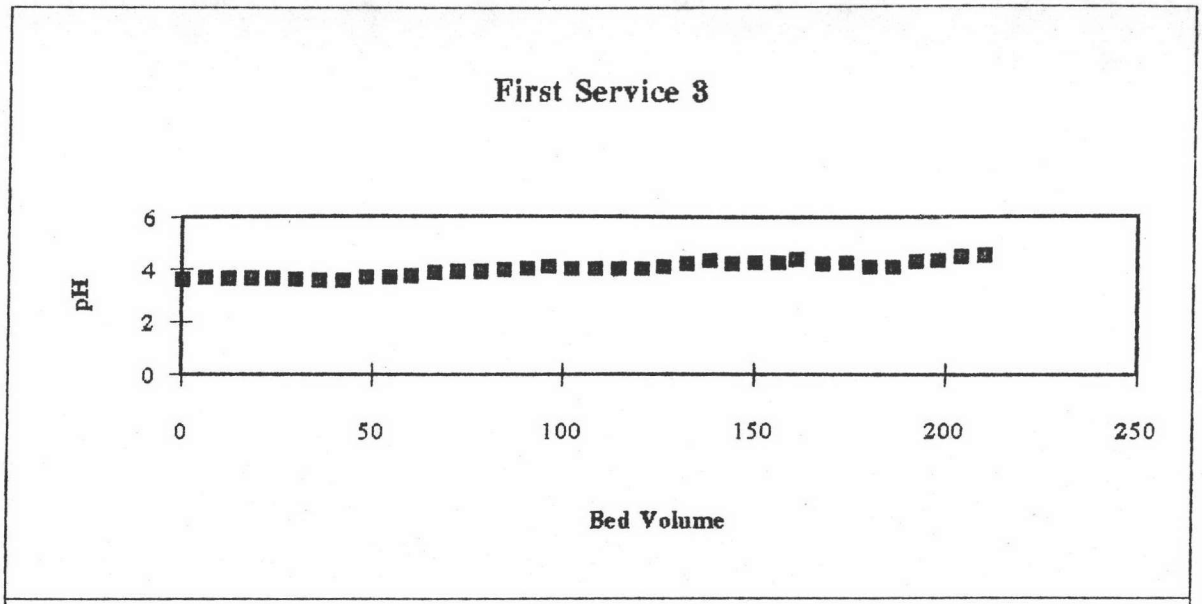

Fourth Regeneration 2
NL Conc. (mg/L)
600.0
400.0
200.0
0.0
0
1
2
3
4
5
6
Bed Volume

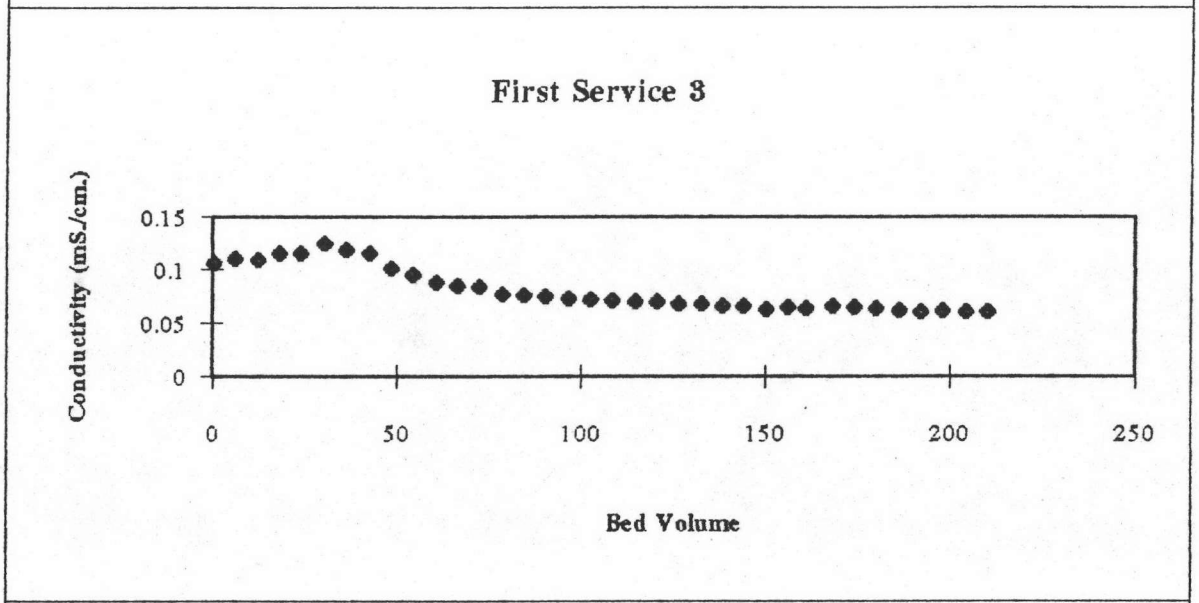
EXPERIMENT 3 First Service

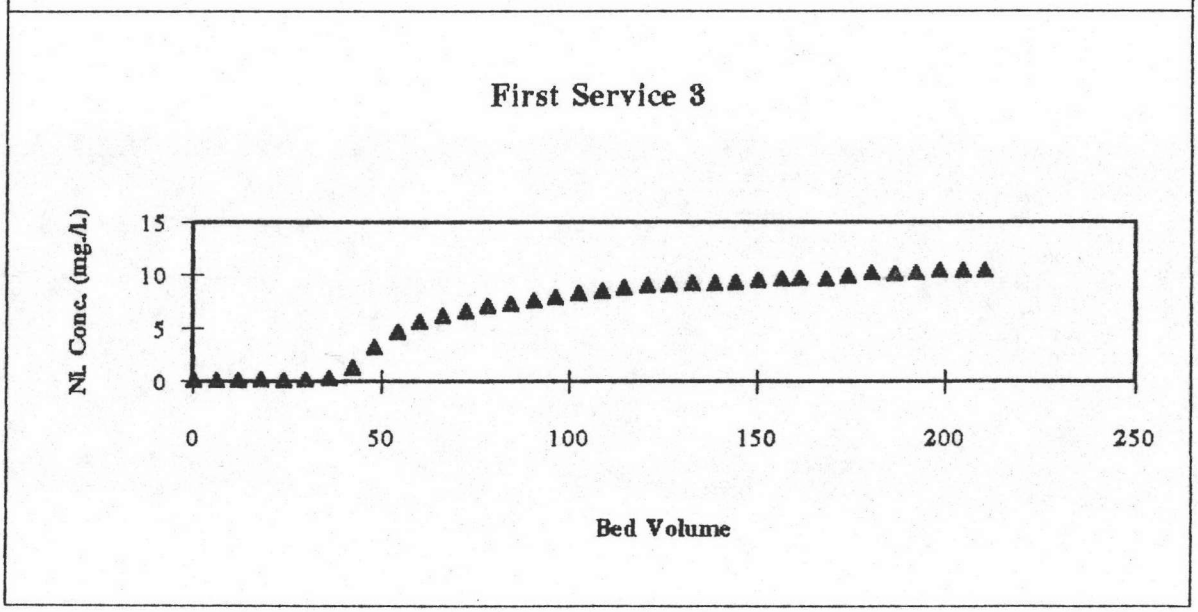
Column Size ∅ 2*50 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	3	5.01	0.05099	11.72

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l resin)
					Value	Average	Value	Cumulation	
1	0.5	3.61	0.1061	0.15	0.01	0.01	0.50	0.50	5.82
2	6.5	3.66	0.1102	0.1	0.01	0.01	5.94	6.43	75.39
3	12.5	3.62	0.1097	0.09	0.01	0.01	5.95	12.38	145.14
4	18.5	3.65	0.1153	0.16	0.01	0.01	5.94	18.32	214.71
5	24.5	3.62	0.1156	0.11	0.01	0.01	5.93	24.25	284.22
6	30.5	3.58	0.1245	0.18	0.02	0.01	5.93	30.18	353.67
7	36.5	3.54	0.1181	0.34	0.03	0.02	5.87	36.04	422.43
8	42.5	3.56	0.1155	1.36	0.12	0.07	5.56	41.61	487.65
9	48.5	3.67	0.1016	3.21	0.27	0.19	4.83	46.44	544.26
10	54.5	3.69	0.0953	4.67	0.40	0.34	3.98	50.42	590.94
11	60.5	3.73	0.0886	5.56	0.47	0.44	3.38	53.80	630.57
12	66.5	3.84	0.0852	6.14	0.52	0.50	3.01	56.81	665.79
13	72.5	3.88	0.0838	6.6	0.56	0.54	2.74	59.55	697.89
14	78.5	3.86	0.0774	7.05	0.60	0.58	2.51	62.05	727.26
15	84.5	3.94	0.0763	7.3	0.62	0.61	2.33	64.38	754.53
16	90.5	4	0.0747	7.61	0.65	0.64	2.18	66.56	780.12
17	96.5	4.1	0.0733	7.88	0.67	0.66	2.03	68.60	803.97
18	102.5	3.99	0.0717	8.3	0.71	0.69	1.86	70.46	825.75
19	108.5	3.98	0.071	8.54	0.73	0.72	1.69	72.15	845.55
20	114.5	4.02	0.0698	8.85	0.76	0.74	1.55	73.69	863.70
21	120.5	3.99	0.0889	9.03	0.77	0.76	1.42	75.12	880.38
22	126.5	4.1	0.0683	9.11	0.78	0.77	1.36	76.47	896.28
23	132.5	4.2	0.0675	9.21	0.79	0.78	1.31	77.79	911.64
24	138.5	4.33	0.0663	9.25	0.79	0.79	1.27	79.06	926.58
25	144.5	4.2	0.0656	9.33	0.80	0.79	1.24	80.30	941.16
26	150.5	4.23	0.0633	9.53	0.81	0.80	1.17	81.48	954.90
27	156.5	4.25	0.0646	9.62	0.82	0.82	1.10	82.57	967.77
28	161.5	4.36	0.0639	9.76	0.83	0.83	0.87	83.44	977.92
29	168.5	4.21	0.0657	9.65	0.82	0.83	1.20	84.64	992.03
30	174.5	4.25	0.0646	9.94	0.85	0.84	0.99	85.63	1003.58
31	180.5	4.08	0.064	10.24	0.87	0.86	0.83	86.46	1013.36
32	186.5	4.1	0.062	10.1	0.86	0.87	0.79	87.26	1022.66
33	192.5	4.27	0.0611	10.23	0.87	0.87	0.80	88.05	1031.99
34	198.5	4.33	0.0618	10.41	0.89	0.88	0.72	88.77	1040.39
35	204.5	4.49	0.0611	10.44	0.89	0.89	0.66	89.43	1048.16
36	210.5	4.53	0.0609	10.47	0.89	0.89	0.65	90.08	1055.75


First Service 3
pH
6
4
2
0
0
50
100
150
200
250
Bed Volume


First Service 3
Conductivity (mS./cm.)
0.15
0.1
0.05
0
0
50
100
150
200
250
Bed Volume

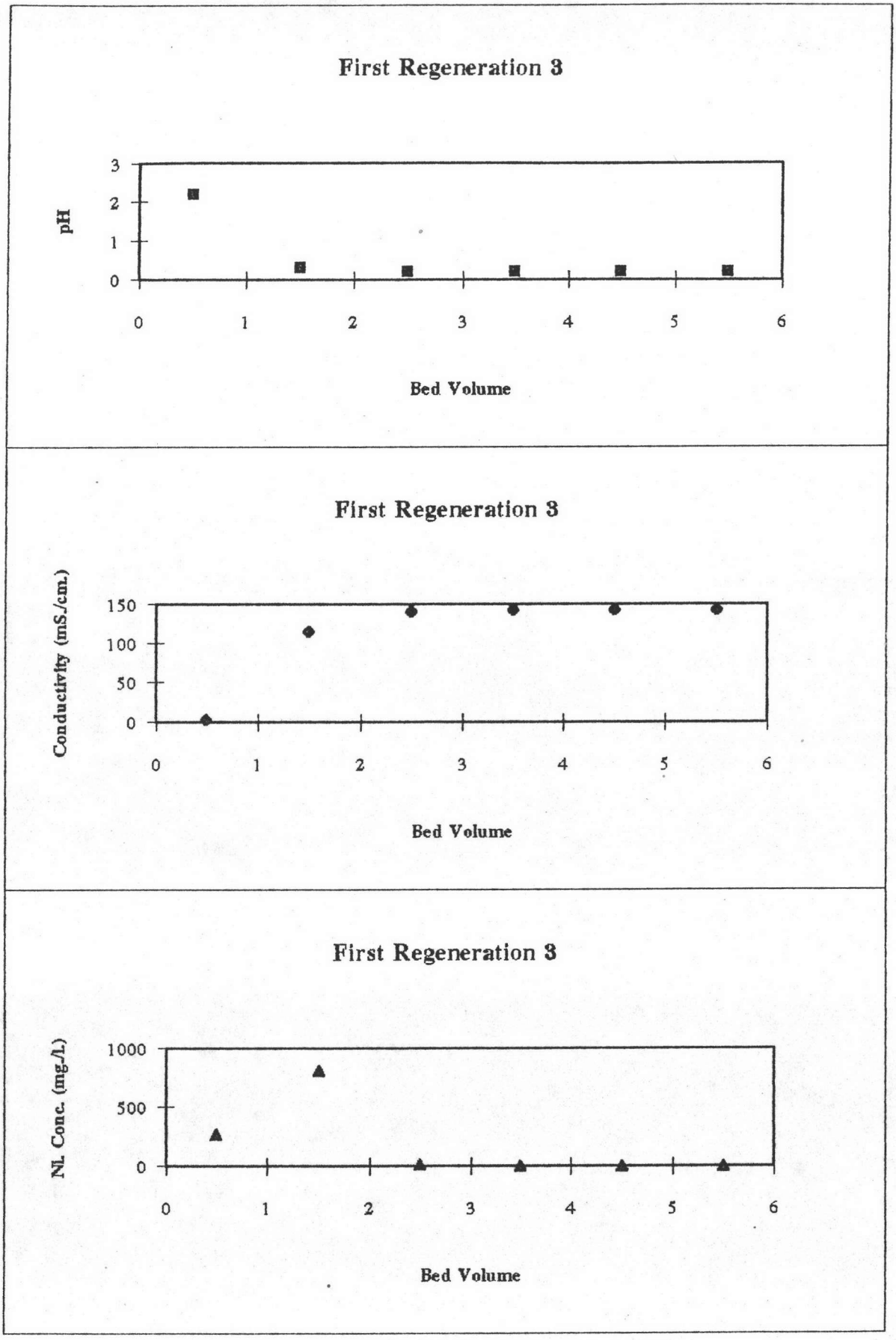

First Service 3
NL Conc. (mg./L)
15
10
5
0
0
50
100
150
200
250
Bed Volume

EXPERIMENT 3 First regeneration

Column Size ∅ 2"50 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	10	0.22	141.5	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	2.19	3.22	264.4	0.25	0.25	0.25	264.40	264.40	264.40
2	1.5	0.32	114.9	805.4	0.76	0.76	1.01	805.4	1069.8	534.90
3	2.5	0.21	141.2	11.06	0.01	0.01	1.02	11.1	1080.9	360.29
4	3.5	0.2	142.5	2.2	0.00	0.00	1.03	2.2	1083.1	270.77
5	4.5	0.2	142.9	1.2	0.00	0.00	1.03	1.2	1084.3	216.85
6	5.5	0.2	142.9	0.83	0.00	0.00	1.03	0.8	1085.1	180.85

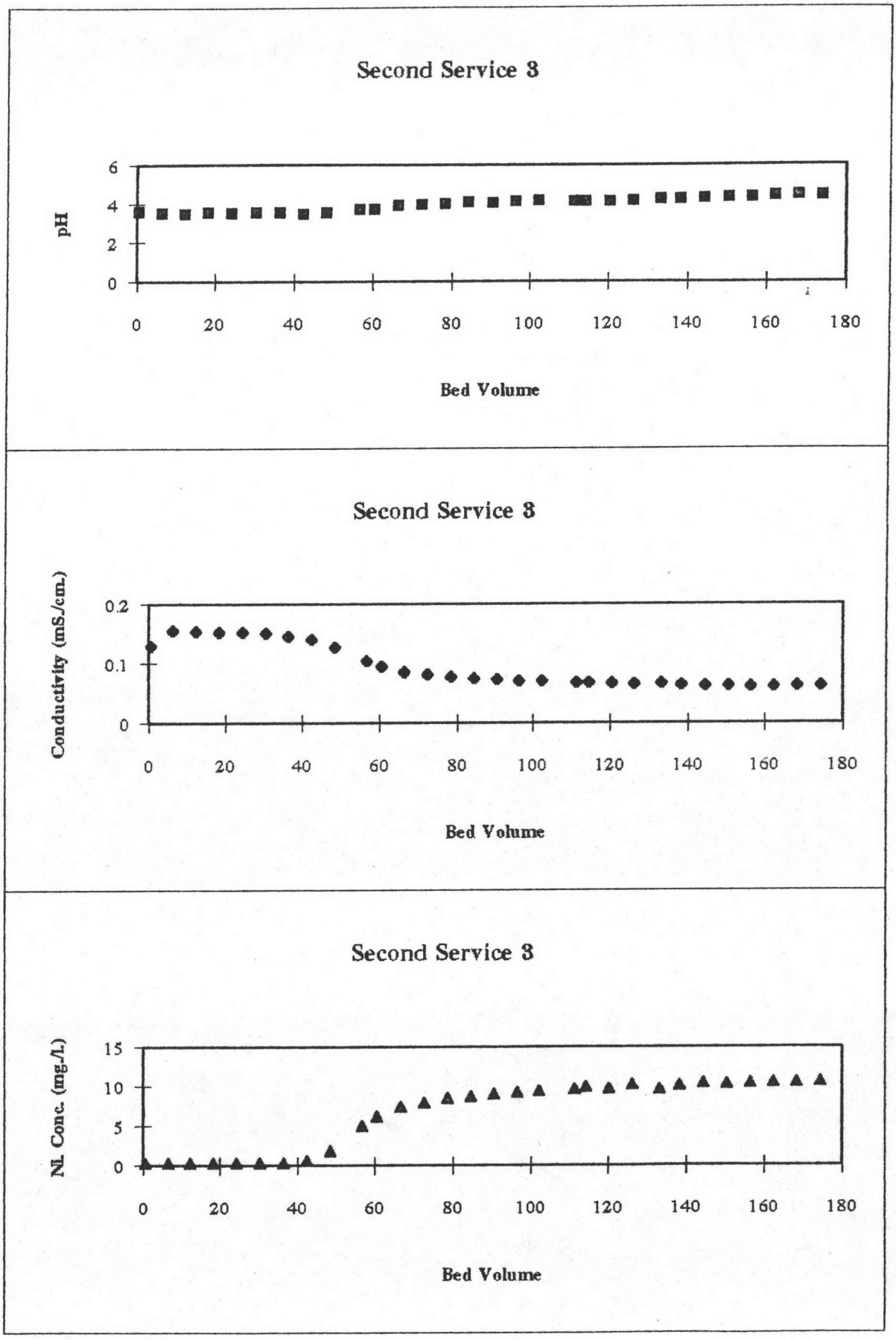

First Regeneration 3
pH
3
2
1
0
0
1
2
3
4
5
6
Bed Volume
First Regeneration 3
Conductivity (mS./cm.)
150
100
50
0
0
1
2
3
4
5
6
Bed Volume
First Regeneration 3
NL Conc. (mg/L)
1000
500
0
0
1
2
3
4
5
6
Bed Volume

EXPERIMENT 3 Second Service

Column Size ∅ 2*50 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni.in.conc. (mg./l.)
synthetic	3	5.02	0.0529	11.87

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni.eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	0.5	3.59	0.1299	0.31	0.03	0.01	0.49	0.49	5.86
2	6.5	3.48	0.1553	0.27	0.02	0.02	5.85	6.35	75.34
3	12.5	3.47	0.1542	0.27	0.02	0.02	5.86	12.21	144.94
4	18.5	3.52	0.153	0.29	0.02	0.02	5.86	18.07	214.48
5	24.5	3.48	0.1528	0.28	0.02	0.02	5.86	23.92	283.99
6	30.5	3.54	0.1514	0.32	0.03	0.03	5.85	29.77	353.41
7	36.5	3.54	0.146	0.29	0.02	0.03	5.85	35.62	422.80
8	42.5	3.45	0.14	0.58	0.05	0.04	5.78	41.40	491.41
9	48.5	3.52	0.1276	1.85	0.16	0.10	5.39	46.78	555.34
10	56.75	3.7	0.104	4.97	0.42	0.29	5.88	52.66	625.13
11	60.5	3.7	0.0941	6.18	0.52	0.47	1.99	54.65	648.74
12	66.5	3.89	0.085	7.43	0.63	0.57	2.56	57.21	679.13
13	72.5	3.94	0.0807	7.94	0.67	0.65	2.12	59.33	704.24
14	78.5	3.96	0.0772	8.48	0.71	0.69	1.85	61.18	726.20
15	84.5	4.05	0.0747	8.71	0.73	0.72	1.66	62.83	745.85
16	90.5	4.04	0.0728	9	0.76	0.75	1.52	64.36	763.94
17	96.5	4.13	0.0706	9.27	0.78	0.77	1.38	65.74	780.35
18	102.5	4.17	0.0696	9.43	0.79	0.79	1.27	67.02	795.47
19	111.5	4.12	0.0677	9.67	0.81	0.80	1.76	68.77	816.35
20	114.5	4.12	0.0672	9.92	0.84	0.83	0.52	69.30	822.57
21	120.5	4.13	0.0663	9.7	0.82	0.83	1.04	70.34	834.93
22	126.5	4.17	0.0653	10.21	0.86	0.84	0.97	71.31	846.42
23	133.5	4.23	0.0657	9.63	0.81	0.84	1.15	72.46	860.07
24	138.5	4.24	0.0632	10.14	0.85	0.83	0.84	73.29	870.00
25	144.5	4.26	0.0624	10.4	0.88	0.87	0.81	74.10	879.60
26	150.5	4.31	0.0618	10.37	0.87	0.87	0.75	74.85	888.51
27	156.5	4.33	0.0608	10.4	0.88	0.87	0.75	75.60	897.42
28	162.5	4.38	0.0613	10.52	0.89	0.88	0.71	76.32	905.88
29	168.5	4.43	0.0617	10.52	0.89	0.89	0.68	77.00	913.98
30	174.5	4.4	0.0619	10.68	0.90	0.89	0.64	77.64	921.60

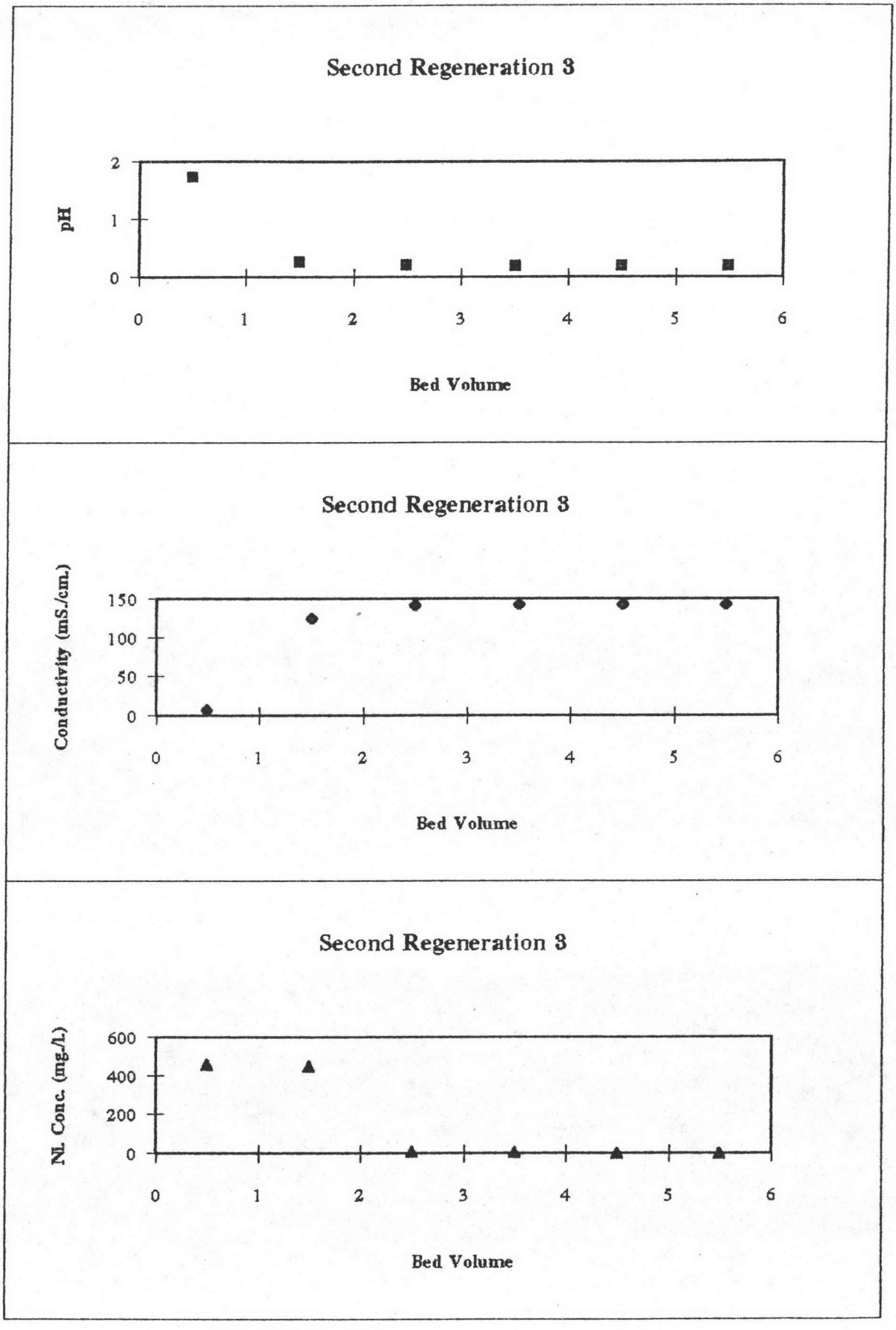

Second Service 3
pH
6
4
2
0
0
20
40
60
80
100
120
140
160
180
Bed Volume
Second Service 3
Conductivity (mS./cm.)
0.2
0.1
0
0
20
40
60
80
100
120
140
160
180
Bed Volume
Second Service 3
NL Conc. (mg./L)
15
10
5
0
0
20
40
60
80
100
120
140
160
180
Bed Volume

EXPERIMENT 3 Second regeneration

Column Size ∅ 2*50 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	10	0.21	141.6	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	1.72	7.31	456.65	0.50	0.50	0.50	456.65	456.65	456.65
2	1.5	0.26	124.8	446.65	0.48	0.48	0.98	446.7	903.3	451.65
3	2.5	0.2	141.5	9.09	0.01	0.01	0.99	9.1	912.4	304.13
4	3.5	0.19	142.5	3.27	0.00	0.00	0.99	3.3	915.7	228.92
5	4.5	0.19	142.7	1.64	0.00	0.00	1.00	1.6	917.3	183.46
6	5.5	0.19	142.5	1.18	0.00	0.00	1.00	1.2	918.5	153.08

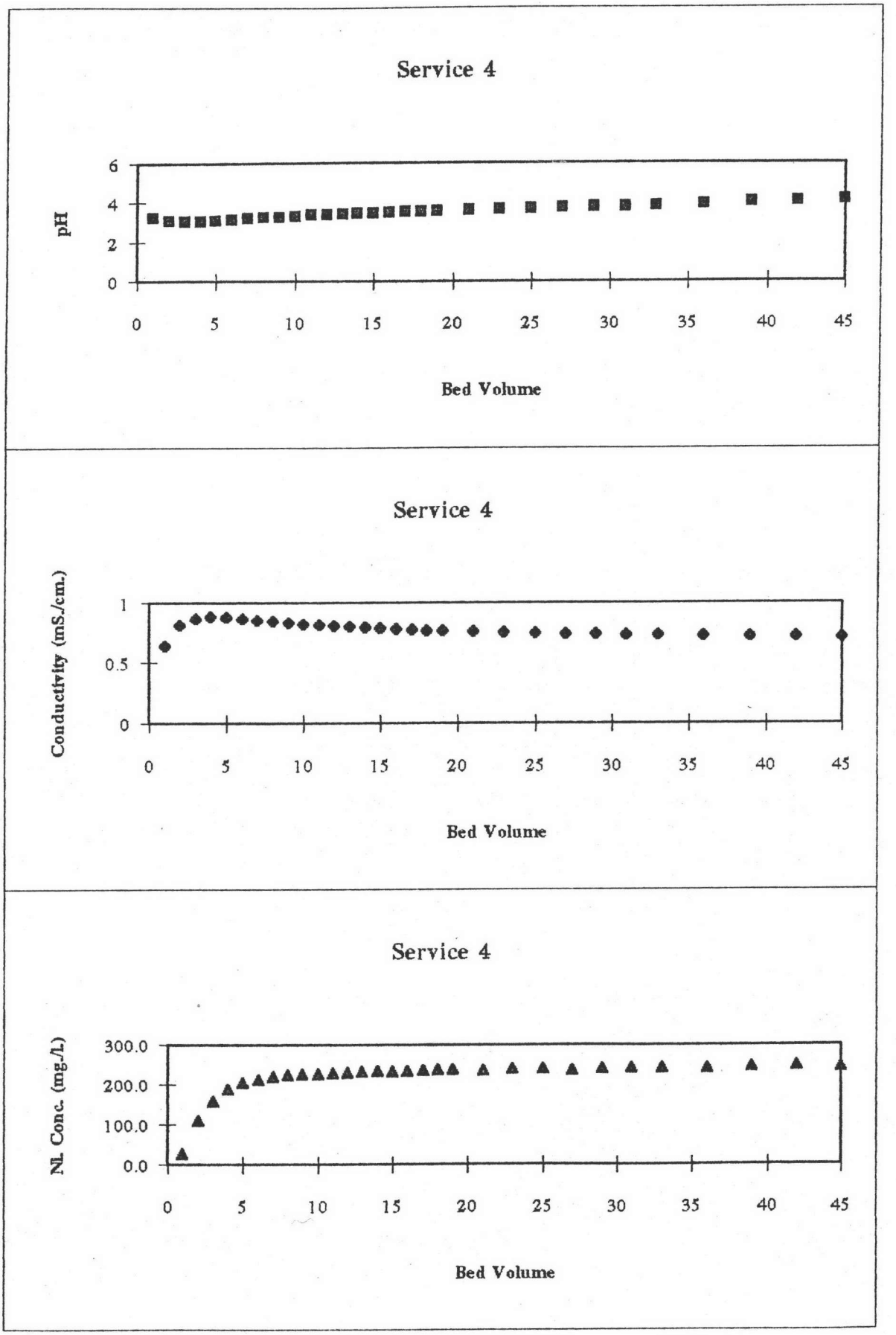

Second Regeneration 3
pH
2
1
0
0
1
2
3
4
5
6
Bed Volume
Second Regeneration 3
Conductivity (mS./cm.)
150
100
50
0
0
1
2
3
4
5
6
Bed Volume
Second Regeneration 3
Ni. Conc. (mg./L)
600
400
200
0
0
1
2
3
4
5
6
Bed Volume

EXPERIMENT 4 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	3	6.55	0.687	250.7

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	3.24	0.638	27.1	0.11	0.05	0.95	0.95	237.20
2	2	3.07	0.815	109.2	0.44	0.27	0.73	1.67	419.79
3	3	3.05	0.87	157.5	0.63	0.53	0.47	2.14	537.18
4	4	3.06	0.887	187.3	0.75	0.69	0.31	2.45	615.51
5	5	3.1	0.881	203.4	0.81	0.78	0.22	2.68	670.90
6	6	3.14	0.869	211.2	0.84	0.83	0.17	2.85	714.37
7	7	3.2	0.856	219.6	0.88	0.86	0.14	2.99	749.75
8	8	3.23	0.844	223.8	0.89	0.88	0.12	3.11	778.84
9	9	3.26	0.833	225.9	0.90	0.90	0.10	3.21	804.77
10	10	3.3	0.823	225.1	0.90	0.90	0.10	3.31	830.03
11	11	3.35	0.814	227.9	0.91	0.90	0.10	3.41	854.28
12	12	3.36	0.805	229.3	0.91	0.91	0.09	3.50	876.44
13	13	3.39	0.799	231.3	0.92	0.92	0.08	3.58	896.86
14	14	3.43	0.791	233.6	0.93	0.93	0.07	3.65	915.13
15	15	3.46	0.785	231.9	0.93	0.93	0.07	3.72	933.08
16	16	3.49	0.78	233.7	0.93	0.93	0.07	3.79	950.99
17	17	3.51	0.775	236.4	0.94	0.94	0.06	3.86	966.68
18	18	3.53	0.77	237.3	0.95	0.94	0.06	3.91	980.60
19	19	3.55	0.765	237.8	0.95	0.95	0.05	3.96	993.77
20	21	3.6	0.758	236.5	0.94	0.95	0.11	4.07	1020.97
21	23	3.63	0.755	239.6	0.96	0.95	0.10	4.17	1046.38
22	25	3.69	0.747	240.5	0.96	0.96	0.09	4.26	1067.80
23	27	3.73	0.742	236.8	0.94	0.95	0.10	4.36	1092.05
24	29	3.77	0.738	240.2	0.96	0.95	0.10	4.45	1116.52
25	31	3.78	0.736	242.6	0.97	0.96	0.07	4.53	1135.21
26	33	3.83	0.731	241.3	0.96	0.96	0.07	4.60	1152.85
27	36	3.9	0.726	242.0	0.97	0.96	0.11	4.71	1180.10
28	39	4	0.721	245.5	0.98	0.97	0.08	4.79	1201.04
29	42	4.07	0.717	247.4	0.99	0.98	0.05	4.84	1213.96
30	45	4.12	0.714	244.4	0.97	0.98	0.06	4.90	1228.45

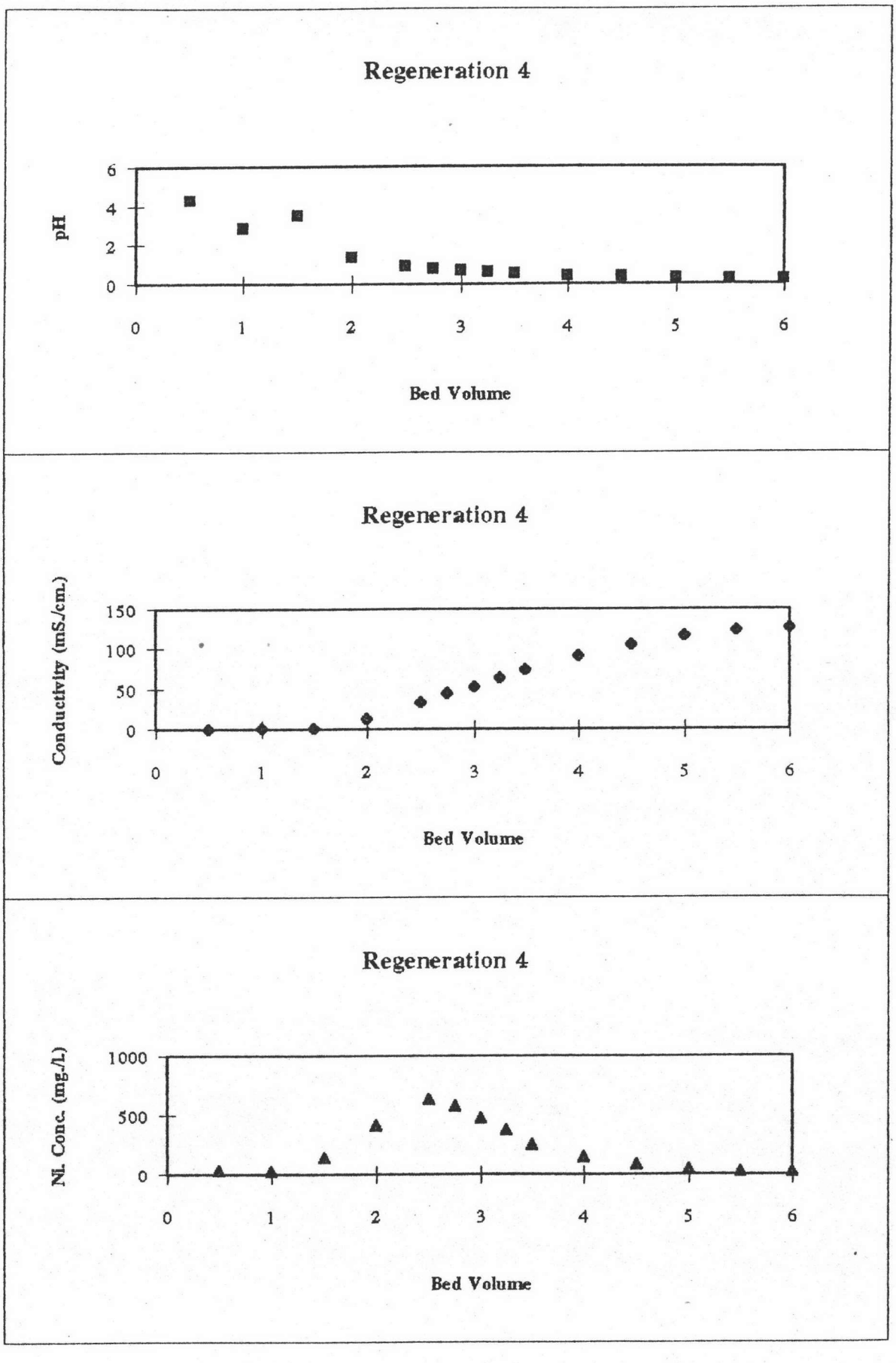

Service 4
pH
6
4
2
0
0
5
10
15
20
25
30
35
40
45
Bed Volume
Service 4
Conductivity (mS./cm.)
1
0.5
0
0
5
10
15
20
25
30
35
40
45
Bed Volume
Service 4
NL Conc. (mg./L)
300.0
200.0
100.0
0.0
0
5
10
15
20
25
30
35
40
45
Bed Volume

EXPERIMENT 4 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV /Hr.)	pH	Conductivity (mS /cm)	Conc (Normal)
HCl	3	0.2	138	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS /cm)	Ni reg. Conc (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	4.29	0.109	33.5	0.01	0.01	0.01	8.38	8.38	16.75
2	1	2.82	0.73	29.5	0.01	0.01	0.02	15.8	24.1	24.13
3	1.5	3.51	0.704	141.3	0.06	0.03	0.05	42.7	66.8	44.55
4	2	1.37	13.39	412	0.17	0.11	0.17	138.3	205.2	102.58
5	2.5	0.92	33.2	631	0.26	0.21	0.38	260.8	465.9	186.36
6	2.75	0.78	44.2	576	0.12	0.19	0.57	150.9	616.8	224.28
7	3	0.69	53.1	479.1	0.10	0.11	0.67	131.9	748.7	249.55
8	3.25	0.6	63.8	372.9	0.08	0.09	0.76	106.5	855.2	263.13
9	3.5	0.52	73.9	249.2	0.05	0.06	0.82	77.8	932.9	266.55
10	4	0.42	91.2	153	0.06	0.06	0.88	100.6	1033.5	258.37
11	4.5	0.35	105.4	88.8	0.04	0.05	0.93	60.5	1093.9	243.09
12	5	0.29	116.9	48.3	0.02	0.03	0.96	34.3	1128.2	225.64
13	5.5	0.26	123.7	30.2	0.01	0.02	0.97	19.6	1147.8	208.70
14	6	0.24	127.1	25.9	0.01	0.01	0.98	14.0	1161.9	193.64

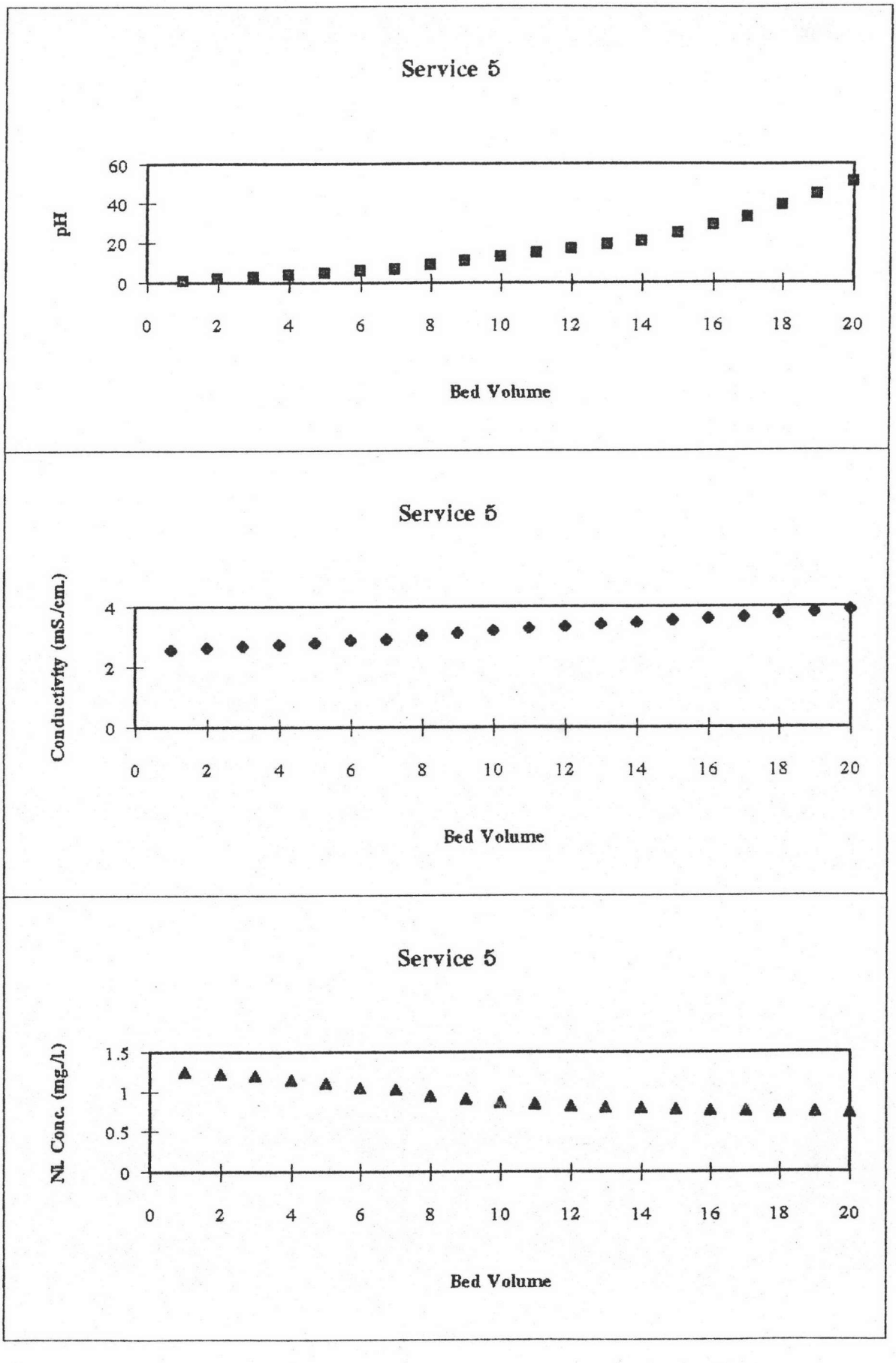

Regeneration 4
pH
6
4
2
0
0
1
2
3
4
5
6
Bed Volume
Regeneration 4
Conductivity (mS./cm.)
150
100
50
0
0
1
2
3
4
5
6
Bed Volume
Regeneration 4
Ni. Conc. (mg./L)
1000
500
0
0
1
2
3
4
5
6
Bed Volume

EXPERIMENT 5 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	Flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	6	6.5	0.707	249.9

Effluent NO.		pH	Conductivity	Ni eff Conc	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging
			(mS./cm.)	(mg./l.)	Value	Average	Value	Cumulation	(mg./l resin)
1	1	2.54	1.253	129.4	0.52	0.26	0.74	0.74	185.22
2	2	2.64	1.215	165.6	0.66	0.59	0.41	1.15	287.65
3	3	2.69	1.195	186.8	0.75	0.71	0.29	1.45	361.36
4	4	2.74	1.146	199.1	0.80	0.77	0.23	1.67	418.32
5	5	2.8	1.108	208.6	0.83	0.82	0.18	1.86	464.36
6	6	2.87	1.044	214.6	0.86	0.85	0.15	2.01	502.64
7	7	2.89	1.03	215.4	0.86	0.86	0.14	2.15	537.55
8	9	3.03	0.946	223.2	0.89	0.88	0.24	2.40	598.76
9	11	3.12	0.904	227.5	0.91	0.90	0.20	2.59	647.80
10	13	3.2	0.869	231.0	0.92	0.92	0.17	2.76	689.06
11	15	3.27	0.842	233.2	0.93	0.93	0.14	2.90	724.66
12	17	3.34	0.819	234.5	0.94	0.94	0.13	3.03	756.79
13	19	3.40	0.806	238.5	0.95	0.95	0.11	3.14	783.67
14	21	3.45	0.793	237.5	0.95	0.95	0.10	3.23	807.50
15	25	3.54	0.776	239.6	0.96	0.95	0.18	3.41	852.86
16	29	3.61	0.764	240.9	0.96	0.96	0.15	3.57	891.50
17	33	3.66	0.756	243.1	0.97	0.97	0.13	3.69	923.21
18	39	3.75	0.749	244.2	0.98	0.98	0.15	3.84	960.70
19	45	3.81	0.742	241.2	0.97	0.97	0.17	4.02	1003.85
20	51	3.89	0.734	244.2	0.98	0.97	0.17	4.19	1047.01

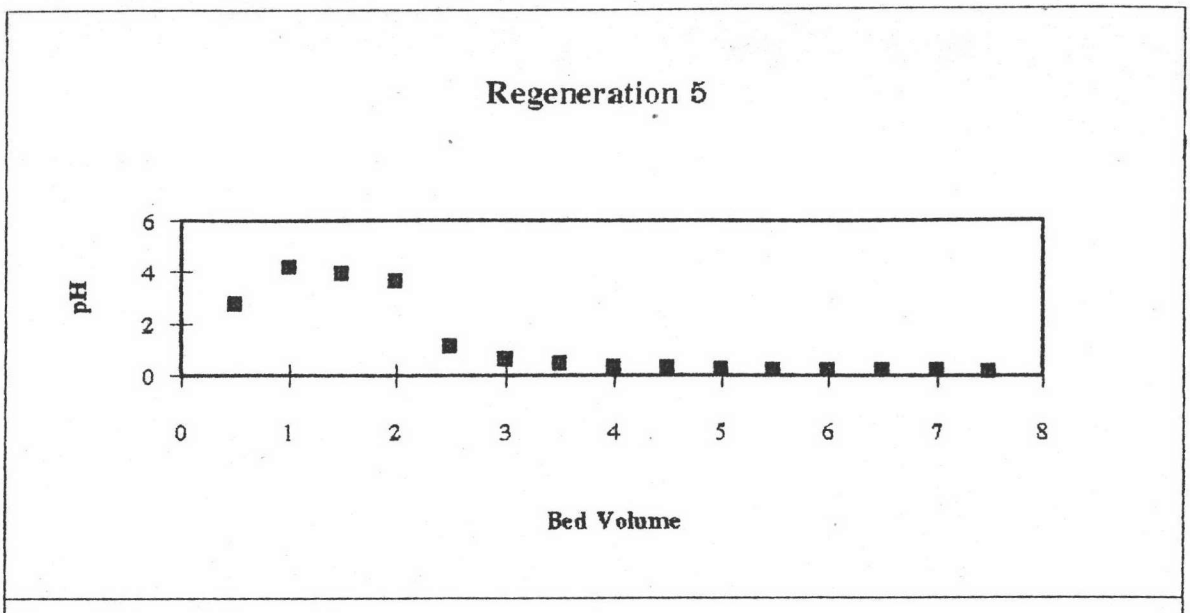

Service 5
pH
60
40
20
0
0 2 4 6 8 10 12 14 16 18 20
Bed Volume
Service 5
Conductivity (mS./cm.)
4
2
0
0 2 4 6 8 10 12 14 16 18 20
Bed Volume
Service 5
NL Conc. (mg/L)
1.5
1
0.5
0
0 2 4 6 8 10 12 14 16 18 20
Bed Volume

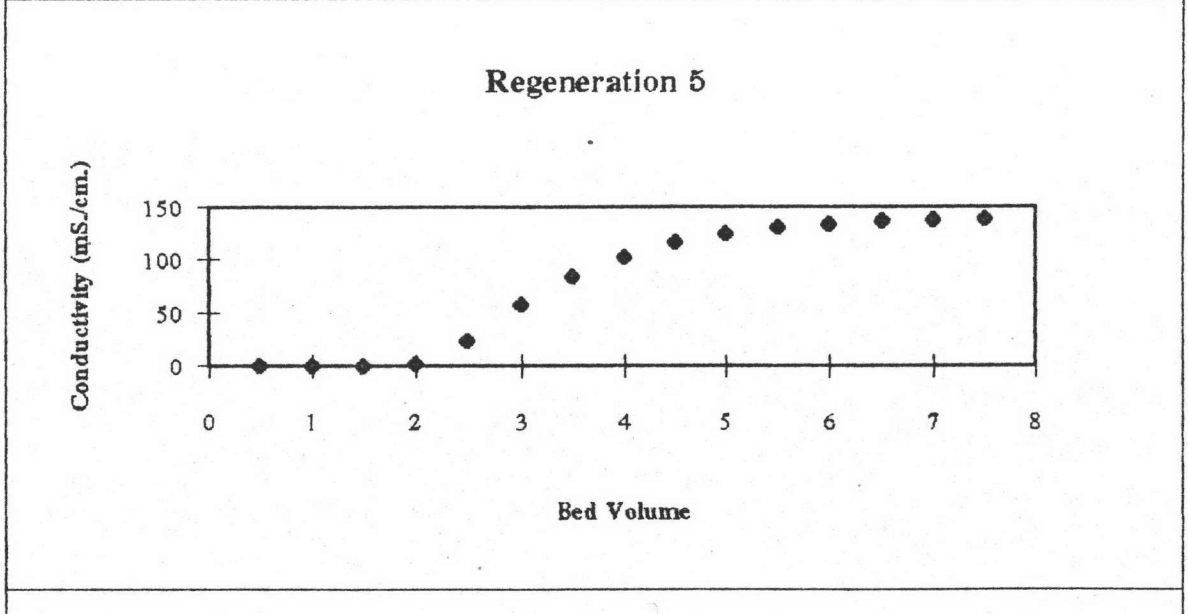
EXPERIMENT 5 Regeneration

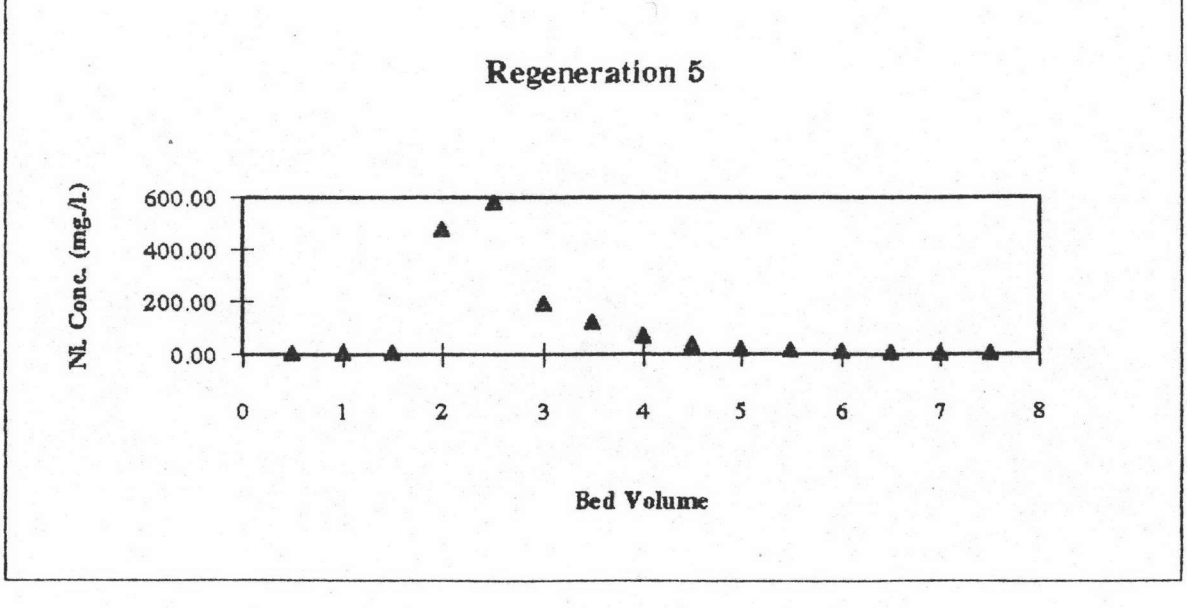
Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	3	0.19	139.4	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	2.79	0.482	2.56	0.00	0.00	0.00	0.64	0.64	1.28
2	1	4.19	0.0318	2.33	0.00	0.00	0.00	1.2	1.9	1.86
3	1.5	3.95	0.0679	7.67	0.00	0.00	0.00	2.5	4.4	2.91
4	2	3.63	1.705	478.5	0.23	0.12	0.12	121.5	125.9	62.95
5	2.5	1.1	23.4	580.7	0.28	0.25	0.37	264.8	390.7	156.27
6	3	0.64	58.1	191.1	0.09	0.18	0.56	192.9	583.6	194.54
7	3.5	0.45	84.2	124.2	0.06	0.08	0.63	78.8	662.5	189.27
8	4	0.35	102.7	70.8	0.03	0.05	0.68	48.7	711.2	177.80
9	4.5	0.28	116.3	36.3	0.02	0.03	0.70	26.8	738.0	163.99
10	5	0.24	124.9	21.9	0.01	0.01	0.72	14.6	752.5	150.51
11	5.5	0.22	130.7	15.44	0.01	0.01	0.73	9.3	761.9	138.52
12	6	0.2	134	11.87	0.01	0.01	0.73	6.8	768.7	128.12
13	6.5	0.19	136.5	8.35	0.00	0.00	0.74	5.1	773.8	119.04
14	7	0.19	138	5.74	0.00	0.00	0.74	3.5	777.3	111.04
15	7.5	0.18	139.1	4.21	0.00	0.00	0.74	2.5	779.8	103.97


Regeneration 5
pH
6
4
2
0
0
1
2
3
4
5
6
7
8
Bed Volume


Regeneration 5
Conductivity (mS./cm.)
150
100
50
0
0
1
2
3
4
5
6
7
8
Bed Volume

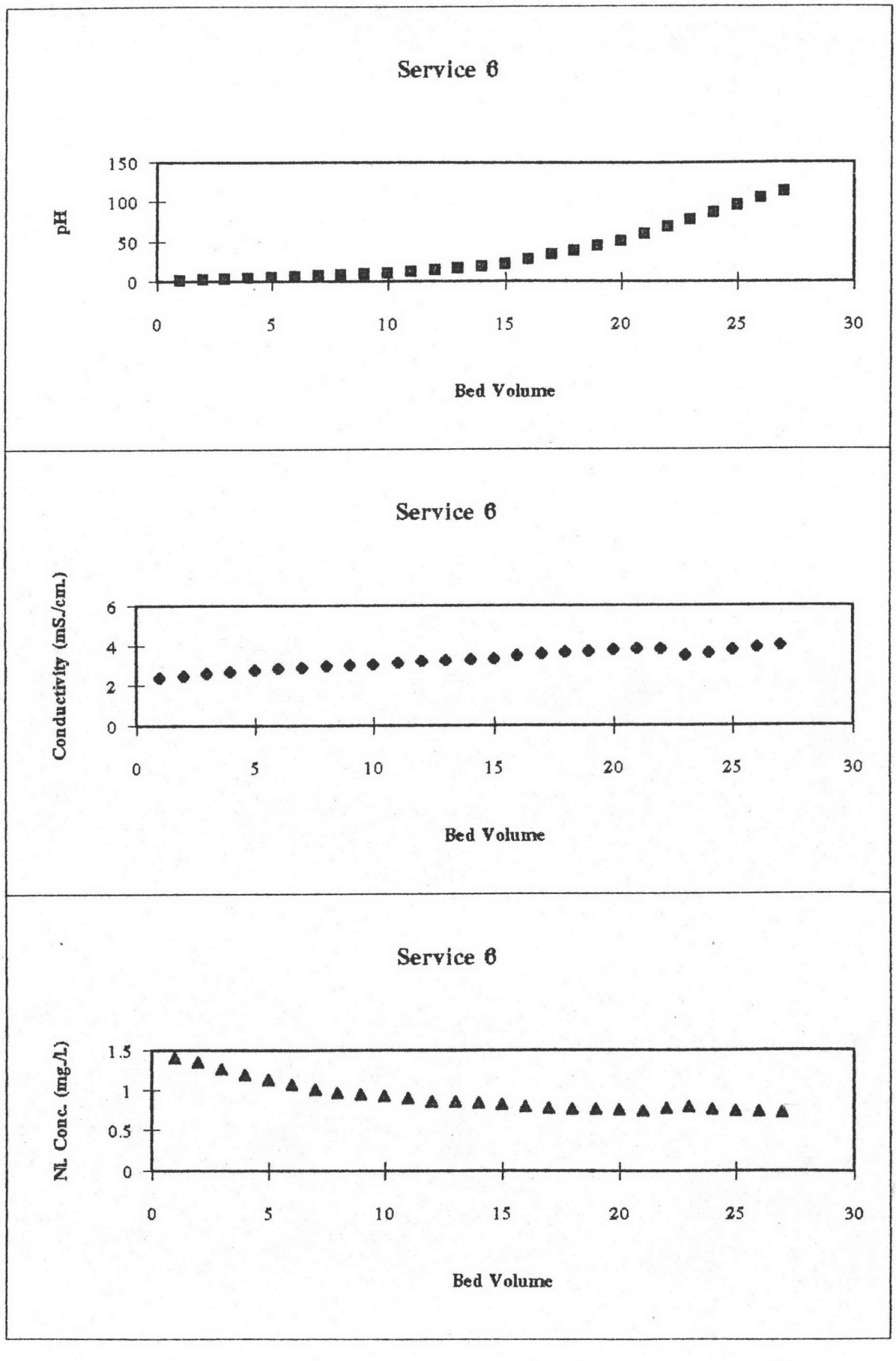

Regeneration 5
NL Conc. (mg./L)
600.00
400.00
200.00
0.00
0
1
2
3
4
5
6
7
8
Bed Volume

EXPERIMENT 6 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	9	6.52	0.689	252.4

Effluent NO.	Bed Volume	pH	Conductivity	Ni eff. Conc.	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging
			(mS./cm.)	(mg./l.)	Value	Average	Value	Cumulation	(mg./l resin)
1	1	2.42	1.399	95.7	0.38	0.19	0.81	0.81	204.58
2	2	2.51	1.351	153.9	0.61	0.49	0.51	1.32	332.24
3	3	2.61	1.261	183.8	0.73	0.67	0.33	1.65	415.80
4	4	2.69	1.19	205.3	0.81	0.77	0.23	1.88	473.64
5	5	2.76	1.124	218.1	0.86	0.84	0.16	2.04	514.35
6	6	2.84	1.063	221.8	0.88	0.87	0.13	2.17	546.82
7	7	2.91	1.01	224.0	0.89	0.88	0.12	2.28	576.36
8	8	2.97	0.97	225.2	0.89	0.89	0.11	2.39	604.18
9	9	3.02	0.944	231.8	0.92	0.91	0.09	2.49	628.09
10	10	3.06	0.926	232.5	0.92	0.92	0.08	2.57	648.37
11	12	3.14	0.895	236.9	0.94	0.93	0.14	2.71	683.78
12	14	3.22	0.859	238.9	0.95	0.94	0.11	2.82	712.78
13	16	3.26	0.851	242.9	0.96	0.95	0.09	2.92	735.79
14	18	3.29	0.842	242.8	0.96	0.96	0.08	2.99	754.94
15	21	3.35	0.825	241.2	0.96	0.96	0.12	3.11	786.24
16	27	3.5	0.791	242.0	0.96	0.96	0.26	3.37	851.08
17	33	3.59	0.775	240.5	0.95	0.96	0.26	3.64	917.85
18	39	3.67	0.763	244.1	0.97	0.96	0.24	3.88	978.52
19	45	3.69	0.764	246.1	0.97	0.97	0.17	4.05	1022.49
20	51	3.78	0.752	247.1	0.98	0.98	0.14	4.19	1057.48
21	60	3.84	0.743	247.5	0.98	0.98	0.18	4.37	1103.71
22	69	3.82	0.771	251.7	1.00	0.99	0.10	4.47	1129.22
23	78	3.49	0.796	240.1	0.95	0.97	0.23	4.71	1187.97
24	87	3.64	0.764	242.0	0.96	0.96	0.40	5.11	1290.05
25	96	3.8	0.744	243.0	0.96	0.96	0.35	5.46	1379.12
26	105	3.91	0.733	243.4	0.96	0.96	0.33	5.79	1461.94
27	114	4.02	0.724	245.9	0.97	0.97	0.28	6.07	1531.76

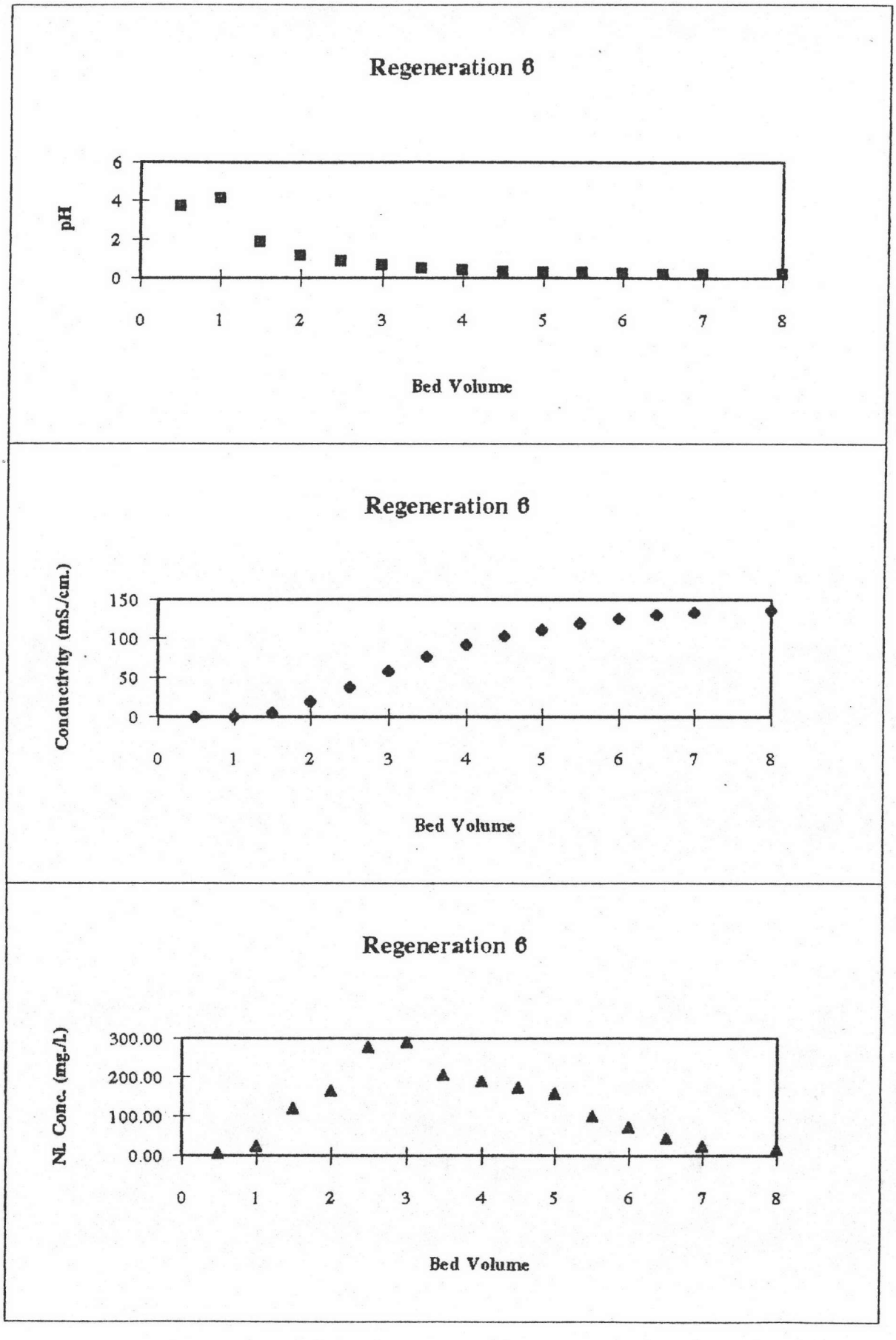

Service 6
pH
150
100
50
0
0
5
10
15
20
25
30
Bed Volume
Service 6
Conductivity (mS./cm.)
6
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 6
NL Conc. (mg./L)
1.5
1
0.5
0
0
5
10
15
20
25
30
Bed Volume

EXPERIMENT 6 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	3	0.2	139.2	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.72	0.0681	5.78	0.00	0.00	0.00	1.44	1.44	2.89
2	1	4.12	0.1099	23.8	0.01	0.00	0.01	7.4	8.8	8.83
3	1.5	1.85	4.64	119.8	0.04	0.02	0.03	35.9	44.7	29.82
4	2	1.17	19.45	166.0	0.05	0.05	0.08	71.4	116.2	58.09
5	2.5	0.86	37.7	278.2	0.09	0.07	0.15	111.0	227.2	90.89
6	3	0.65	57.8	288.9	0.09	0.09	0.24	141.8	369.0	123.00
7	3.5	0.51	76.6	206.8	0.07	0.08	0.32	123.9	492.9	140.83
8	4	0.41	91.5	190.1	0.06	0.06	0.39	99.2	592.2	148.04
9	4.5	0.35	103.2	173.9	0.06	0.06	0.45	91.0	683.2	151.82
10	5	0.31	111.6	156.9	0.05	0.05	0.50	82.7	765.9	153.17
11	5.5	0.28	119.3	99.1	0.03	0.04	0.54	64.0	829.8	150.88
12	6	0.24	125.7	74.3	0.02	0.03	0.57	43.3	873.2	145.53
13	6.5	0.22	130.4	45.5	0.01	0.02	0.59	29.9	903.1	138.94
14	7	0.21	133.5	24.5	0.01	0.01	0.60	17.5	920.6	131.51
15	8	0.2	136.4	16.48	0.01	0.01	0.61	20.5	941.1	117.64


Regeneration 6
pH
6
4
2
0
0 1 2 3 4 5 6 7 8
Bed Volume
Regeneration 6
Conductivity (mS./cm.)
150
100
50
0
0 1 2 3 4 5 6 7 8
Bed Volume
Regeneration 6
NL Conc. (mg./L)
300.00
200.00
100.00
0.00
0 1 2 3 4 5 6 7 8
Bed Volume

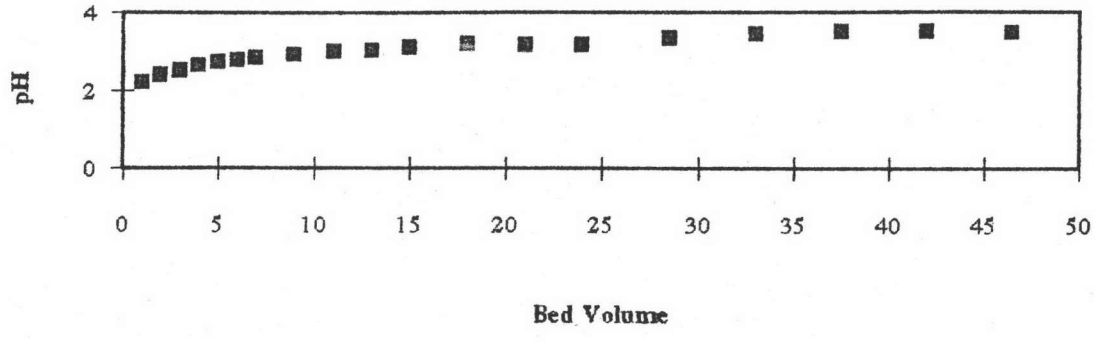
EXPERIMENT 7 Service

Column Size ∅ 6.75*100 cm.

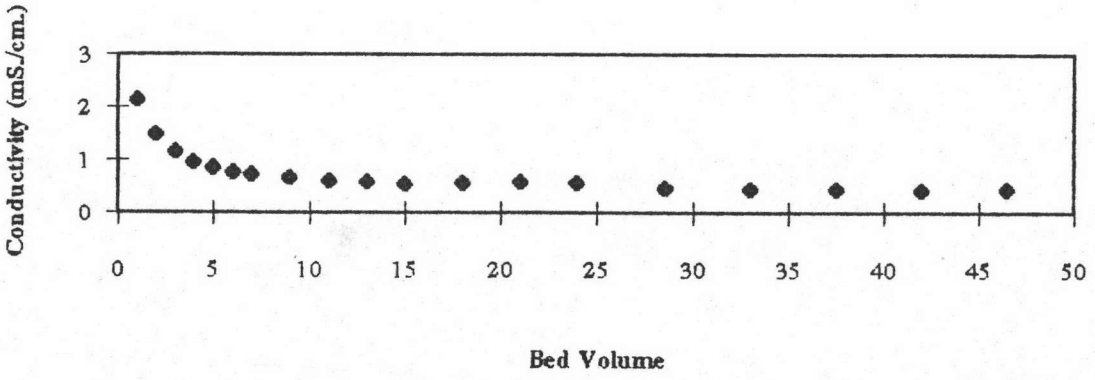
Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	3	5.9	0.325	99.9

Effluent NO.	Bed Volume	pH	Conductivity	Ni eff. Conc.	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging
			(mS./cm.)	(mg./l.)	Value	Average	Value	Cumulation	(mg./l.resin)
1	1	2.2	2.15	39.8	0.40	0.20	0.80	0.80	79.97
2	2	2.39	1.488	50.3	0.50	0.45	0.55	1.35	134.79
3	3	2.52	1.17	56.8	0.57	0.54	0.46	1.81	181.12
4	4	2.64	0.957	60.5	0.61	0.59	0.41	2.23	222.32
5	5	2.72	0.849	65.0	0.65	0.63	0.37	2.60	259.44
6	6	2.79	0.778	68.7	0.69	0.67	0.33	2.93	292.45
7	7	2.84	0.733	69.7	0.70	0.69	0.31	3.24	323.11
8	9	2.92	0.672	76.5	0.77	0.73	0.54	3.77	376.69
9	11	3.01	0.613	78.7	0.79	0.78	0.45	4.22	421.28
10	13	3.04	0.597	82.5	0.83	0.81	0.39	4.60	459.82
11	15	3.11	0.557	81.8	0.82	0.82	0.35	4.96	495.24
12	18	3.2	0.564	90.2	0.90	0.86	0.42	5.38	536.89
13	21	3.18	0.598	103.9	1.04	0.97	0.09	5.46	545.44
14	24	3.17	0.569	94.3	0.94	0.99	0.02	5.48	547.71
15	28.5	3.35	0.477	93.6	0.94	0.94	0.26	5.75	574.14
16	33	3.45	0.449	95.1	0.95	0.94	0.25	6.00	598.97
17	37.5	3.49	0.44	96.7	0.97	0.96	0.18	6.18	616.79
18	42	3.5	0.437	97.0	0.97	0.97	0.13	6.31	630.21
19	46.5	3.47	0.446	97.5	0.98	0.97	0.12	6.43	642.02

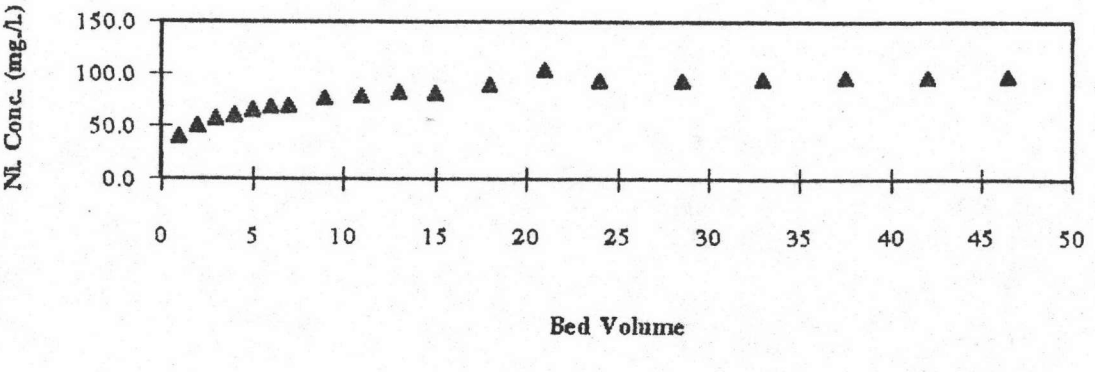
Service 7



Service 7



Service 7

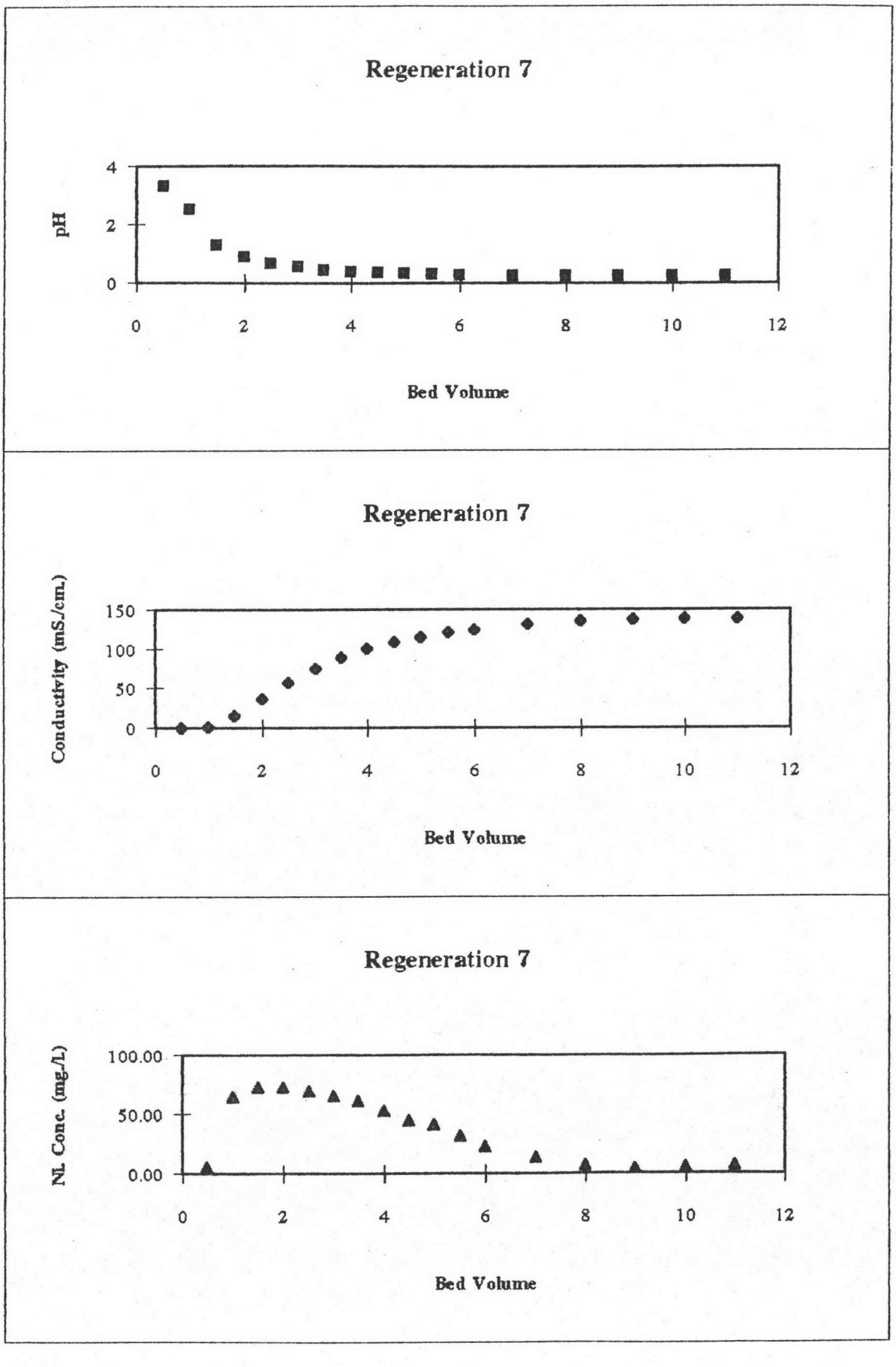


EXPERIMENT 7 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	3	0.21	139.5	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.3	0.1887	5.49	0.00	0.00	0.00	1.37	1.37	2.75
2	1	2.5	1.295	64.5	0.05	0.03	0.03	17.5	18.9	18.88
3	1.5	1.29	15.41	72.5	0.06	0.05	0.08	34.3	53.1	35.43
4	2	0.89	36.8	72.3	0.06	0.06	0.14	36.2	89.3	44.67
5	2.5	0.68	57.1	69.0	0.05	0.05	0.19	35.3	124.7	49.86
6	3	0.55	75.1	65.2	0.05	0.05	0.25	33.6	158.2	52.74
7	3.5	0.45	89.8	60.9	0.05	0.05	0.30	31.5	189.7	54.21
8	4	0.4	100.4	53.0	0.04	0.04	0.34	28.5	218.2	54.55
9	4.5	0.36	109.3	44.3	0.03	0.04	0.38	24.3	242.6	53.90
10	5	0.33	115.5	41.0	0.03	0.03	0.41	21.3	263.9	52.78
11	5.5	0.31	120.8	31.2	0.02	0.03	0.44	18.1	282.0	51.27
12	6	0.29	124.8	22.9	0.02	0.02	0.46	13.5	295.5	49.25
13	7	0.26	131.7	14.0	0.02	0.02	0.48	18.4	313.9	44.84
14	8	0.25	135.8	7.08	0.01	0.02	0.50	10.5	324.4	40.55
15	9	0.24	137.8	4.25	0.01	0.01	0.51	5.7	330.1	36.68
16	10	0.24	138.2	5.75	0.01	0.01	0.51	5.0	335.1	33.51
17	11	0.24	139	7.06	0.01	0.01	0.52	6.4	341.5	31.05

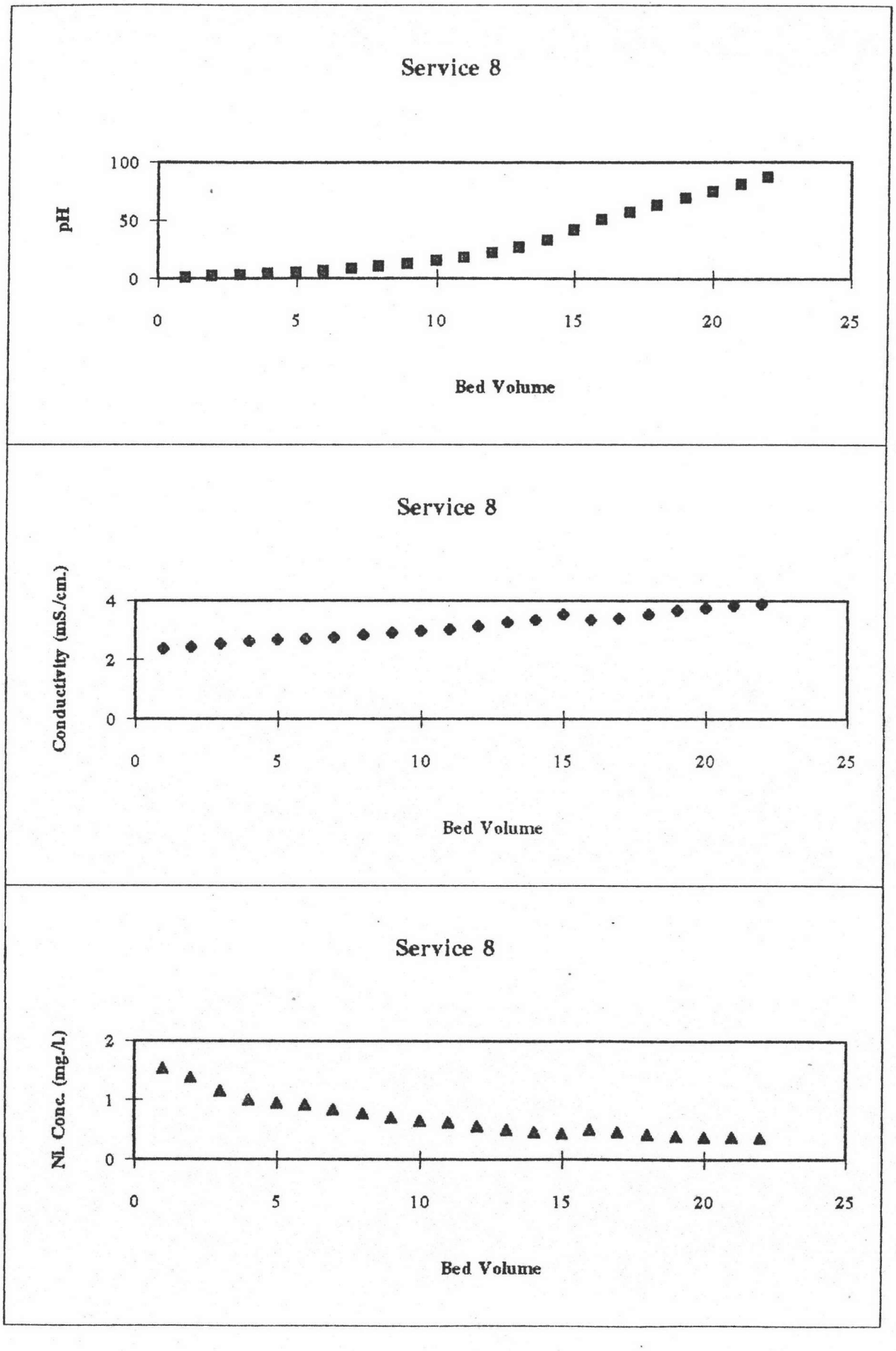

Regeneration 7
pH
4
2
0
0
2
4
6
8
10
12
Bed Volume
Regeneration 7
Conductivity (mS./cm.)
150
100
50
0
0
2
4
6
8
10
12
Bed Volume
Regeneration 7
NL Conc. (mg./L)
100.00
50.00
0.00
0
2
4
6
8
10
12
Bed Volume

EXPERIMENT 8 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	6	5.96	0.32	101.1

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2.38	1.53	42.1	0.42	0.21	0.79	0.79	80.05
2	2	2.44	1.377	53.3	0.53	0.47	0.53	1.32	133.45
3	3	2.55	1.142	60	0.59	0.56	0.44	1.76	177.90
4	4	2.63	1.001	66.5	0.66	0.63	0.37	2.13	215.75
5	5	2.67	0.942	69.1	0.68	0.67	0.33	2.46	249.05
6	6	2.7	0.913	73.5	0.73	0.71	0.29	2.76	278.85
7	8	2.77	0.832	76.7	0.76	0.74	0.51	3.27	330.85
8	10	2.83	0.77	79.9	0.79	0.77	0.45	3.72	376.45
9	12	2.91	0.705	82.9	0.82	0.81	0.39	4.11	415.85
10	15	2.98	0.647	85.3	0.84	0.83	0.50	4.62	466.85
11	18	3.03	0.617	87.1	0.86	0.85	0.44	5.06	511.55
12	22	3.14	0.553	87.8	0.87	0.86	0.54	5.60	566.15
13	27	3.26	0.494	92.1	0.91	0.89	0.55	6.15	621.90
14	33	3.36	0.461	84.3	0.83	0.87	0.77	6.92	699.30
15	42	3.53	0.429	92.9	0.92	0.88	1.11	8.03	811.80
16	51	3.34	0.503	92.5	0.91	0.92	0.75	8.78	887.40
17	57	3.40	0.462	88.8	0.88	0.90	0.62	9.40	950.10
18	63	3.55	0.419	92	0.91	0.89	0.64	10.03	1014.30
19	69	3.68	0.392	93.70	0.93	0.92	0.49	10.52	1063.80
20	75	3.75	0.382	94.20	0.93	0.93	0.42	10.95	1106.70
21	81	3.83	0.372	95.2	0.94	0.94	0.38	11.33	1145.10
22	87	3.89	0.365	83.5	0.83	0.88	0.70	12.02	1215.60

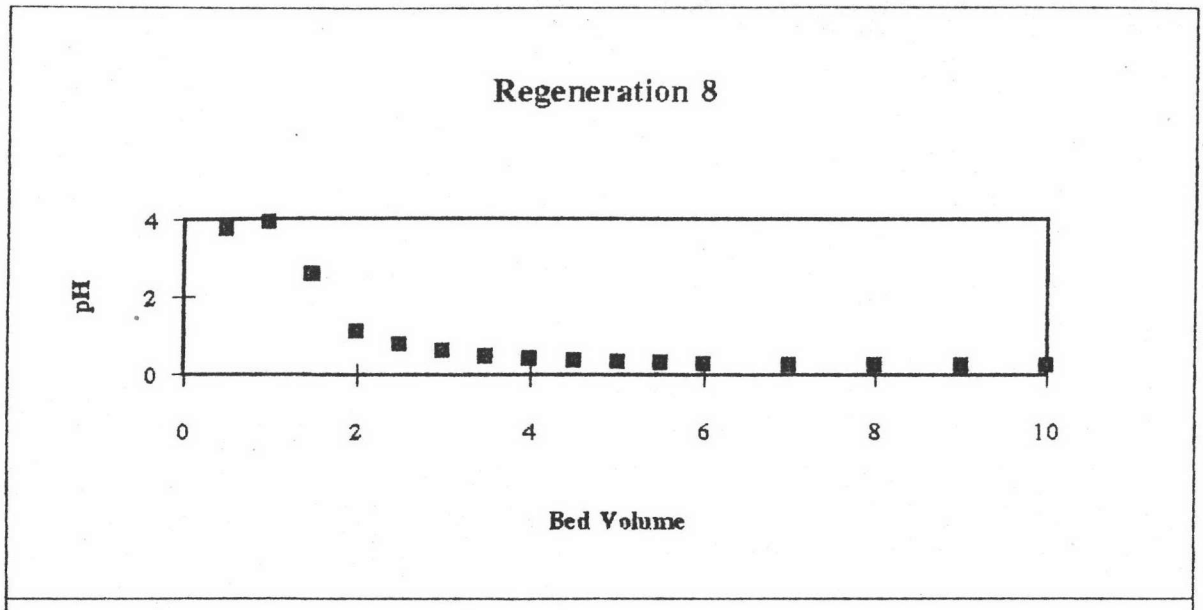

Service 8
pH
100
50
0
0
5
10
15
20
25
Bed Volume
Service 8
Conductivity (mS./cm.)
4
2
0
0
5
10
15
20
25
Bed Volume
Service 8
NL Conc. (mg./L)
2
1
0
0
5
10
15
20
25
Bed Volume

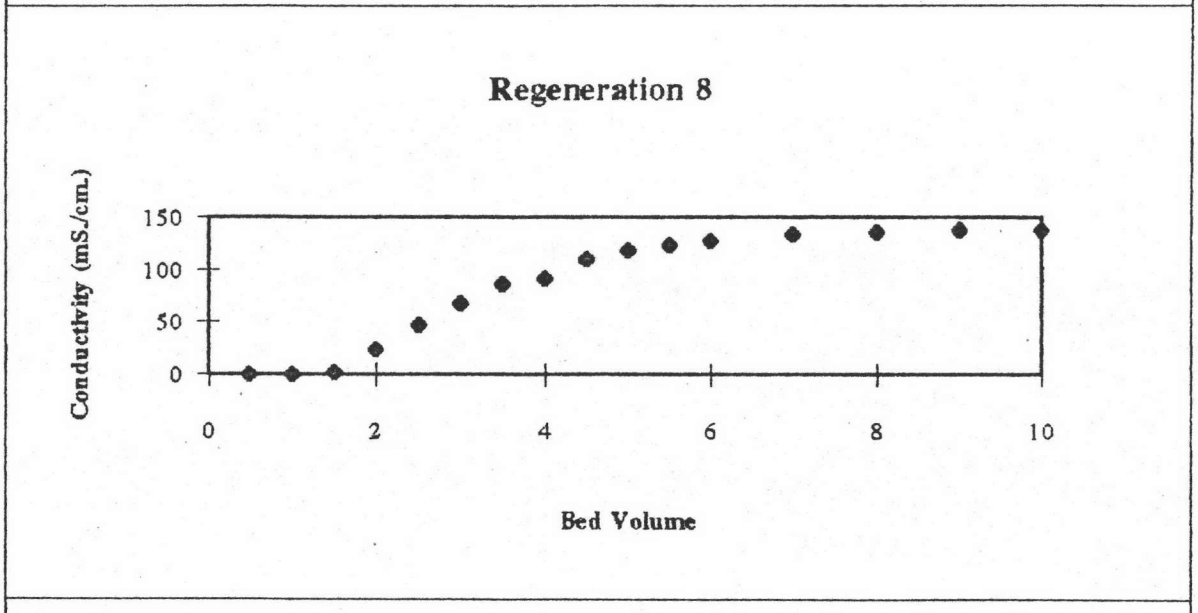
EXPERIMENT 8 Regeneration

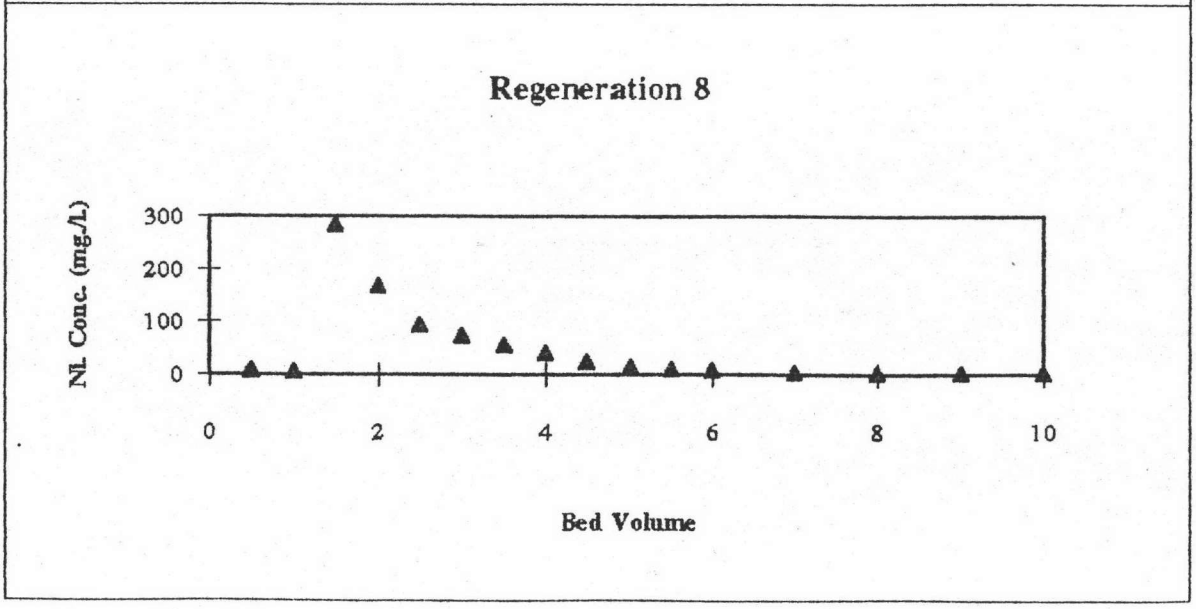
Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	3	0.24	138.2	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.76	0.0947	8.8	0.00	0.00	0.00	2.20	2.20	4.40
2	1	3.91	0.0685	5.3	0.00	0.00	0.00	3.5	5.7	5.73
3	1.5	2.56	1.987	283.5	0.12	0.06	0.06	72.2	77.9	51.95
4	2	1.11	23.3	168.5	0.07	0.09	0.16	113.0	190.9	95.46
5	2.5	0.78	46.8	94.2	0.04	0.05	0.21	65.7	256.6	102.64
6	3	0.6	68.2	74.6	0.03	0.03	0.25	42.2	298.8	99.60
7	3.5	0.48	86	55.8	0.02	0.03	0.27	32.6	331.4	94.69
8	4	0.41	91.6	41.1	0.02	0.02	0.29	24.2	355.6	88.91
9	4.5	0.36	110	25	0.01	0.01	0.31	16.5	372.2	82.70
10	5	0.32	117.9	14.8	0.01	0.01	0.31	10.0	382.1	76.42
11	5.5	0.3	123.5	9.8	0.00	0.01	0.32	6.2	388.3	70.59
12	6	0.28	127.9	7.77	0.00	0.00	0.32	4.4	392.6	65.44
13	7	0.26	133.4	4.24	0.00	0.00	0.33	6.0	398.6	56.95
14	8	0.25	136	2.57	0.00	0.00	0.33	3.4	402.1	50.26
15	9	0.25	137.6	1.72	0.00	0.00	0.33	2.1	404.2	44.91
16	10	0.24	137.9	1.14	0.00	0.00	0.33	1.4	405.6	40.56


Regeneration 8
pH
4
2
0
0
2
4
6
8
10
Bed Volume


Regeneration 8
Conductivity (mS./cm.)
150
100
50
0
0
2
4
6
8
10
Bed Volume

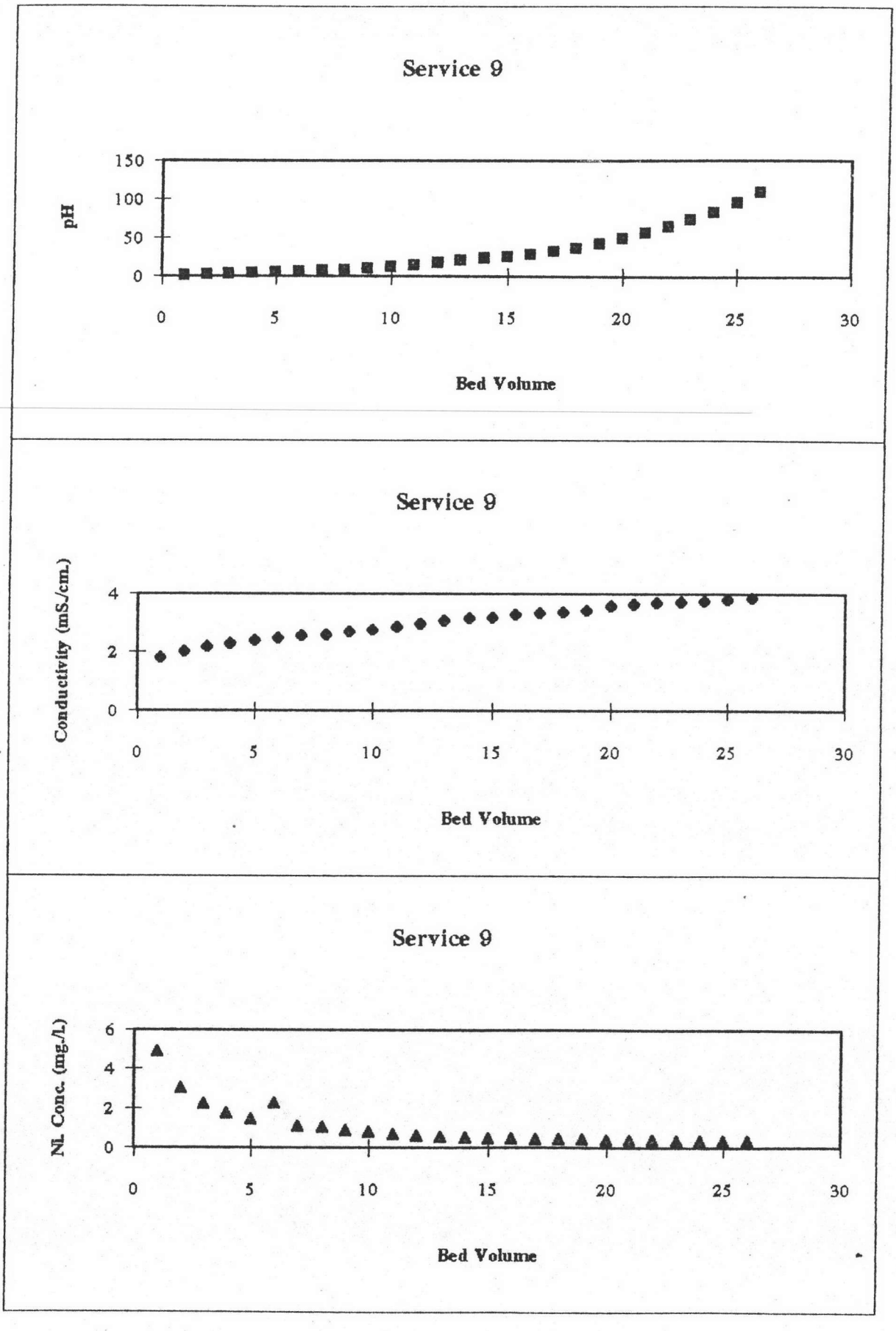

Regeneration 8
NL Conc. (mg/L)
300
200
100
0
0
2
4
6
8
10
Bed Volume

EXPERIMENT 9 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	9	5.39	0.319	99

Effluent NO.	Bed Volume	pH	Conductivity	Ni eff. Conc.	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging
			(mS./cm.)	(mg./l.)	Value	Average	Value	Cumulation	(mg./l.resin)
1	1	1.81	4.89	61.4	0.64	0.32	0.68	0.68	64.70
2	2	2.04	3.05	73.1	0.77	0.70	0.30	0.97	92.85
3	3	2.19	2.22	75.3	0.79	0.78	0.22	1.20	114.05
4	4	2.31	1.757	74.1	0.78	0.78	0.22	1.41	134.75
5	5	2.41	1.457	71.4	0.75	0.76	0.24	1.65	157.40
6	6	2.49	2.253	72.7	0.76	0.76	0.24	1.89	180.75
7	7	2.56	1.102	74.7	0.78	0.77	0.23	2.12	202.45
8	8	2.6	1.043	76.9	0.81	0.79	0.21	2.33	222.05
9	10	2.69	0.89	75.5	0.79	0.80	0.40	2.73	260.45
10	12	2.75	0.8	75.3	0.79	0.79	0.42	3.15	300.45
11	14	2.86	0.697	77.5	0.81	0.80	0.40	3.55	338.45
12	17	2.98	0.616	84.2	0.88	0.85	0.46	4.01	382.10
13	20	3.08	0.552	84.7	0.89	0.89	0.34	4.35	414.95
14	23	3.17	0.518	89.2	0.94	0.91	0.27	4.62	440.30
15	26	3.2	0.496	87.4	0.92	0.93	0.22	4.84	461.60
16	29	3.29	0.476	90.6	0.95	0.93	0.20	5.04	480.80
17	33	3.34	0.451	90.1	0.94	0.95	0.21	5.25	501.00
18	37	3.38	0.442	90.5	0.95	0.95	0.21	5.47	521.40
19	43	3.44	0.45	91.70	0.96	0.95	0.27	5.74	547.20
20	50	3.6	0.403	92.30	0.97	0.96	0.25	5.99	571.00
21	57	3.65	0.396	92.1	0.97	0.97	0.23	6.22	593.40
22	65	3.7	0.386	91.8	0.96	0.96	0.29	6.51	621.00
23	74	3.74	0.381	91.8	0.96	0.96	0.34	6.85	653.40
24	84	3.75	0.377	92.3	0.97	0.96	0.35	7.20	686.90
25	96	3.8	0.374	91.1	0.95	0.96	0.47	7.67	731.30
26	109.5	3.87	0.367	92.4	0.97	0.96	0.52	8.18	780.58

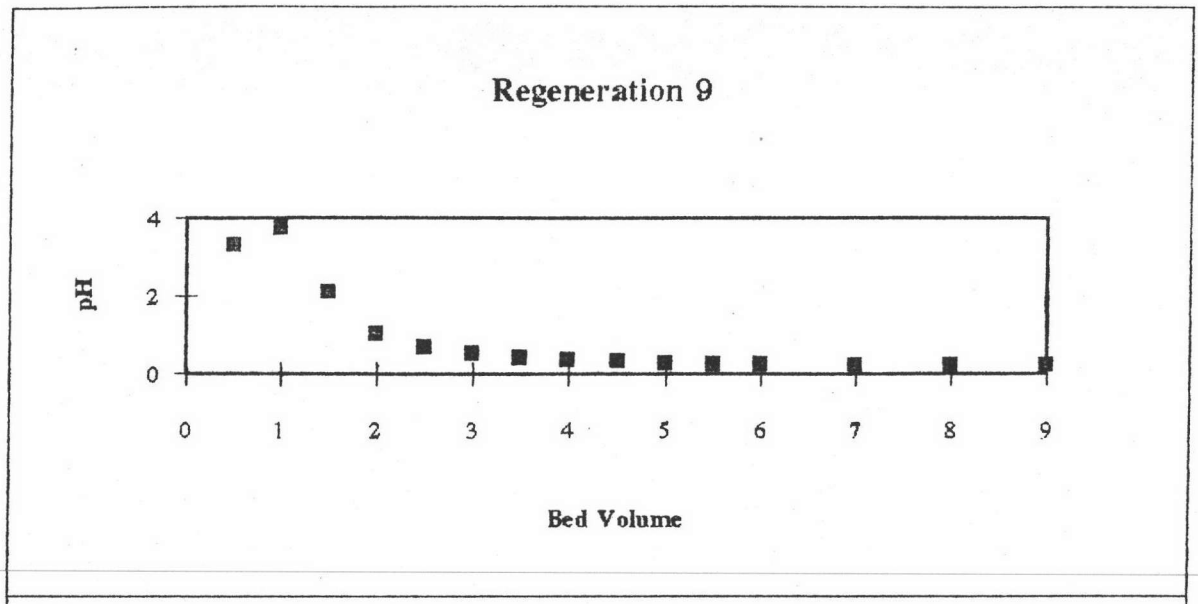

Service 9
pH
150
100
50
0
0
5
10
15
20
25
30
Bed Volume
Service 9
Conductivity (mS./cm.)
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 9
Ni. Conc. (mg./L)
6
4
2
0
0
5
10
15
20
25
30
Bed Volume

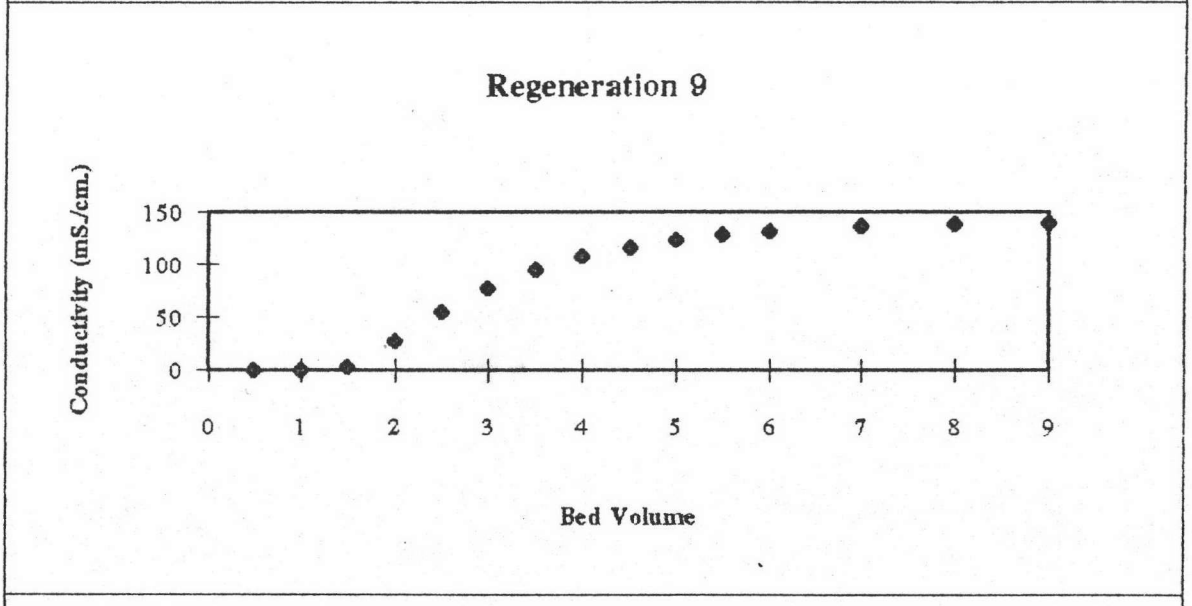
EXPERIMENT 9 Regeneration

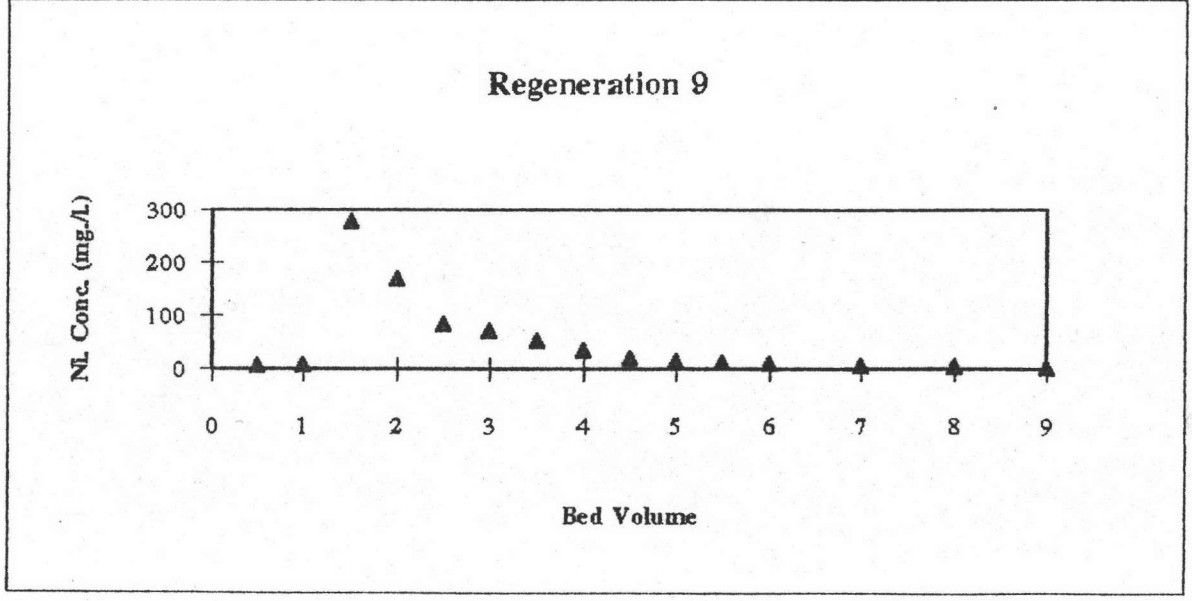
Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	3	0.2	139.2	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.3	0.1977	7	0.00	0.00	0.00	1.75	1.75	3.50
2	1	3.74	0.0998	7.6	0.00	0.00	0.01	3.7	5.4	5.40
3	1.5	2.11	3.53	277.8	0.18	0.09	0.10	71.4	76.8	51.17
4	2	1.02	27.6	170.2	0.11	0.14	0.24	112.0	188.8	94.38
5	2.5	0.69	55.1	84.6	0.05	0.08	0.32	63.7	252.5	100.98
6	3	0.52	77.4	72	0.05	0.05	0.37	39.2	291.6	97.20
7	3.5	0.42	94.6	53.2	0.03	0.04	0.41	31.3	322.9	92.26
8	4	0.35	107.8	33.7	0.02	0.03	0.44	21.7	344.6	86.16
9	4.5	0.32	116.3	19.9	0.01	0.02	0.46	13.4	358.0	79.56
10	5	0.28	123.3	14.4	0.01	0.01	0.47	8.6	366.6	73.32
11	5.5	0.26	128.6	11.7	0.01	0.01	0.48	6.5	373.1	67.84
12	6	0.25	131.6	10.4	0.01	0.01	0.49	5.5	378.7	63.11
13	7	0.23	136.6	5.83	0.01	0.01	0.49	8.1	386.8	55.25
14	8	0.22	139	3.33	0.00	0.01	0.50	4.6	391.3	48.92
15	9	0.22	139.4	2.13	0.00	0.00	0.50	2.7	394.1	43.79


Regeneration 9
pH
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume


Regeneration 9
Conductivity (mS./cm.)
150
100
50
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

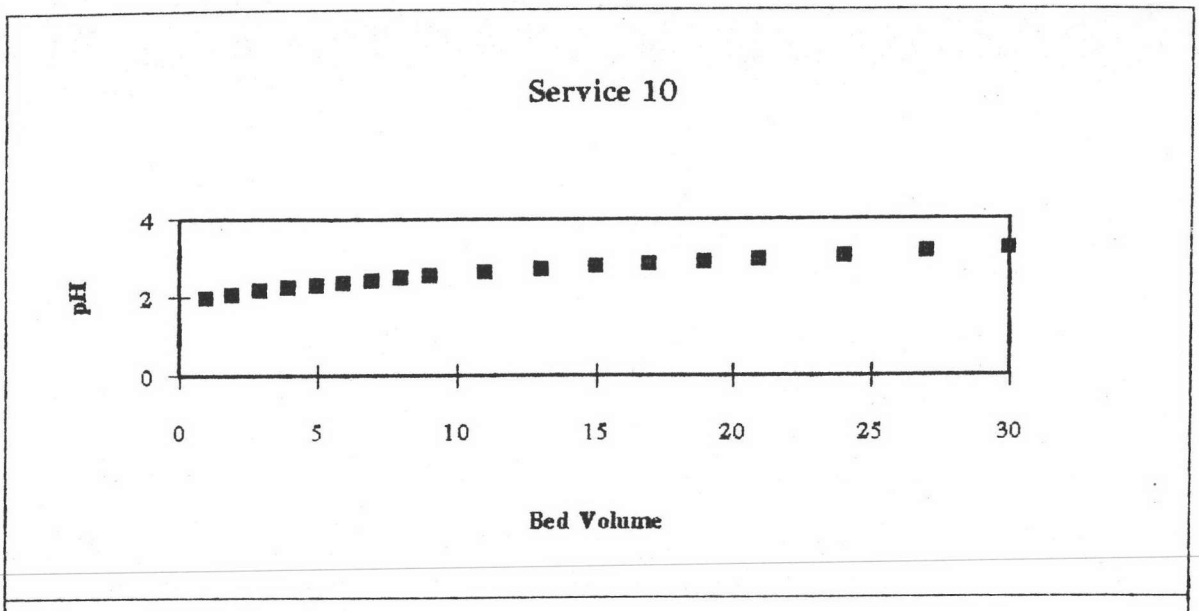

Regeneration 9
Ni. Conc. (mg./L)
300
200
100
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

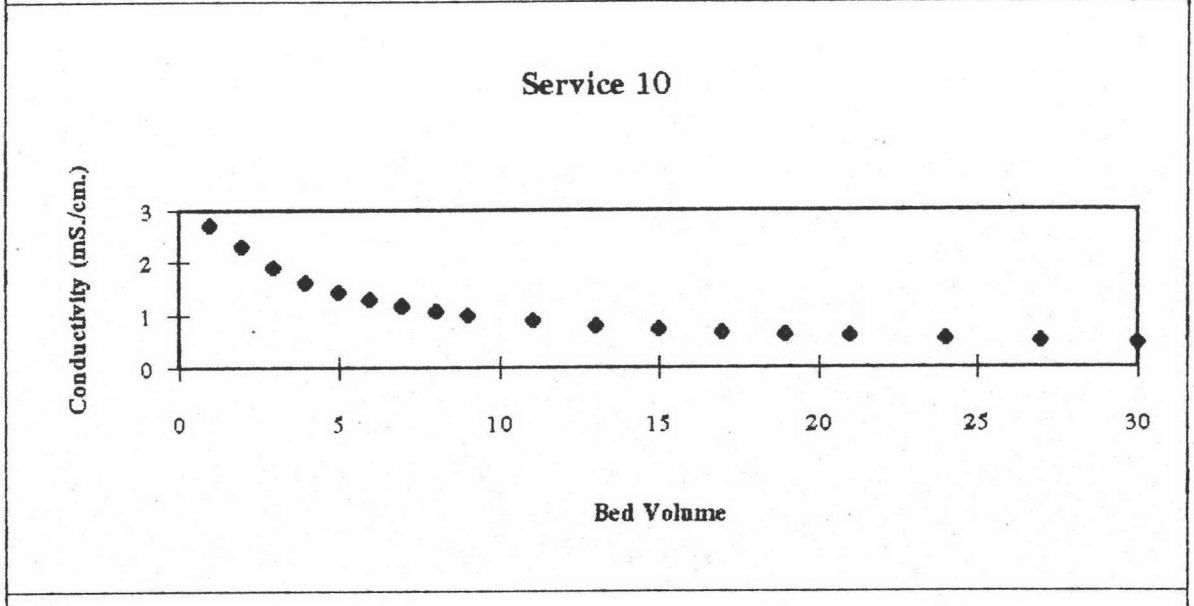
EXPERIMENT 10 Service

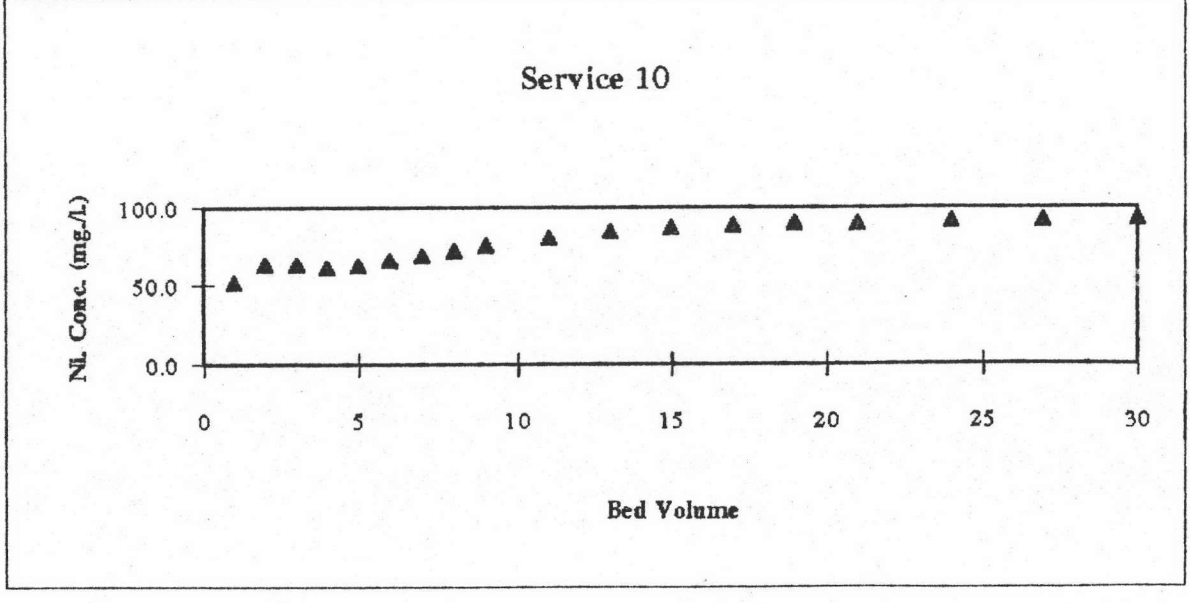
Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni.in.conc. (mg./l.)
synthetic	6	6.46	0.32	98.0

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni.eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	1.98	2.72	51.2	0.52	0.26	0.74	0.74	72.45
2	2	2.06	2.31	62.7	0.64	0.58	0.42	1.16	113.54
3	3	2.16	1.906	62.8	0.64	0.64	0.36	1.52	148.83
4	4	2.24	1.627	61.1	0.62	0.63	0.37	1.89	184.91
5	5	2.3	1.437	62.4	0.64	0.63	0.37	2.26	221.22
6	6	2.36	1.292	65.6	0.67	0.65	0.35	2.60	255.30
7	7	2.42	1.172	68.4	0.70	0.68	0.32	2.92	286.37
8	8	2.48	1.07	71.9	0.73	0.72	0.28	3.21	314.24
9	9	2.54	1	75.4	0.77	0.75	0.25	3.45	338.64
10	11	2.63	0.885	80.4	0.82	0.79	0.41	3.87	378.99
11	13	2.71	0.792	84.0	0.86	0.84	0.32	4.19	410.69
12	15	2.8	0.736	87.2	0.89	0.87	0.25	4.44	435.54
13	17	2.85	0.671	88.4	0.90	0.90	0.21	4.65	456.06
14	19	2.91	0.635	89.5	0.91	0.91	0.19	4.84	474.30
15	21	2.96	0.604	89.8	0.92	0.91	0.17	5.01	491.06
16	24	3.05	0.552	91.0	0.93	0.92	0.23	5.24	513.97
17	27	3.14	0.51	92.0	0.94	0.93	0.20	5.44	533.63
18	30	3.23	0.476	92.2	0.94	0.94	0.18	5.62	551.42


Service 10
pH
4
2
0
0
5
10
15
20
25
30
Bed Volume


Service 10
Conductivity (mS./cm.)
3
2
1
0
0
5
10
15
20
25
30
Bed Volume

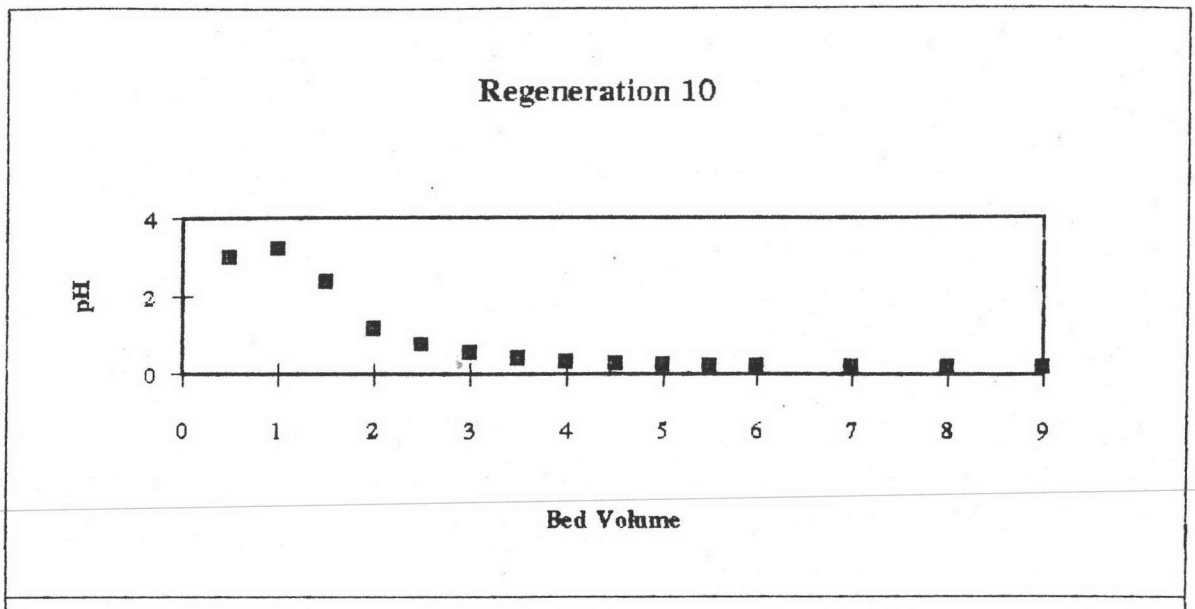

Service 10
Ni. Conc. (mg./L)
100.0
50.0
0.0
0
5
10
15
20
25
30
Bed Volume

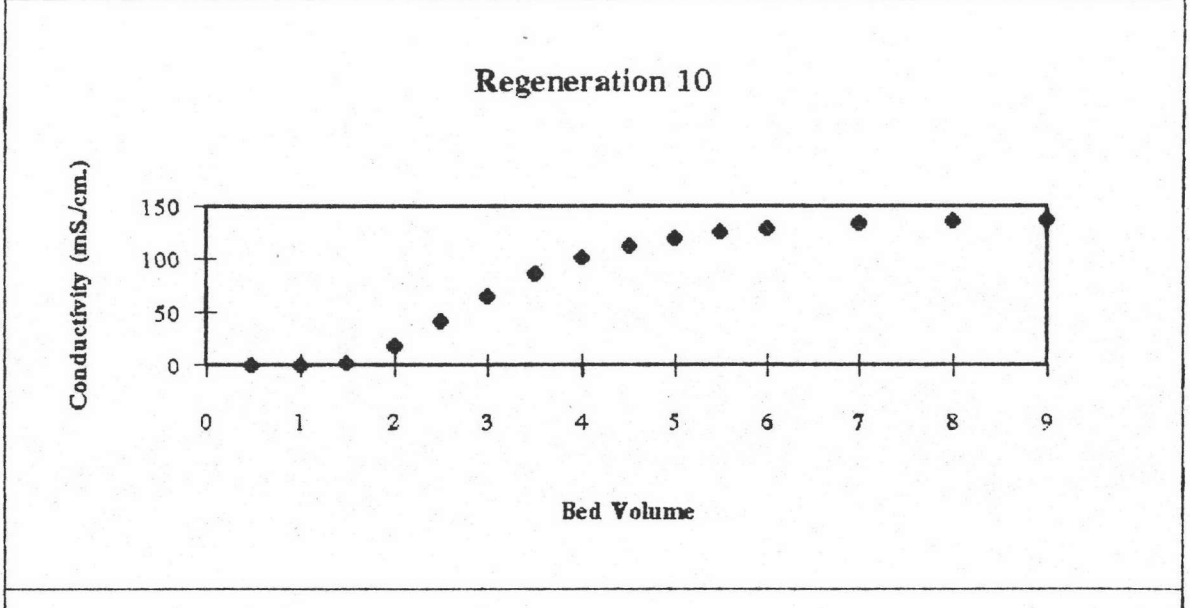
EXPERIMENT 10 Regeneration

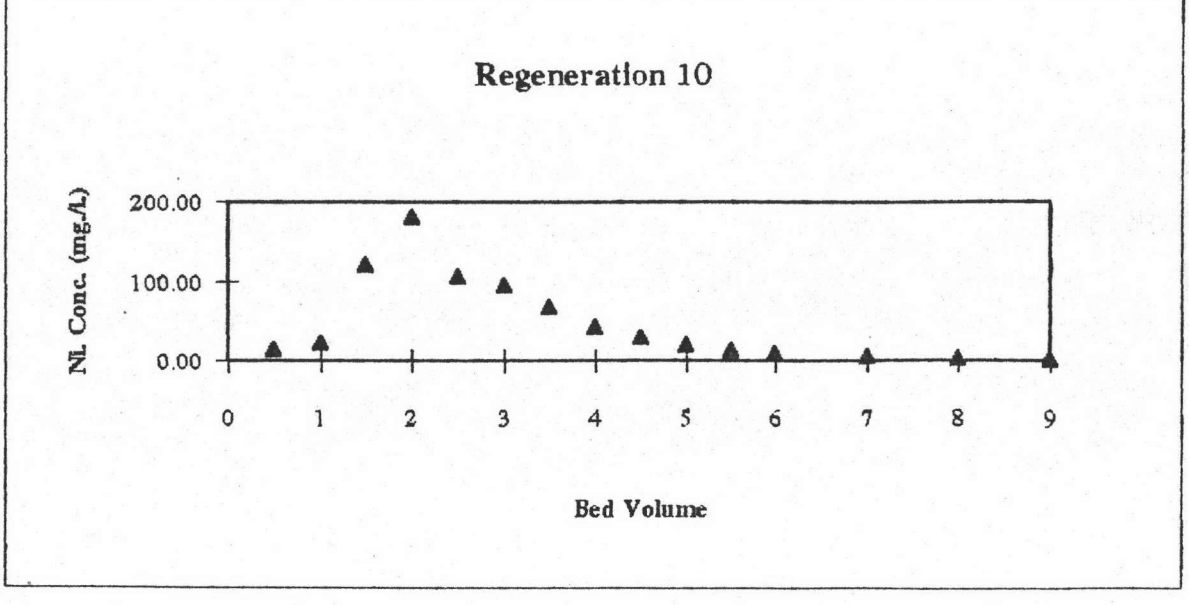
Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	3	0.16	137.3	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc (mg./l.)	Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	2.98	0.274	14.42	0.01	0.01	0.01	3.61	3.61	7.21
2	1	3.2	0.272	22.5	0.02	0.02	0.02	9.2	12.8	12.84
3	1.5	2.38	1.732	121.6	0.11	0.07	0.09	36.0	48.9	32.59
4	2	1.16	18.15	181.3	0.16	0.14	0.23	75.7	124.6	62.30
5	2.5	0.77	41.6	106.0	0.10	0.13	0.36	71.8	196.4	78.57
6	3	0.55	65	94.7	0.09	0.09	0.45	50.2	246.6	82.21
7	3.5	0.42	86	68.4	0.06	0.07	0.52	40.8	287.4	82.11
8	4	0.33	101.5	43.8	0.04	0.05	0.57	28.0	315.4	78.86
9	4.5	0.28	112.2	29.8	0.03	0.03	0.61	18.4	333.8	74.18
10	5	0.24	119.7	20.8	0.02	0.02	0.63	12.6	346.5	69.29
11	5.5	0.23	125.4	13.82	0.01	0.02	0.64	8.6	355.1	64.56
12	6	0.21	129.2	9.60	0.01	0.01	0.65	5.9	361.0	60.16
13	7	0.19	133.9	5.19	0.01	0.01	0.66	7.4	368.3	52.62
14	8	0.18	136	2.83	0.01	0.01	0.67	4.0	372.4	46.54
15	9	0.18	136.9	1.76	0.00	0.00	0.68	2.3	374.6	41.63


Regeneration 10
pH
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume


Regeneration 10
Conductivity (mS./cm.)
150
100
50
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

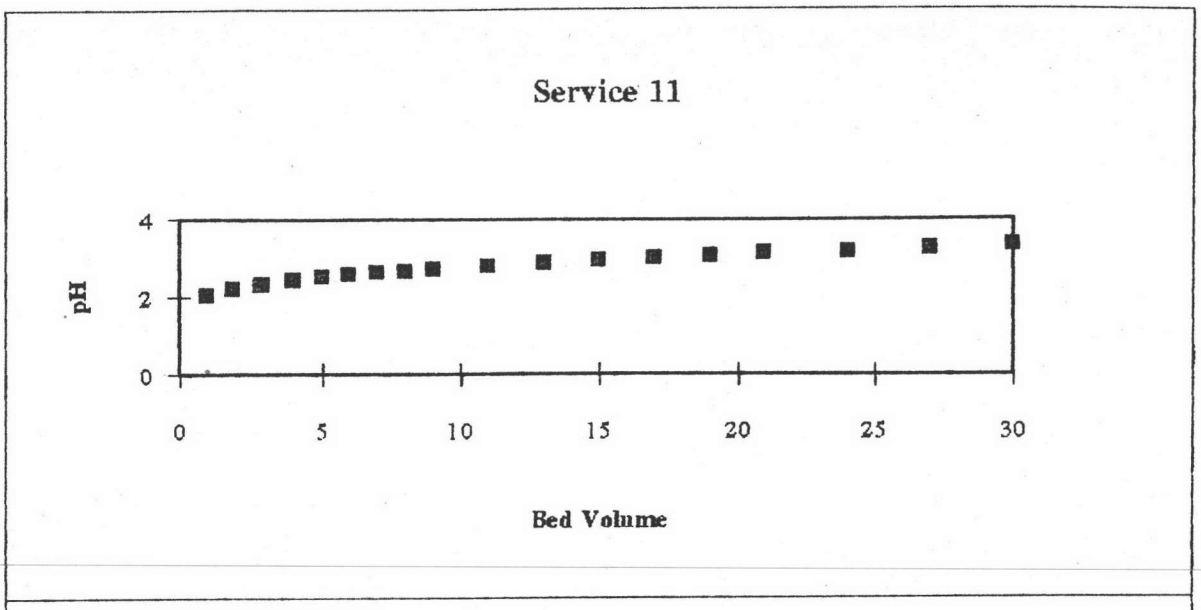

Regeneration 10
NL Conc. (mg./L)
200.00
100.00
0.00
0 1 2 3 4 5 6 7 8 9
Bed Volume

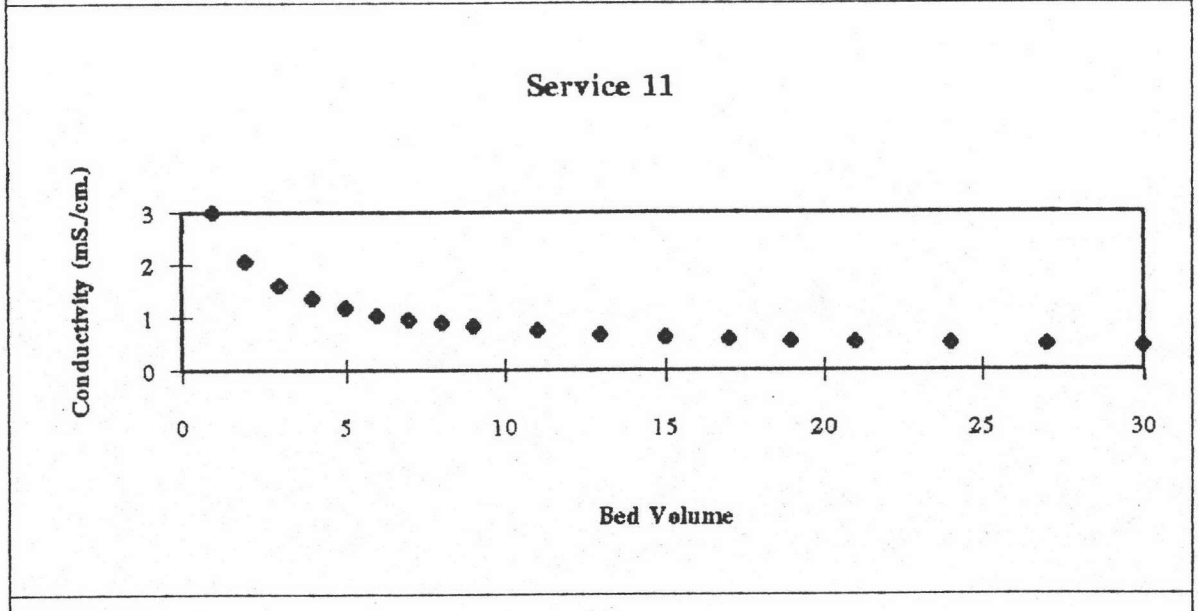
EXPERIMENT 11 Service

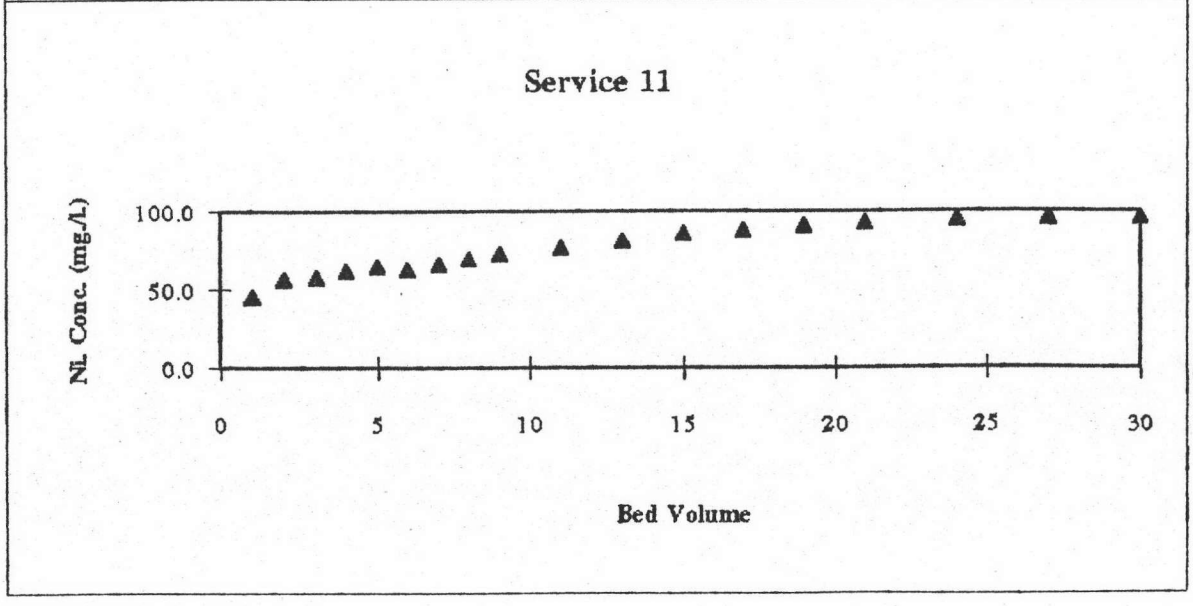
Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	6	6.62	0.32	103.5

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2.04	2.99	44.9	0.43	0.22	0.78	0.78	81.05
2	2	2.21	2.07	55.7	0.54	0.49	0.51	1.30	134.24
3	3	2.33	1.611	57.3	0.55	0.55	0.45	1.75	181.20
4	4	2.42	1.364	61.4	0.59	0.57	0.43	2.18	225.32
5	5	2.5	1.178	64.2	0.62	0.61	0.39	2.57	266.02
6	6	2.56	1.042	62.4	0.60	0.61	0.39	2.96	306.26
7	7	2.62	0.954	65.6	0.63	0.62	0.38	3.34	345.82
8	8	2.66	0.894	69.2	0.67	0.65	0.35	3.69	381.96
9	9	2.71	0.838	72.2	0.70	0.68	0.32	4.01	414.79
10	11	2.8	0.745	76.3	0.74	0.72	0.57	4.57	473.39
11	13	2.88	0.673	80.5	0.78	0.76	0.49	5.06	523.66
12	15	2.95	0.625	85.7	0.83	0.80	0.39	5.45	564.47
13	17	3.02	0.587	87.7	0.85	0.84	0.32	5.78	598.10
14	19	3.07	0.556	90.5	0.87	0.86	0.28	6.06	626.94
15	21	3.15	0.539	92.6	0.89	0.88	0.23	6.29	650.88
16	24	3.18	0.508	94.2	0.91	0.90	0.29	6.58	681.32
17	27	3.26	0.48	95.3	0.92	0.92	0.25	6.84	707.66
18	30	3.35	0.448	95.9	0.93	0.92	0.23	7.07	731.42


Service 11
pH
4
2
0
0
5
10
15
20
25
30
Bed Volume


Service 11
Conductivity (mS./cm.)
3
2
1
0
0
5
10
15
20
25
30
Bed Volume

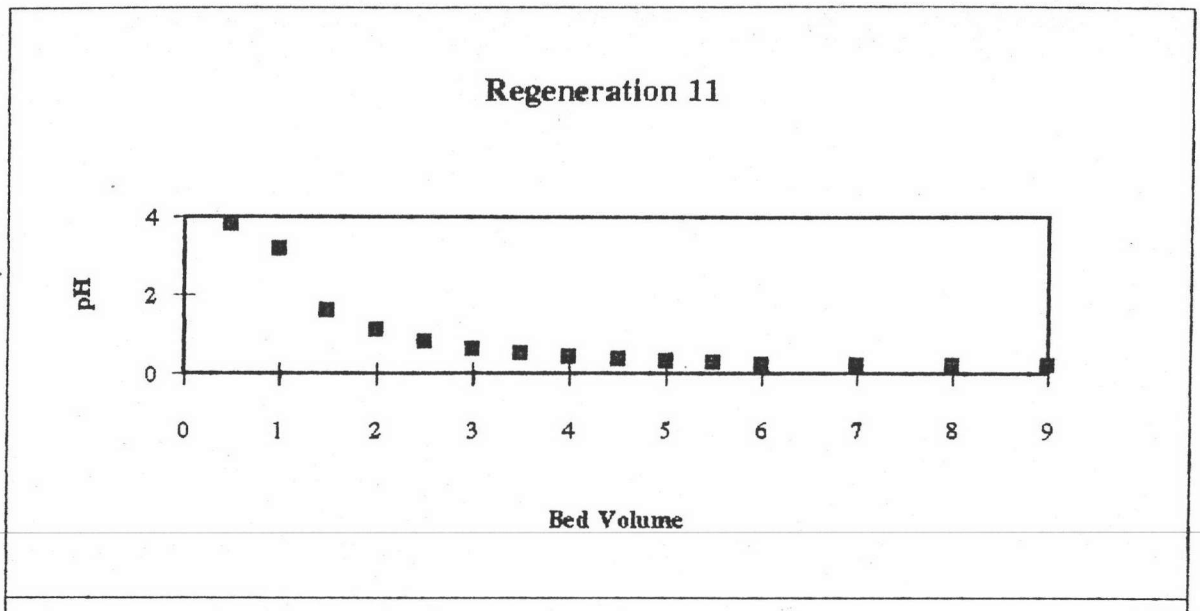

Service 11
NL Conc. (mg/L)
100.0
50.0
0.0
0
5
10
15
20
25
30
Bed Volume

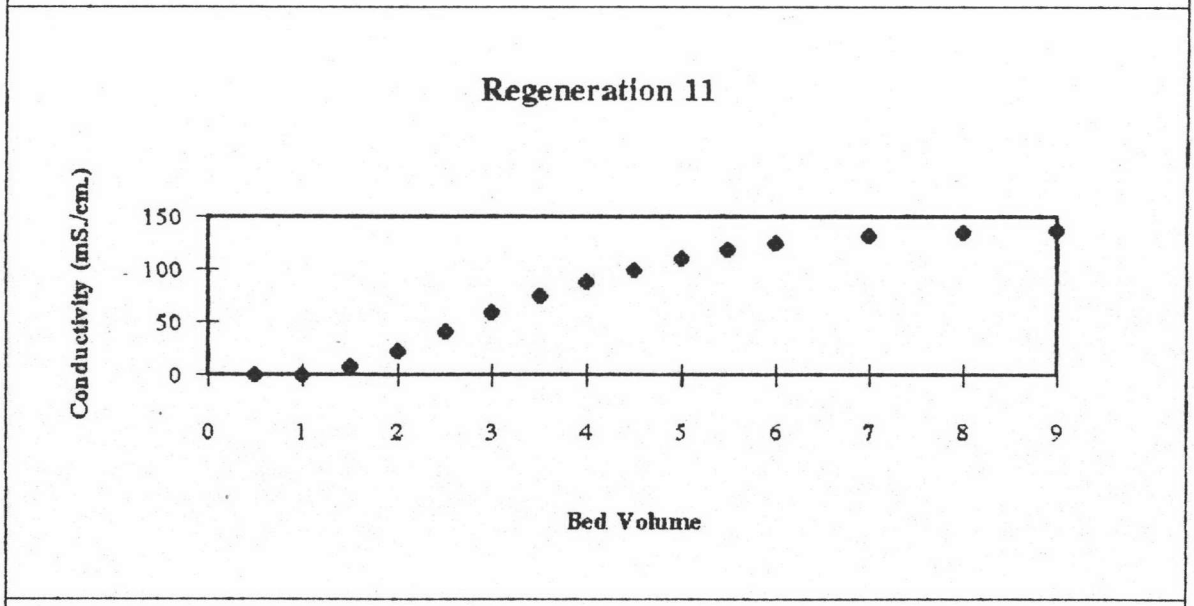
EXPERIMENT 11 Regeneration

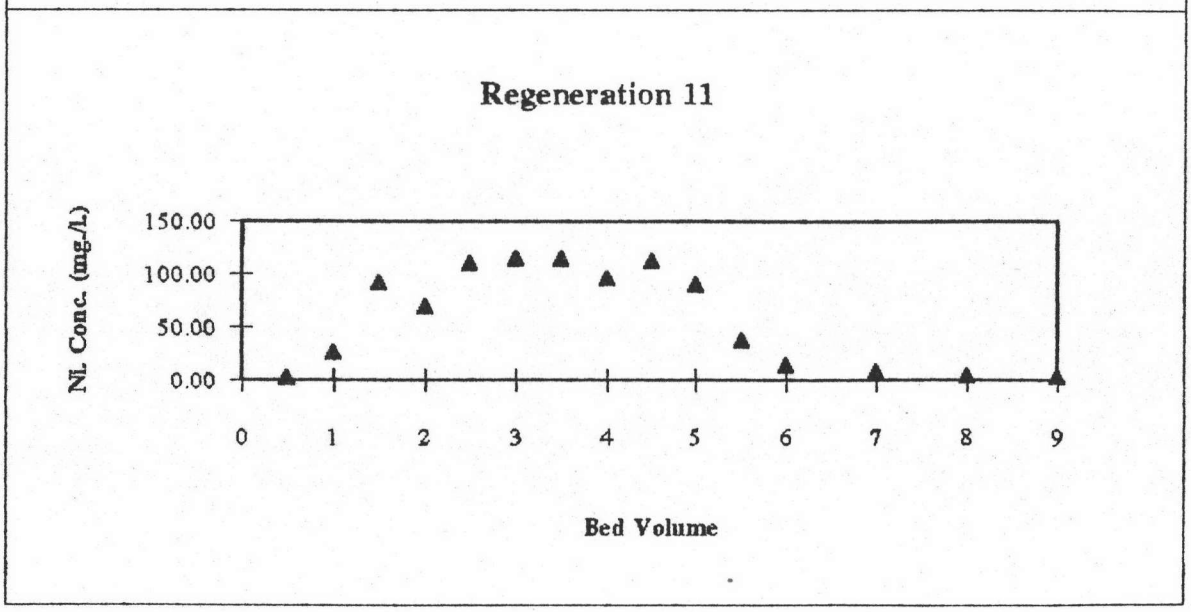
Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	6	0.2	137.5	0.5

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.81	0.0612	2.44	0.00	0.00	0.00	0.61	0.61	1.22
2	1	3.17	0.369	27.0	0.02	0.01	0.01	7.4	8.0	7.97
3	1.5	1.63	7.7	91.5	0.06	0.04	0.05	29.6	37.6	25.08
4	2	1.11	22.3	69.1	0.05	0.05	0.11	40.2	77.8	38.89
5	2.5	0.82	40.9	109.9	0.08	0.06	0.17	44.7	122.5	49.01
6	3	0.64	58.8	114.7	0.08	0.08	0.24	56.1	178.7	59.55
7	3.5	0.52	74.5	114.7	0.08	0.08	0.32	57.3	236.0	67.43
8	4	0.44	88.2	95.9	0.07	0.07	0.39	52.6	288.6	72.16
9	4.5	0.38	99.3	112.5	0.08	0.07	0.47	52.1	340.7	75.72
10	5	0.33	110.5	89.6	0.06	0.07	0.53	50.5	391.3	78.25
11	5.5	0.29	118.5	38.0	0.03	0.04	0.58	31.9	423.2	76.94
12	6	0.26	124.8	14.48	0.01	0.02	0.60	13.1	436.3	72.71
13	7	0.23	131.2	8.16	0.01	0.01	0.61	11.3	447.6	63.94
14	8	0.22	134.6	4.46	0.01	0.01	0.62	6.3	453.9	56.74
15	9	0.21	136.7	2.62	0.00	0.00	0.62	3.5	457.4	50.83


Regeneration 11
pH
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume


Regeneration 11
Conductivity (mS./cm.)
150
100
50
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

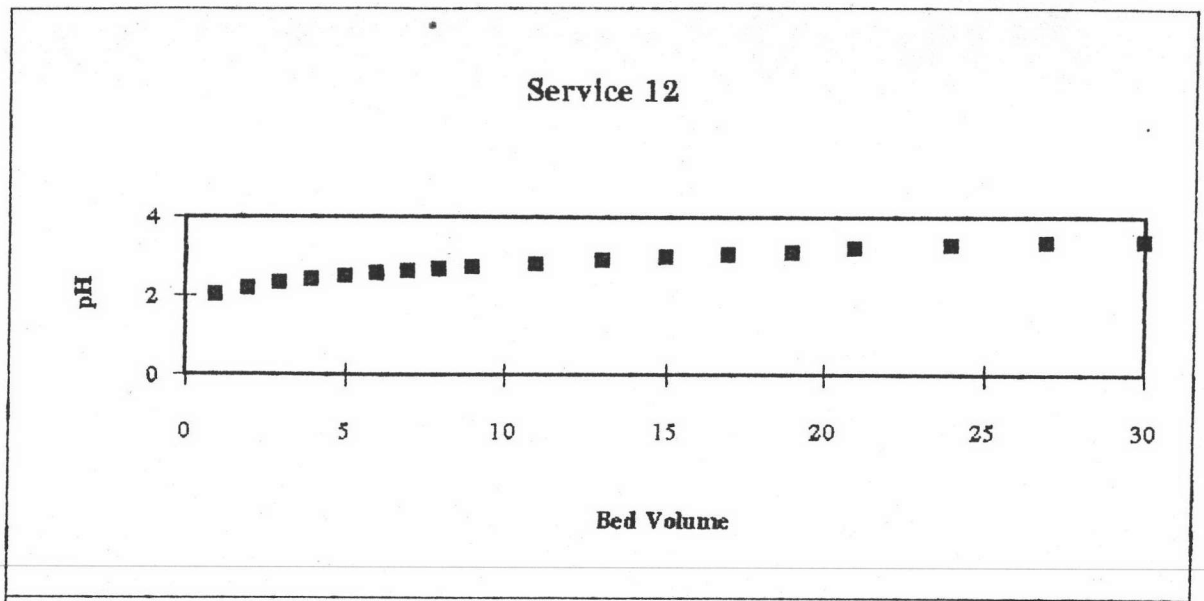

Regeneration 11
NL Conc. (mg./L)
150.00
100.00
50.00
0.00
0 1 2 3 4 5 6 7 8 9
Bed Volume

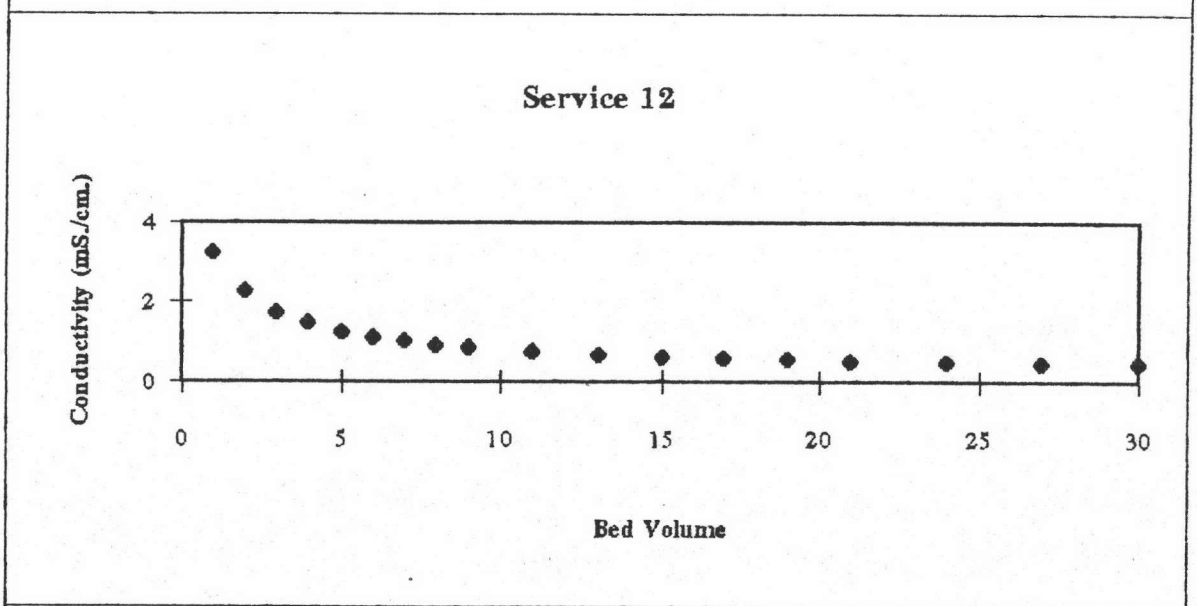
EXPERIMENT 12 Service

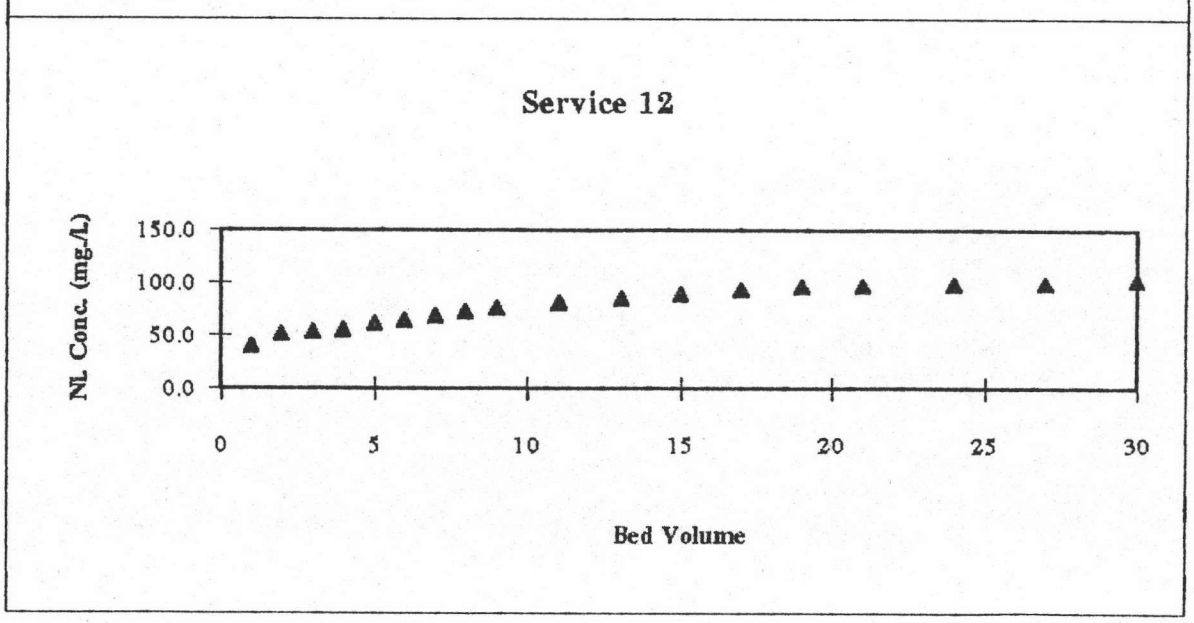
Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV /Hr.)	pH	Conductivity (mS./cm.)	Ni in.conc. (mg./l.)
synthetic	6	6.25	0.32	106.2

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni.eff Conc (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2.02	3.23	39.9	0.38	0.19	0.81	0.81	86.30
2	2	2.19	2.26	51.4	0.48	0.43	0.57	1.38	146.89
3	3	2.31	1.727	53.4	0.50	0.49	0.51	1.89	200.75
4	4	2.39	1.485	55.5	0.52	0.51	0.49	2.38	252.57
5	5	2.48	1.256	60.9	0.57	0.55	0.45	2.83	300.62
6	6	2.56	1.095	64.6	0.61	0.59	0.41	3.24	344.11
7	7	2.61	1.02	68.5	0.64	0.63	0.37	3.61	383.78
8	8	2.67	0.932	72.7	0.68	0.66	0.34	3.95	419.41
9	9	2.72	0.865	75.5	0.71	0.70	0.30	4.25	451.55
10	11	2.81	0.77	80.5	0.76	0.73	0.53	4.78	508.10
11	13	2.91	0.672	84.6	0.80	0.78	0.45	5.23	555.52
12	15	2.98	0.628	88.8	0.84	0.82	0.37	5.60	594.62
13	17	3.05	0.586	92.9	0.87	0.86	0.29	5.89	625.40
14	19	3.1	0.555	95.6	0.90	0.89	0.23	6.11	649.34
15	21	3.21	0.521	96.8	0.91	0.91	0.19	6.30	669.41
16	24	3.28	0.485	97.9	0.92	0.92	0.25	6.55	696.08
17	27	3.36	0.459	98.7	0.93	0.93	0.22	6.78	719.85
18	30	3.38	0.45	102.0	0.96	0.94	0.17	6.94	737.47


Service 12
pH
4
2
0
0
5
10
15
20
25
30
Bed Volume


Service 12
Conductivity (mS./cm.)
4
2
0
0
5
10
15
20
25
30
Bed Volume

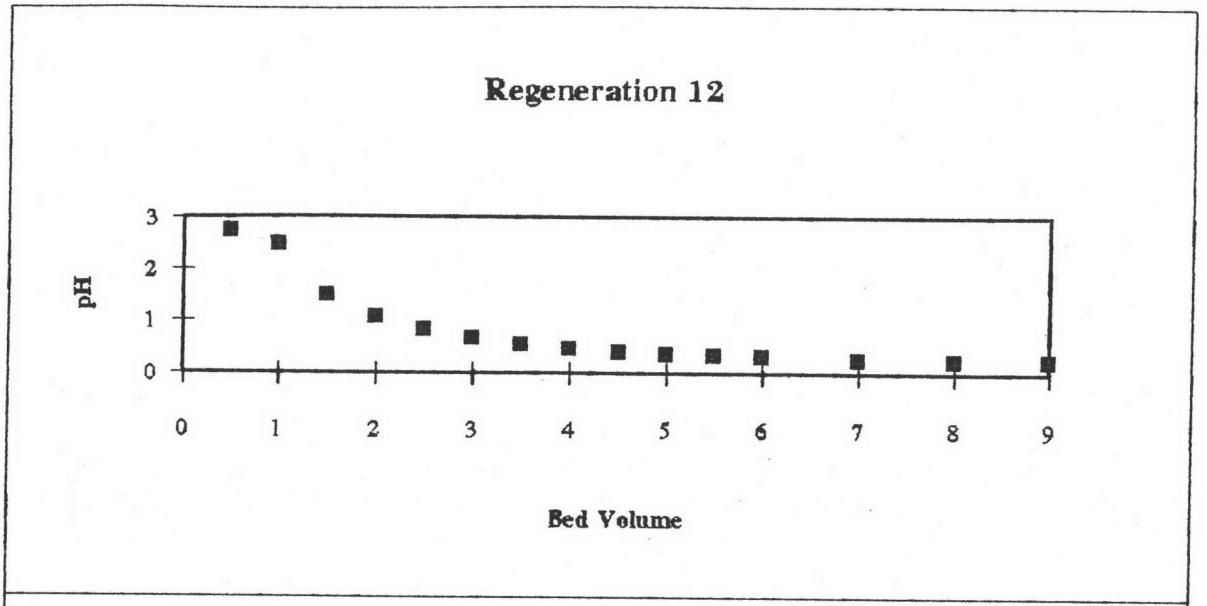

Service 12
NL Conc. (mg/L)
150.0
100.0
50.0
0.0
0
5
10
15
20
25
30
Bed Volume

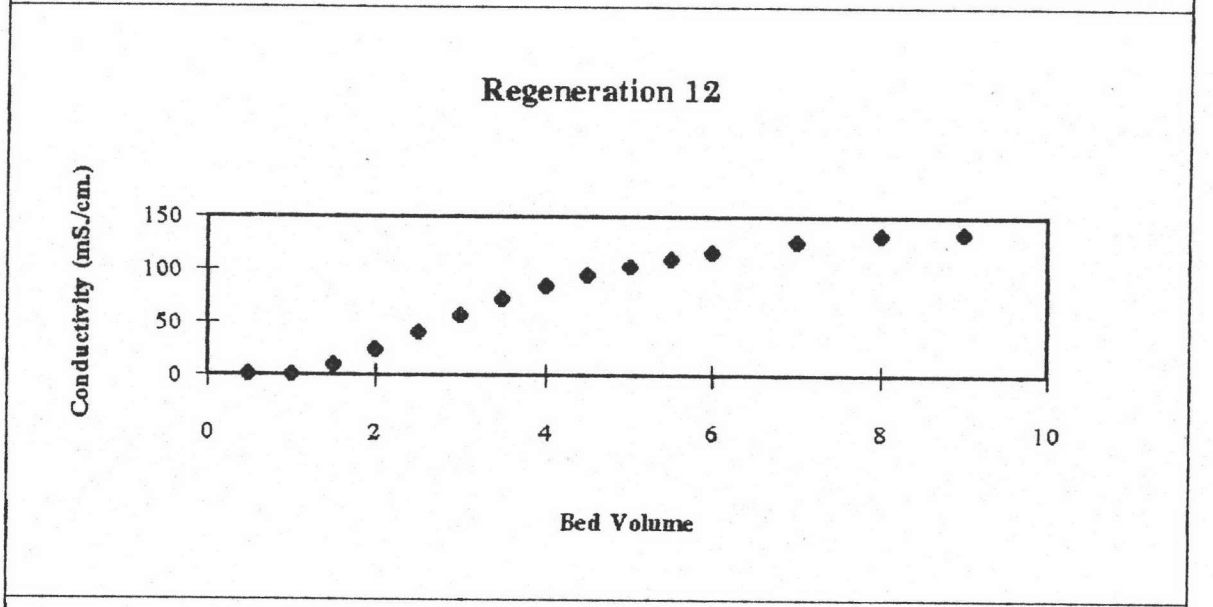
EXPERIMENT 12 Regeneration

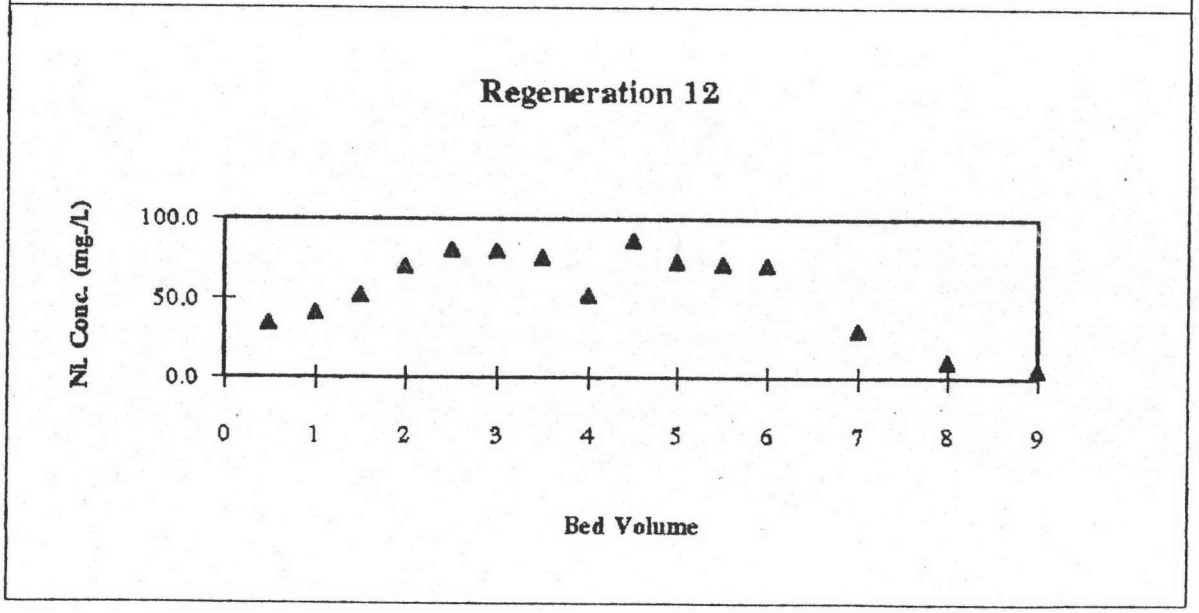
Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV /Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	9	0.22	136.7	0.5

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg Conc (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	2.73	0.815	33.9	0.02	0.01	0.01	8.46	8.46	16.93
2	1	2.47	1.337	40.6	0.03	0.03	0.04	18.6	27.1	27.08
3	1.5	1.49	10.37	51.9	0.04	0.03	0.07	23.1	50.2	33.46
4	2	1.09	24.3	69.9	0.05	0.04	0.11	30.4	80.6	40.31
5	2.5	0.84	40.9	80.0	0.05	0.05	0.16	37.5	118.1	47.24
6	3	0.68	57.2	79.3	0.05	0.05	0.21	39.8	157.9	52.65
7	3.5	0.56	72.3	75.5	0.05	0.05	0.27	38.7	196.7	56.19
8	4	0.48	85.2	51.6	0.04	0.04	0.31	31.8	228.4	57.11
9	4.5	0.42	95.3	86.2	0.06	0.05	0.36	34.5	262.9	58.42
10	5	0.38	103.4	72.5	0.05	0.05	0.41	39.7	302.6	60.51
11	5.5	0.35	110	71.3	0.05	0.05	0.46	35.9	338.5	61.54
12	6	0.32	116.4	70.7	0.05	0.05	0.51	35.5	374.0	62.33
13	7	0.27	126.7	29.9	0.04	0.04	0.55	50.3	424.3	60.61
14	8	0.25	132.3	10.31	0.01	0.03	0.58	20.1	444.3	55.54
15	9	0.24	135	5.27	0.01	0.01	0.59	7.8	452.1	50.24


Regeneration 12
pH
3
2
1
0
0
1
2
3
4
5
6
7
8
9
Bed Volume


Regeneration 12
Conductivity (mS./cm.)
150
100
50
0
0
2
4
6
8
10
Bed Volume

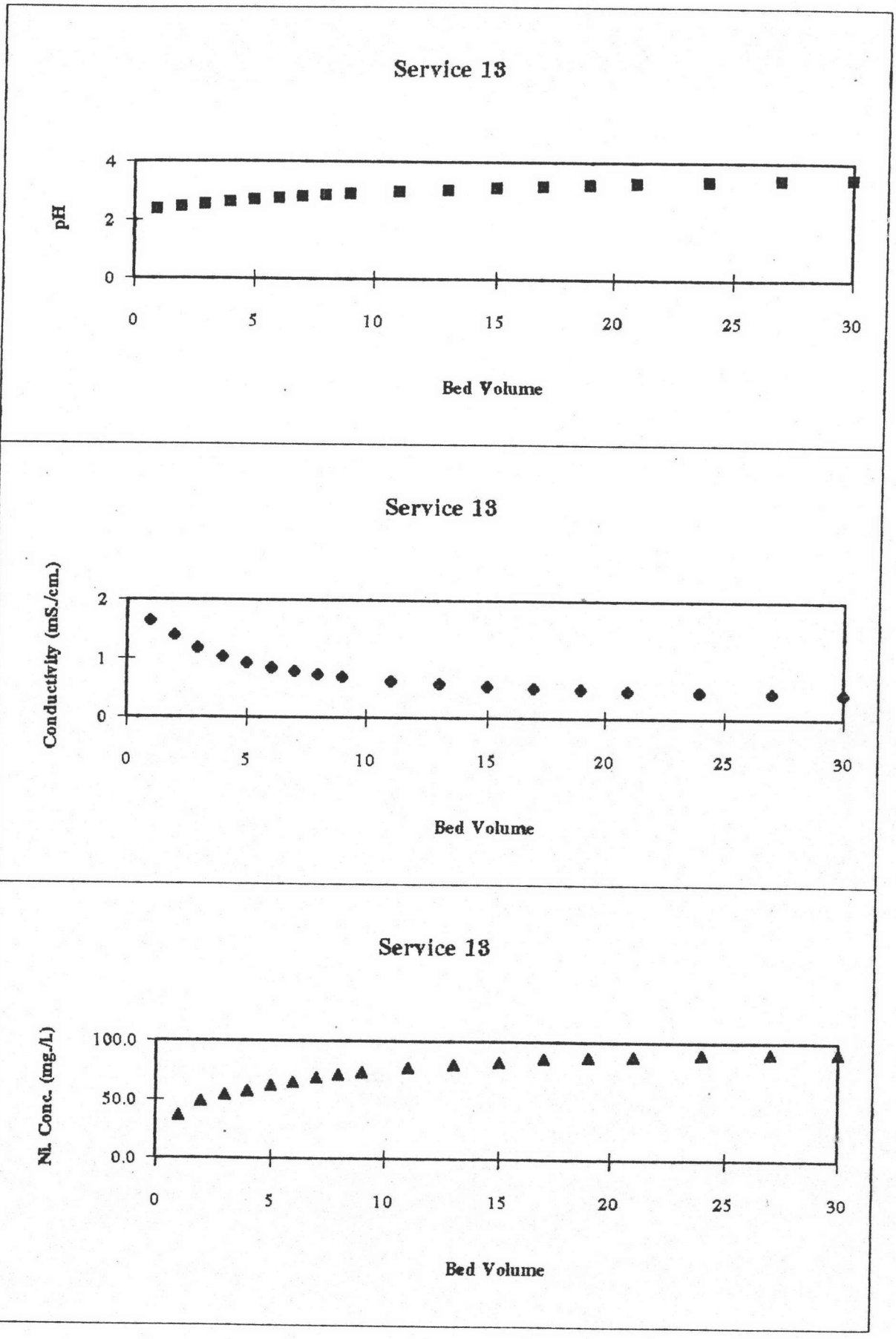

Regeneration 12
NL Conc. (mg./L)
100.0
50.0
0.0
0
1
2
3
4
5
6
7
8
9
Bed Volume

EXPERIMENT 13 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni.in.conc. (mg./l.)
synthetic	6	6.42	0.32	95.6

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni.eff Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2.36	1.646	36.3	0.38	0.19	0.81	0.81	77.52
2	2	2.45	1.396	48.0	0.50	0.44	0.56	1.37	131.04
3	3	2.54	1.181	53.6	0.56	0.53	0.47	1.84	175.90
4	4	2.62	1.033	57.3	0.60	0.58	0.42	2.26	216.09
5	5	2.69	0.919	61.9	0.65	0.62	0.38	2.64	252.11
6	6	2.75	0.844	64.8	0.68	0.66	0.34	2.97	284.43
7	7	2.8	0.789	68.5	0.72	0.70	0.30	3.28	313.44
8	8	2.85	0.739	71.3	0.74	0.73	0.27	3.55	339.21
9	9	2.9	0.698	73.8	0.77	0.76	0.24	3.79	362.35
10	11	2.99	0.628	77.3	0.81	0.79	0.42	4.21	402.59
11	13	3.06	0.583	80.3	0.84	0.82	0.35	4.56	436.34
12	15	3.13	0.548	82.5	0.86	0.85	0.30	4.86	464.84
13	17	3.19	0.519	86.0	0.90	0.88	0.24	5.10	487.84
14	19	3.24	0.499	87.3	0.91	0.91	0.19	5.29	505.65
15	21	3.3	0.479	87.7	0.92	0.91	0.17	5.46	521.95
16	24	3.36	0.458	89.9	0.94	0.93	0.21	5.67	542.47
17	27	3.41	0.446	90.6	0.95	0.94	0.17	5.84	558.54
18	30	3.45	0.434	91.4	0.96	0.95	0.14	5.98	572.39

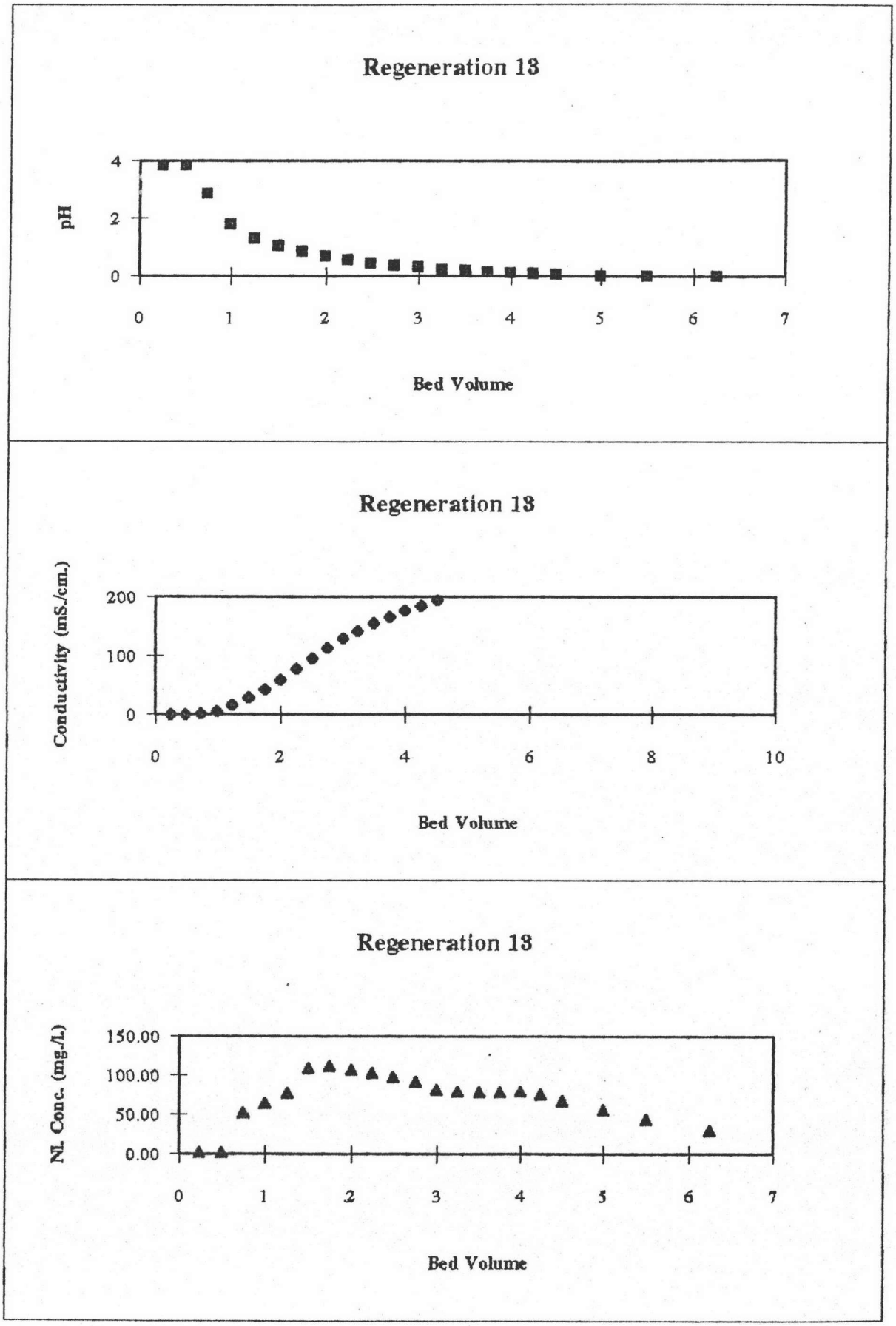

Service 13
pH
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 13
Conductivity (mS./cm.)
2
1
0
0
5
10
15
20
25
30
Bed Volume
Service 13
Ni. Conc. (mg./L)
100.0
50.0
0.0
0
5
10
15
20
25
30
Bed Volume

EXPERIMENT 13 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	3	<0.00	>199.99	1

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.25	3.83	0.0697	1.98	0.00	0.00	0.00	0.25	0.25	0.99
2	0.5	3.84	0.0666	2.11	0.00	0.00	0.00	0.5	0.8	1.52
3	0.75	2.86	0.705	51.9	0.02	0.01	0.01	6.7	7.5	10.01
4	1	1.78	5.91	64.8	0.03	0.03	0.04	14.6	22.1	22.08
5	1.25	1.29	16.5	77.7	0.03	0.03	0.07	17.8	39.9	31.92
6	1.5	1.04	28.4	108.9	0.05	0.04	0.11	23.3	63.2	42.15
7	1.75	0.84	42.7	112.5	0.05	0.05	0.16	27.7	90.9	51.94
8	2	0.68	59	106.8	0.05	0.05	0.21	27.4	118.3	59.16
9	2.25	0.55	77.8	103.5	0.05	0.05	0.25	26.3	144.6	64.27
10	2.5	0.44	95.8	97.6	0.04	0.04	0.30	25.1	169.7	67.90
11	2.75	0.36	112.7	92.3	0.04	0.04	0.34	23.7	193.5	70.36
12	3	0.29	128.6	81.6	0.04	0.04	0.38	21.7	215.2	71.74
13	3.25	0.23	142.1	79.5	0.03	0.04	0.41	20.1	235.4	72.42
14	3.5	0.19	154.6	78.1	0.03	0.03	0.45	19.7	255.1	72.87
15	3.75	0.15	165.6	79.0	0.03	0.03	0.48	19.6	274.7	73.25
16	4	0.11	176.8	79.2	0.03	0.03	0.51	19.8	294.5	73.62
17	4.25	0.08	185.3	75.1	0.03	0.03	0.55	19.3	313.8	73.83
18	4.5	0.05	194.9	67.3	0.03	0.03	0.58	17.8	331.6	73.68
19	5	0.01	>199.99	56.0	0.05	0.04	0.62	30.8	362.4	72.47
20	5.5	<0.00	>199.99	44.2	0.04	0.04	0.66	25.1	387.4	70.44
21	6.25	<0.00	>199.99	29.3	0.04	0.04	0.70	27.6	415.0	66.40

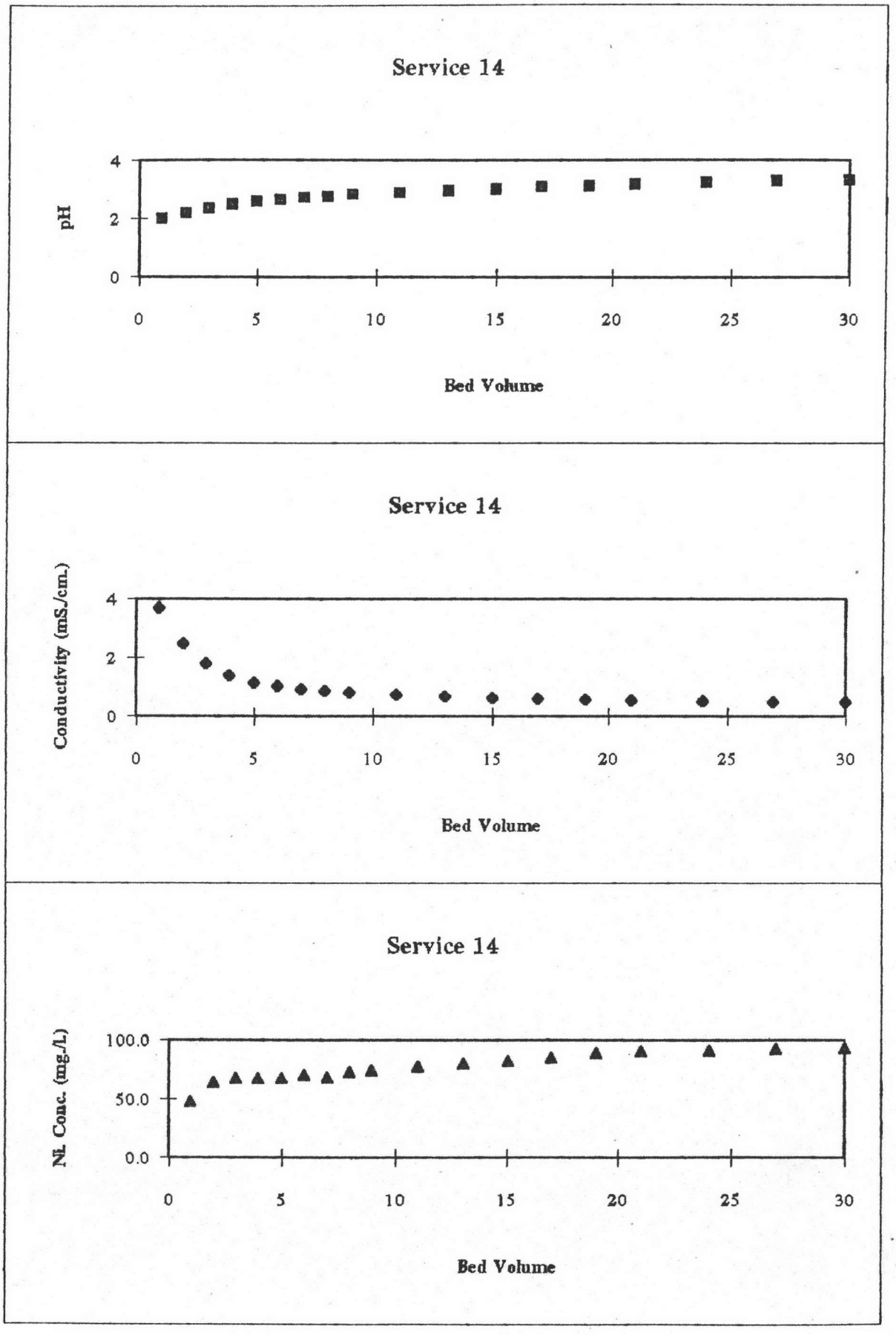

Regeneration 13
pH
4
2
0
0
1
2
3
4
5
6
7
Bed Volume
Regeneration 13
Conductivity (mS./cm.)
200
100
0
0
2
4
6
8
10
Bed Volume
Regeneration 13
NL Conc. (mg./L)
150.00
100.00
50.00
0.00
0
1
2
3
4
5
6
7
Bed Volume

EXPERIMENT 14 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	6	6.24	0.32	96.1

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2	3.7	47.8	0.50	0.25	0.75	0.75	72.22
2	2	2.19	2.48	63.8	0.66	0.58	0.42	1.17	112.52
3	3	2.35	1.787	67.0	0.70	0.68	0.32	1.49	143.18
4	4	2.48	1.389	67.1	0.70	0.70	0.30	1.79	172.20
5	5	2.59	1.146	67.6	0.70	0.70	0.30	2.09	200.93
6	6	2.65	1.027	70.2	0.73	0.72	0.28	2.37	228.11
7	7	2.72	0.93	67.8	0.71	0.72	0.28	2.66	255.19
8	8	2.76	0.868	72.7	0.76	0.73	0.27	2.92	281.01
9	9	2.82	0.804	74.4	0.77	0.77	0.23	3.18	303.53
10	11	2.89	0.728	77.9	0.81	0.79	0.42	3.57	343.43
11	13	2.96	0.672	80.3	0.84	0.82	0.35	3.93	377.51
12	15	3.03	0.623	82.3	0.86	0.85	0.31	4.24	407.15
13	17	3.09	0.589	84.9	0.88	0.87	0.26	4.50	432.12
14	19	3.14	0.561	89.3	0.93	0.91	0.19	4.68	450.13
15	21	3.18	0.542	90.5	0.94	0.94	0.13	4.81	462.56
16	24	3.24	0.519	91.2	0.95	0.95	0.16	4.98	478.29
17	27	3.28	0.503	92.7	0.96	0.96	0.13	5.11	490.77
18	30	3.32	0.488	92.9	0.97	0.97	0.10	5.21	500.69


Service 14
pH
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 14
Conductivity (mS./cm.)
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 14
NL Conc. (mg./L)
100.0
50.0
0.0
0
5
10
15
20
25
30
Bed Volume

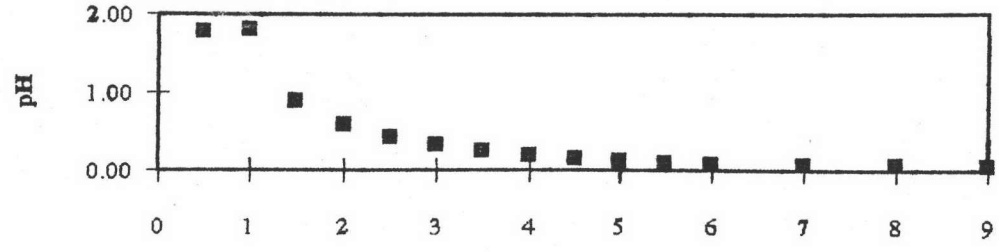
EXPERIMENT 14 Regeneration

Column Size ∅ 6.75*100 cm.

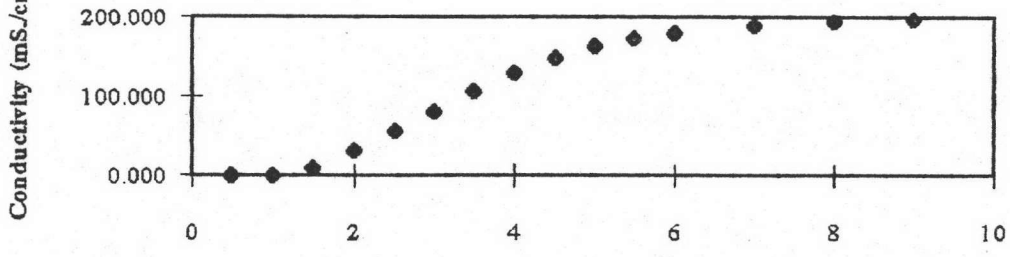
Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	3	0.05	196.8	0.75

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	1.78	0.315	4.40	0.00	0.00	0.00	1.10	1.10	2.20
2	1	1.81	0.365	24.4	0.02	0.01	0.02	7.2	8.3	8.30
3	1.5	0.90	9.27	72.3	0.07	0.05	0.06	24.2	32.5	21.65
4	2	0.58	31.1	64.5	0.06	0.07	0.13	34.2	66.7	33.34
5	2.5	0.43	55.9	117.0	0.12	0.09	0.22	45.4	112.1	44.82
6	3	0.32	79.7	221.0	0.22	0.17	0.39	84.5	196.6	65.52
7	3.5	0.25	106.5	106.7	0.11	0.16	0.56	81.9	278.5	79.57
8	4	0.19	129.3	63.5	0.06	0.08	0.64	42.6	321.0	80.26
9	4.5	0.15	148.3	45.4	0.05	0.05	0.70	27.2	348.3	77.39
10	5	0.12	163.1	34.0	0.03	0.04	0.74	19.8	368.1	73.62
11	5.5	0.10	173.1	24.5	0.02	0.03	0.76	14.6	382.7	69.58
12	6	0.08	179.9	16.94	0.02	0.02	0.79	10.4	393.1	65.51
13	7	0.07	188.9	9.15	0.02	0.02	0.80	13.0	406.1	58.02
14	8	0.07	194.1	5.40	0.01	0.01	0.82	7.3	413.4	51.68
15	9	0.06	197.2	2.88	0.01	0.01	0.83	4.1	417.5	46.39

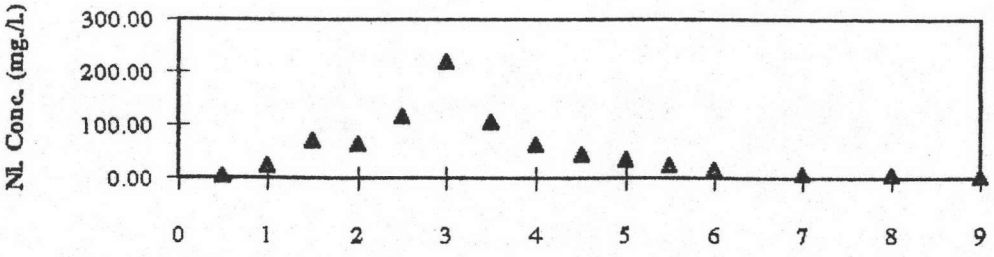
Regeneration 14



Regeneration 14



Regeneration 14

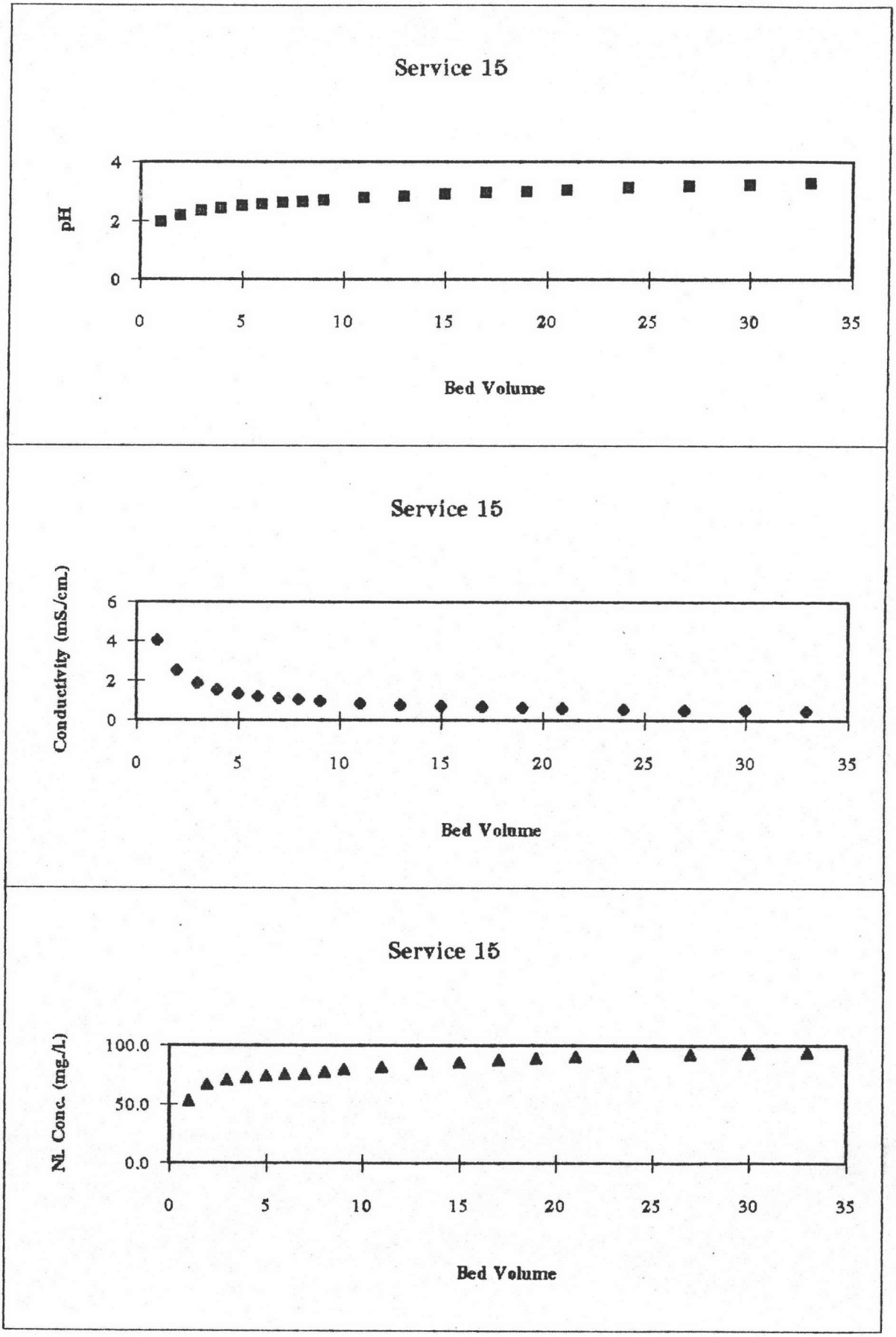


EXPERIMENT 15 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	6	6.43	0.32	101.2

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	1.95	4.05	52.1	0.51	0.26	0.74	0.74	75.18
2	2	2.18	2.53	66.6	0.66	0.59	0.41	1.16	117.08
3	3	2.33	1.87	70.8	0.70	0.68	0.32	1.48	149.63
4	4	2.43	1.548	72.6	0.72	0.71	0.29	1.77	179.15
5	5	2.49	1.362	74.3	0.73	0.73	0.27	2.04	206.91
6	6	2.55	1.223	75.2	0.74	0.74	0.26	2.31	233.36
7	7	2.61	1.12	75.5	0.75	0.74	0.26	2.56	259.24
8	8	2.65	1.042	77.6	0.77	0.76	0.24	2.80	283.92
9	9	2.7	0.966	79.7	0.79	0.78	0.22	3.03	306.49
10	11	2.77	0.866	82.0	0.81	0.80	0.40	3.43	347.30
11	13	2.84	0.794	84.4	0.83	0.82	0.36	3.79	383.44
12	15	2.9	0.743	86.0	0.85	0.84	0.32	4.11	415.59
13	17	2.96	0.688	87.8	0.87	0.86	0.28	4.39	444.32
14	19	2.99	0.655	88.9	0.88	0.87	0.25	4.64	470.08
15	21	3.05	0.618	90.2	0.89	0.88	0.23	4.87	493.45
16	24	3.12	0.579	91.0	0.90	0.89	0.32	5.19	525.43
17	27	3.18	0.549	92.6	0.91	0.91	0.28	5.47	553.81
18	30	3.22	0.528	93.5	0.92	0.92	0.24	5.71	578.44
19	33	3.27	0.51	93.9	0.93	0.93	0.22	5.94	601.01

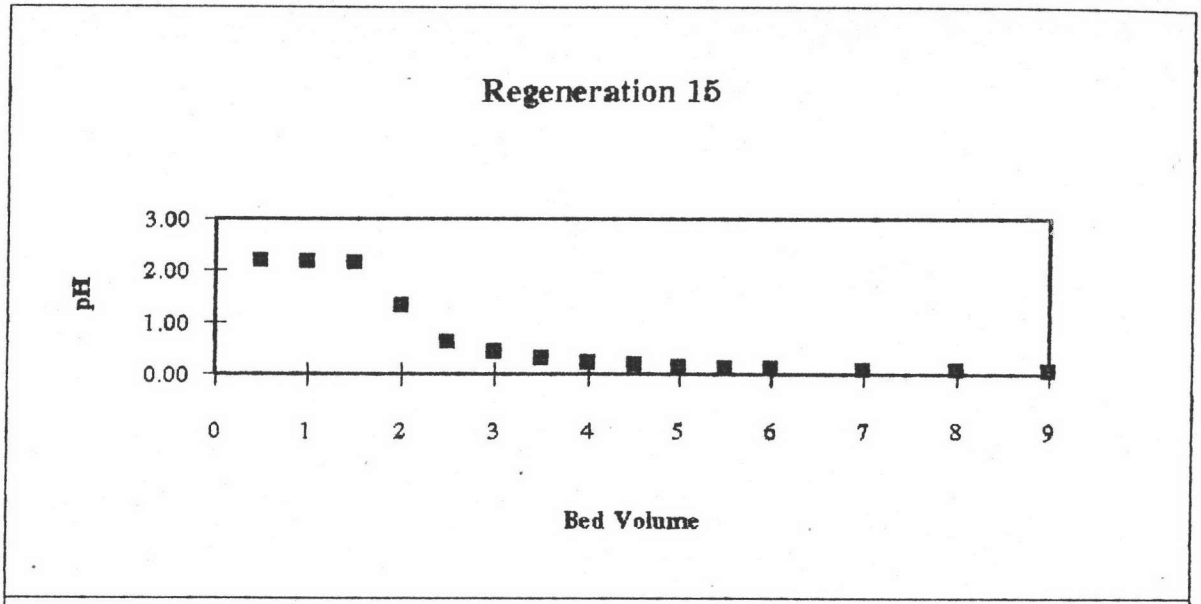

Service 15
pH
4
2
0
0
5
10
15
20
25
30
35
Bed Volume
Service 15
Conductivity (mS/cm.)
6
4
2
0
0
5
10
15
20
25
30
35
Bed Volume
Service 15
Ni. Conc. (mg/L)
100.0
50.0
0.0
0
5
10
15
20
25
30
35
Bed Volume

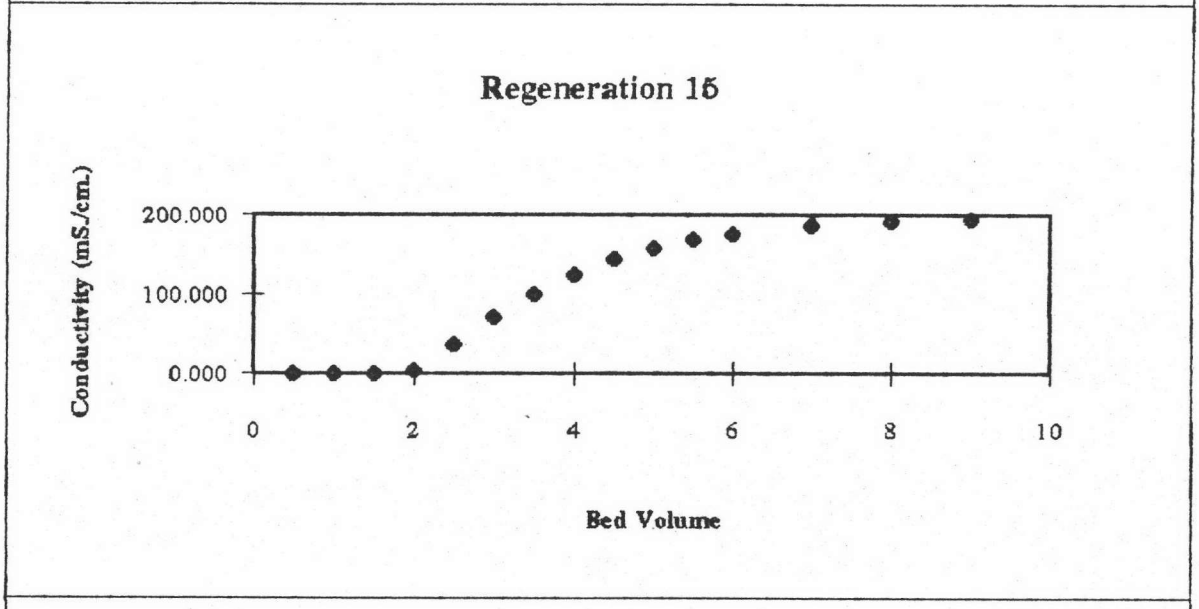
EXPERIMENT 15 Regeneration

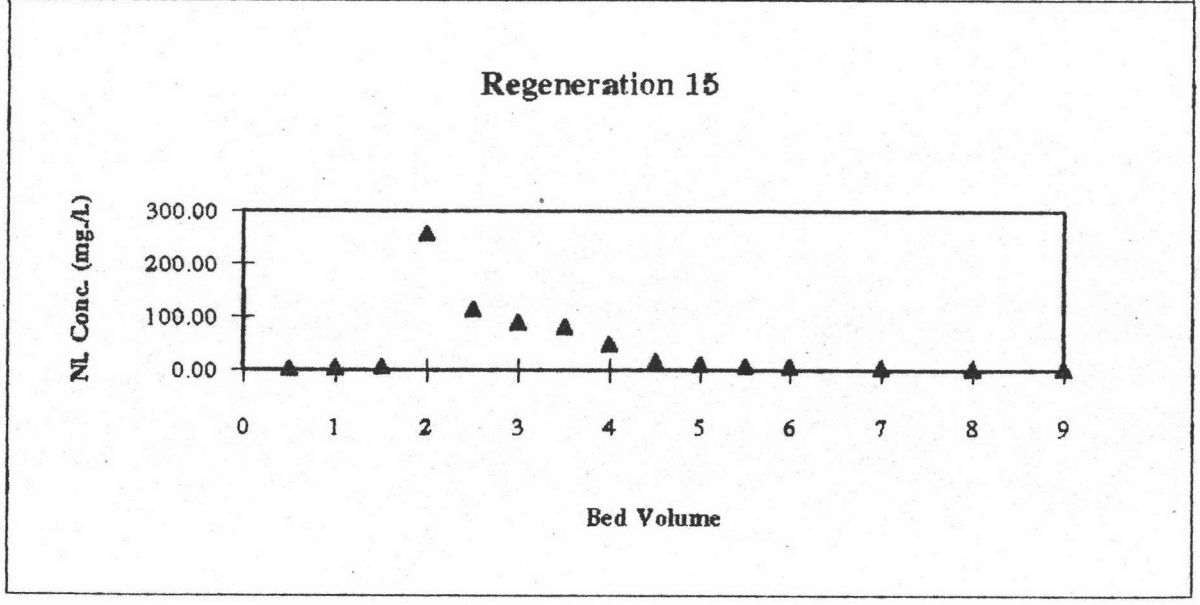
Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	6	0.06	196.0	0.75

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	2.20	0.236	2.70	0.00	0.00	0.00	0.68	0.68	1.35
2	1	2.18	0.259	3.60	0.00	0.00	0.00	1.6	2.3	2.25
3	1.5	2.14	0.297	5.27	0.00	0.00	0.01	2.2	4.5	2.98
4	2	1.33	4.59	257.3	0.21	0.11	0.12	65.6	70.1	35.06
5	2.5	0.63	37.0	114.1	0.09	0.15	0.27	92.9	163.0	65.19
6	3	0.43	70.3	89.9	0.07	0.08	0.36	51.0	214.0	71.33
7	3.5	0.31	99.0	82.4	0.07	0.07	0.43	43.1	257.1	73.45
8	4	0.23	123.5	48.5	0.04	0.05	0.48	32.7	289.8	72.45
9	4.5	0.18	144.1	16.85	0.01	0.03	0.51	16.3	306.1	68.03
10	5	0.15	157.9	10.94	0.01	0.01	0.52	6.9	313.1	62.61
11	5.5	0.13	168.5	8.54	0.01	0.01	0.53	4.9	317.9	57.81
12	6	0.12	176.2	6.84	0.01	0.01	0.54	3.8	321.8	53.63
13	7	0.09	186.7	4.42	0.01	0.01	0.54	5.6	327.4	46.77
14	8	0.07	192.4	2.88	0.00	0.01	0.55	3.7	331.1	41.38
15	9	0.07	195.1	1.48	0.00	0.00	0.55	2.2	333.2	37.03


Regeneration 15
pH
3.00
2.00
1.00
0.00
0
1
2
3
4
5
6
7
8
9
Bed Volume


Regeneration 15
Conductivity (mS./cm.)
200.000
100.000
0.000
0
2
4
6
8
10
Bed Volume


Regeneration 15
NL Conc. (mg./L)
300.00
200.00
100.00
0.00
0
1
2
3
4
5
6
7
8
9
Bed Volume

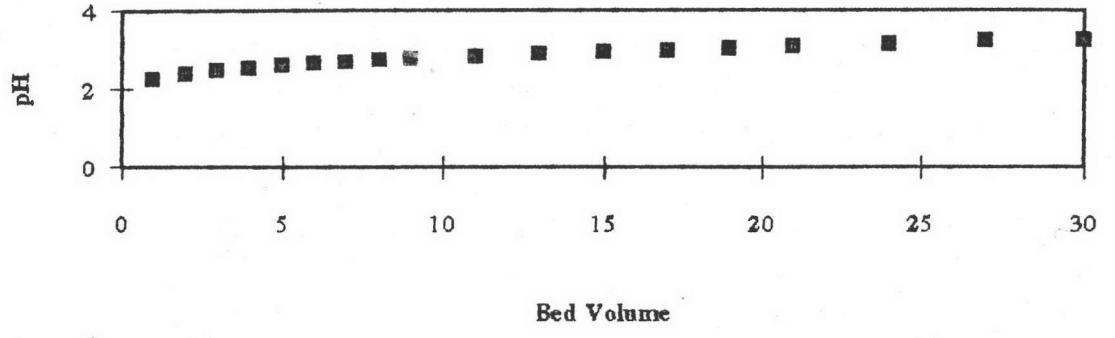
EXPERIMENT 16 Service

Column Size ∅ 6.75*100 cm.

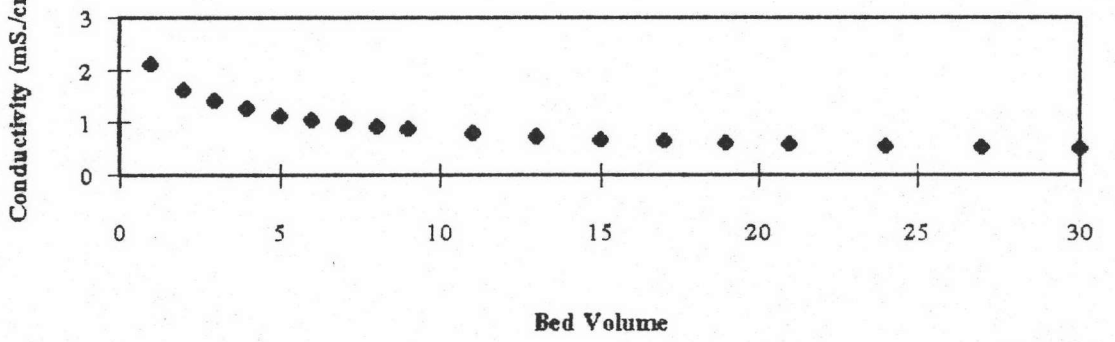
Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	6	6.35	0.339	101.7

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2.26	2.12	44.4	0.44	0.22	0.78	0.78	79.50
2	2	2.39	1.63	54.8	0.54	0.49	0.51	1.29	131.60
3	3	2.47	1.425	64.9	0.64	0.59	0.41	1.71	173.45
4	4	2.53	1.27	67.6	0.66	0.65	0.35	2.05	208.90
5	5	2.6	1.135	69.1	0.68	0.67	0.33	2.38	242.25
6	6	2.65	1.048	71.3	0.70	0.69	0.31	2.69	273.75
7	7	2.69	0.982	73.2	0.72	0.71	0.29	2.98	303.20
8	8	2.74	0.92	75.4	0.74	0.73	0.27	3.25	330.60
9	9	2.77	0.885	77.8	0.76	0.75	0.25	3.50	355.70
10	11	2.83	0.81	80.9	0.80	0.78	0.44	3.94	400.40
11	13	2.91	0.731	80.3	0.79	0.79	0.41	4.35	442.60
12	15	2.97	0.686	85.6	0.84	0.82	0.37	4.72	480.10
13	17	3	0.666	92.6	0.91	0.88	0.25	4.97	505.30
14	19	3.04	0.626	89.4	0.88	0.89	0.21	5.18	526.70
15	21	3.1	0.588	88.2	0.87	0.87	0.25	5.43	552.50
16	24	3.16	0.565	93.2	0.92	0.89	0.32	5.76	585.50
17	27	3.22	0.531	91.6	0.90	0.91	0.27	6.03	613.40
18	30	3.27	0.511	94.1	0.93	0.91	0.26	6.29	639.95

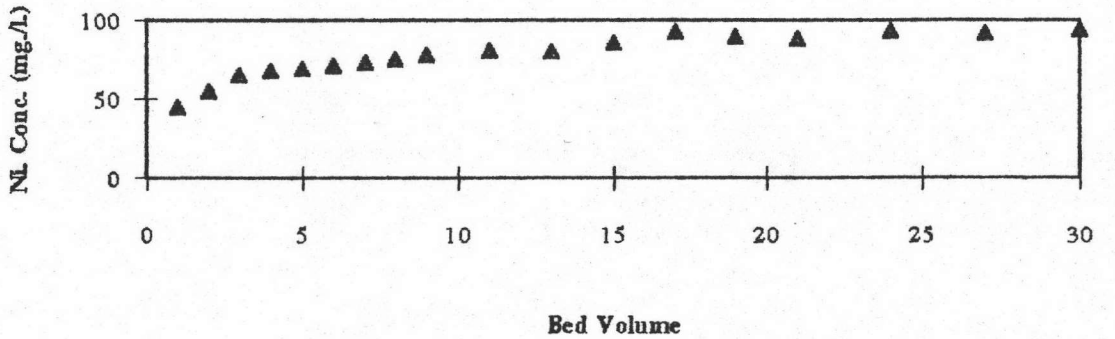
Service 16



Service 16



Service 16

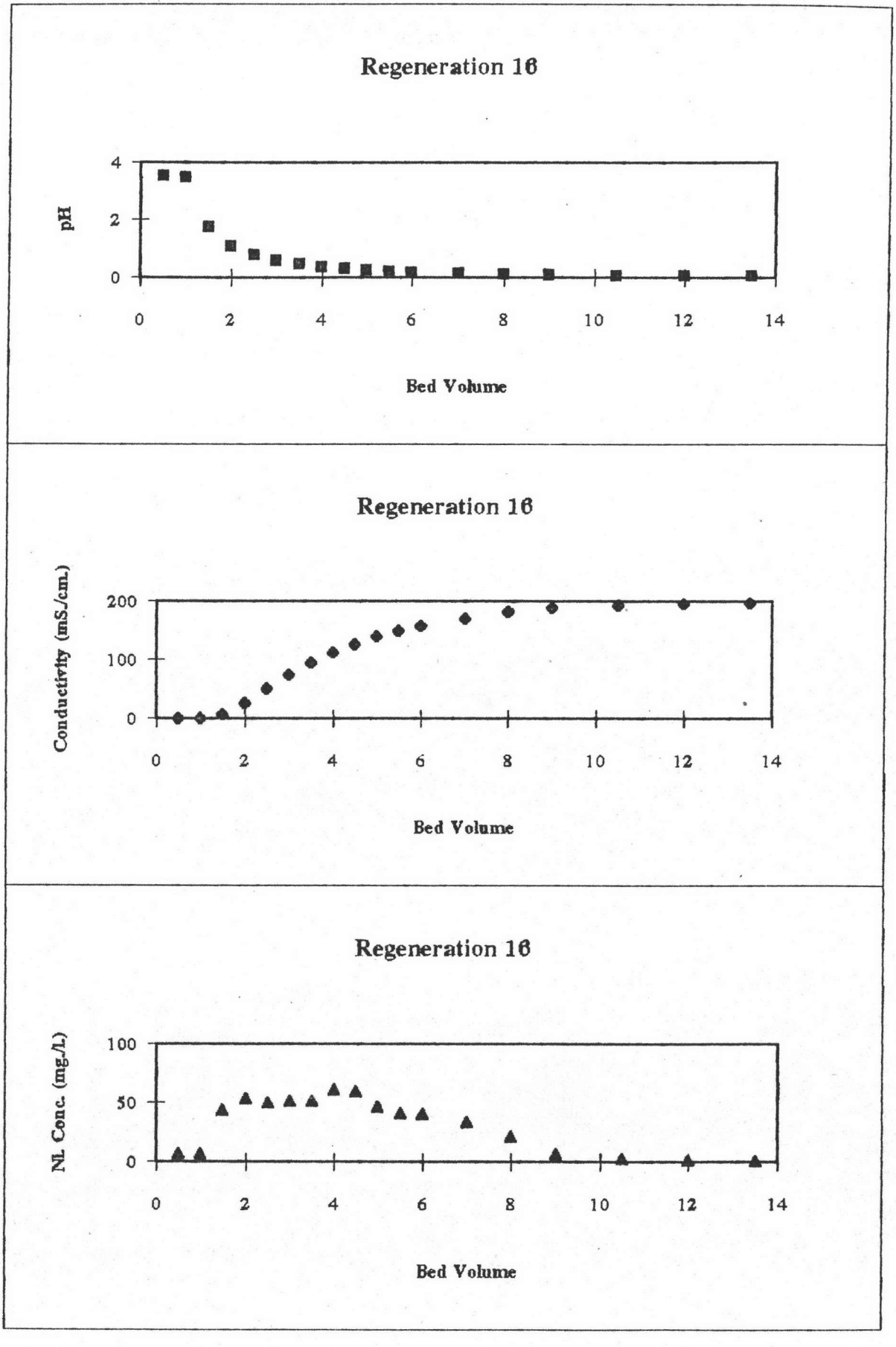


EXPERIMENT 16 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV/Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	9	0.05	196.3	0.75

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.53	0.1724	6.91	0.01	0.00	0.00	1.73	1.73	3.48
2	1	3.47	0.1753	6.69	0.01	0.01	0.01	3.4	5.1	5.13
3	1.5	1.75	6.57	43.5	0.03	0.02	0.03	12.5	17.7	11.78
4	2	1.09	25.9	53.5	0.04	0.04	0.07	24.3	41.9	20.96
5	2.5	0.77	50.6	50.3	0.04	0.04	0.11	26.0	67.9	27.15
6	3	0.58	74.3	51.3	0.04	0.04	0.15	25.4	93.3	31.09
7	3.5	0.46	94.3	51.4	0.04	0.04	0.19	25.7	119.0	33.99
8	4	0.37	112	61.3	0.05	0.04	0.23	28.2	147.1	36.78
9	4.5	0.3	126.6	59.6	0.05	0.05	0.28	30.2	177.4	39.41
10	5	0.25	139.7	46.3	0.04	0.04	0.32	26.5	203.8	40.77
11	5.5	0.2	149.4	41.4	0.03	0.03	0.35	21.9	225.8	41.05
12	6	0.18	157.4	40.3	0.03	0.03	0.38	20.4	246.2	41.03
13	7	0.13	170.5	33.5	0.05	0.04	0.43	36.9	283.1	40.44
14	8	0.1	181.8	21.16	0.03	0.04	0.47	27.3	310.4	38.80
15	9	0.07	188.7	6.94	0.01	0.02	0.49	14.1	324.5	36.05
16	10.5	0.06	193.2	2.99	0.01	0.01	0.50	7.4	331.9	31.61
17	12	0.05	196.8	1.53	0.00	0.01	0.51	3.4	335.3	27.94
18	13.5	0.05	197.1	0.94	0.00	0.00	0.51	1.9	337.1	24.97

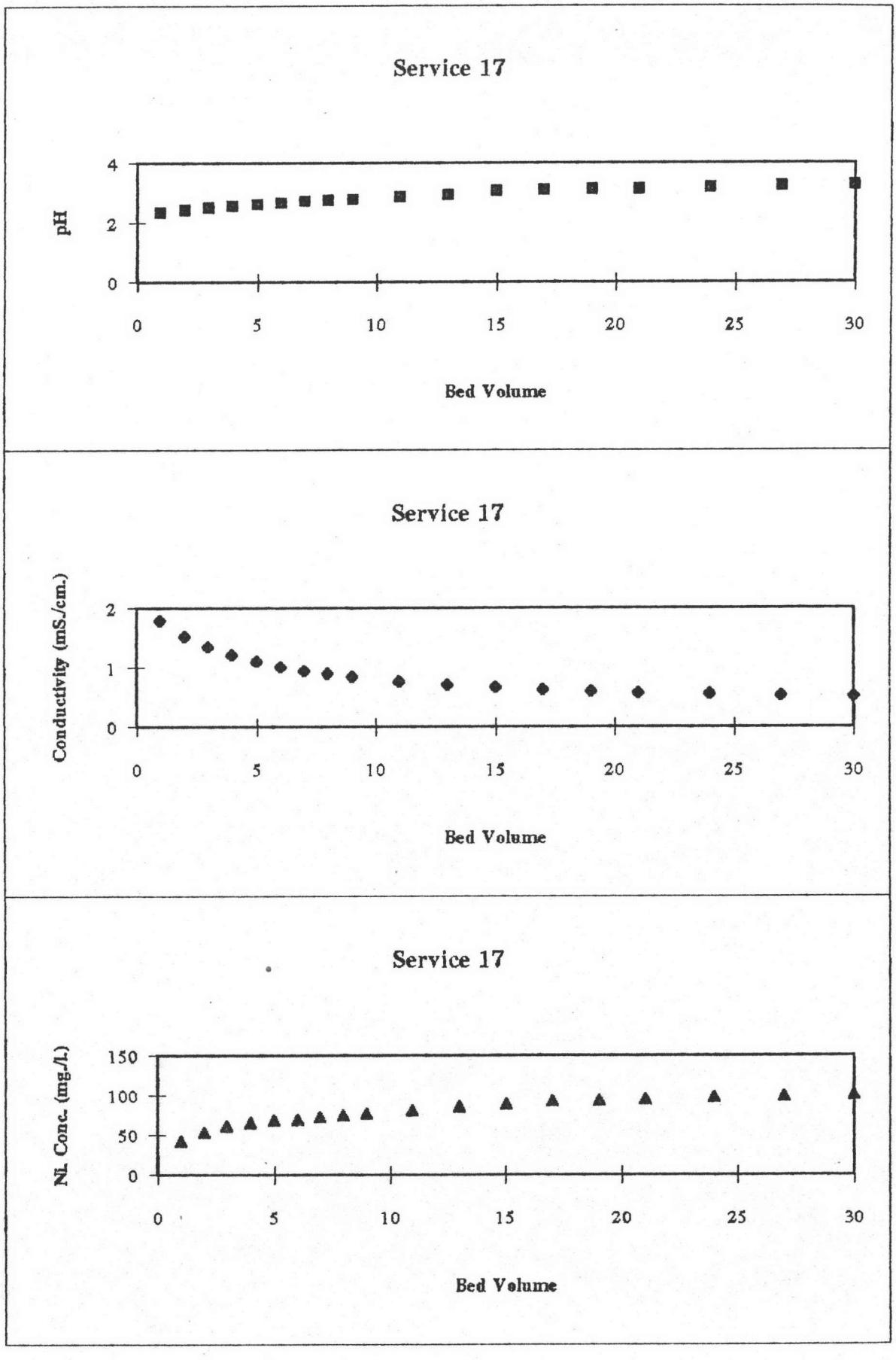

Regeneration 16
pH
4
2
0
0
2
4
6
8
10
12
14
Bed Volume
Regeneration 16
Conductivity (mS/cm)
200
100
0
0
2
4
6
8
10
12
14
Bed Volume
Regeneration 16
NL Conc. (mg/L)
100
50
0
0
2
4
6
8
10
12
14
Bed Volume

EXPERIMENT 17 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	6	6	0.337	104.3

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l resin)
					Value	Average	Value	Cumulation	
1	1	2.33	1.795	41.6	0.40	0.20	0.80	0.80	83.50
2	2	2.42	1.527	52.6	0.50	0.45	0.55	1.35	140.70
3	3	2.49	1.345	61.1	0.59	0.55	0.45	1.80	188.15
4	4	2.56	1.207	65.3	0.63	0.61	0.39	2.20	229.25
5	5	2.61	1.099	68.2	0.65	0.64	0.36	2.56	266.80
6	6	2.66	1.011	69.1	0.66	0.66	0.34	2.90	302.45
7	7	2.71	0.94	72.5	0.70	0.68	0.32	3.22	335.95
8	8	2.75	0.9	74.4	0.71	0.70	0.30	3.52	366.80
9	9	2.78	0.839	76.7	0.74	0.72	0.28	3.79	395.55
10	11	2.86	0.764	81.1	0.78	0.76	0.49	4.28	446.35
11	13	2.93	0.704	85.5	0.82	0.80	0.40	4.68	488.35
12	15	3.08	0.66	88.6	0.85	0.83	0.33	5.01	522.85
13	17	3.11	0.625	92.5	0.89	0.87	0.26	5.28	550.35
14	19	3.14	0.598	94.2	0.90	0.90	0.21	5.49	572.25
15	21	3.14	0.575	95.1	0.91	0.91	0.19	5.67	591.55
16	24	3.18	0.553	97.7	0.94	0.92	0.23	5.90	615.25
17	27	3.23	0.53	99.2	0.95	0.94	0.17	6.07	632.80
18	30	3.27	0.515	101.5	0.97	0.96	0.11	6.18	644.65

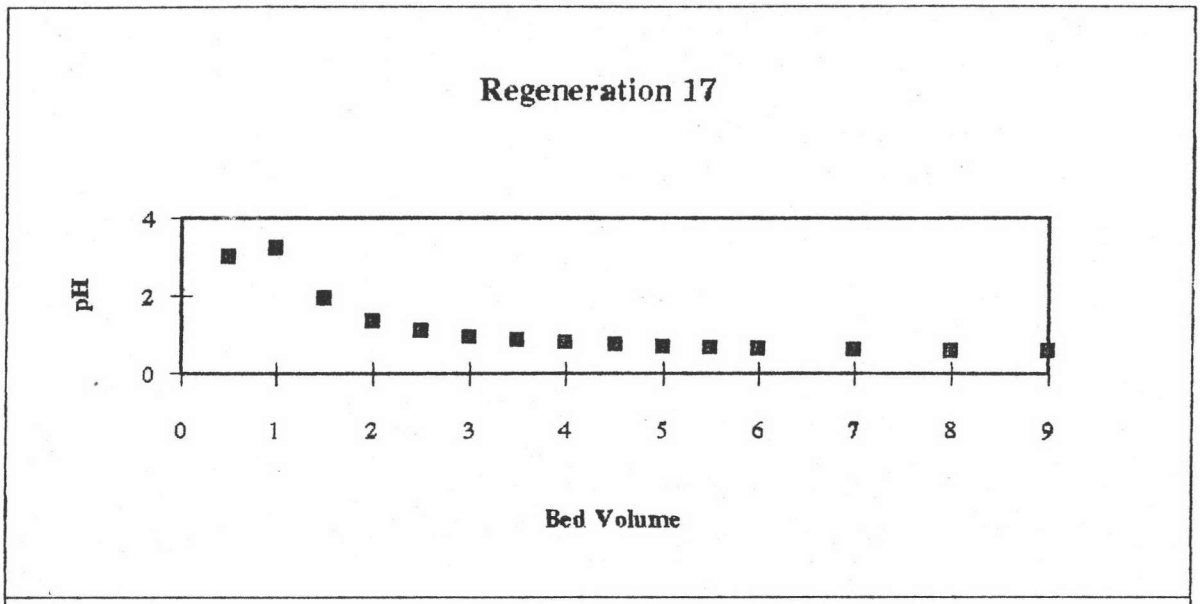

Service 17
pH
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 17
Conductivity (mS./cm.)
2
1
0
0
5
10
15
20
25
30
Bed Volume
Service 17
Ni. Conc. (mg./L)
150
100
50
0
0
5
10
15
20
25
30
Bed Volume

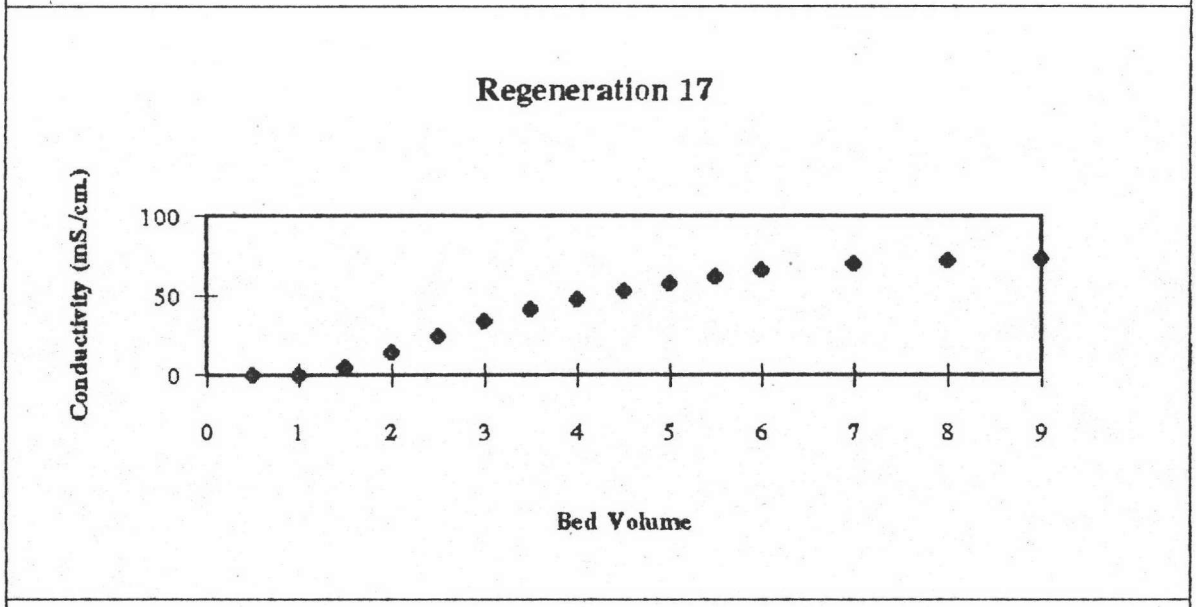
EXPERIMENT 17 Regeneration

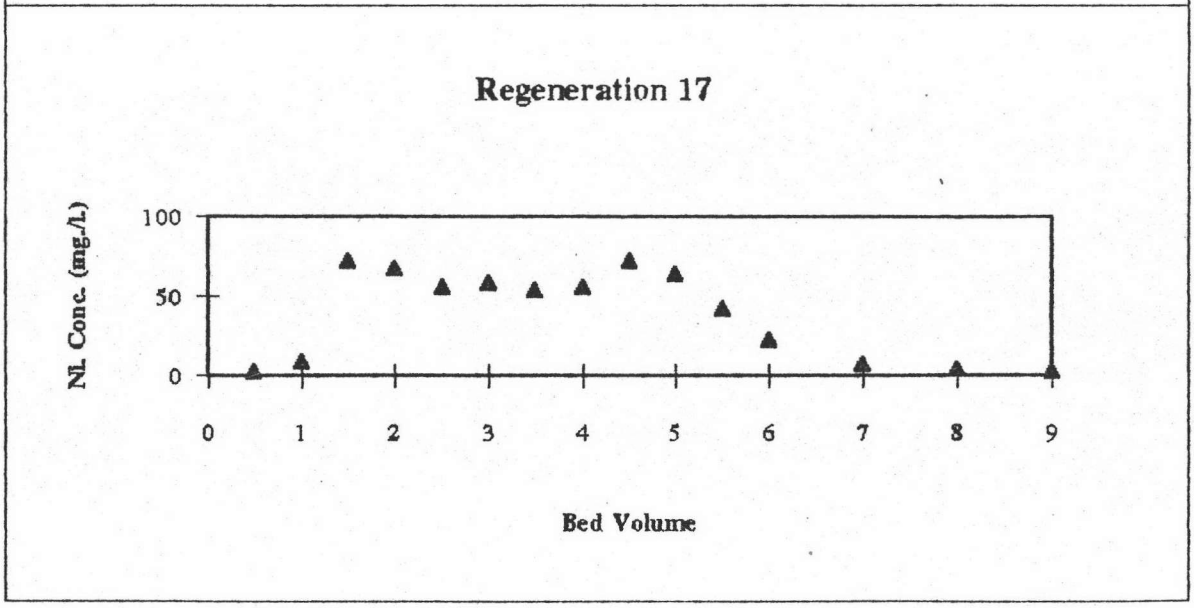
Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	3	0.57	74.4	0.25

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc (mg./l.)	Total Regenerated Nickel / Total exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.02	0.324	2.73	0.00	0.00	0.00	0.68	0.68	1.37
2	1	3.24	0.264	8.65	0.01	0.00	0.01	2.8	3.5	3.53
3	1.5	1.92	4.51	71.8	0.06	0.03	0.04	20.1	23.6	15.76
4	2	1.36	14.12	67.6	0.05	0.05	0.09	34.9	58.5	29.25
5	2.5	1.1	24.8	55.5	0.04	0.05	0.14	30.8	89.3	35.71
6	3	0.95	33.9	58.4	0.05	0.04	0.18	28.5	117.7	39.25
7	3.5	0.86	41.2	53.9	0.04	0.04	0.23	28.1	145.8	41.66
8	4	0.79	47.8	56	0.04	0 04	0.27	27.5	173.3	43.32
9	4 5	0.74	53.1	72	0.06	0.05	0.32	32.0	205.3	45.62
10	5	0.7	58	63.9	0.05	0.05	0.37	34.0	239.3	47.85
11	5.5	0.67	62	42.5	0.03	0.04	0.41	26.6	265.9	48.34
12	6	0.64	65.8	22.4	0.02	0.03	0.44	16.2	282.1	47.02
13	7	0.6	70.2	7.72	0.01	0.01	0.45	15.1	297.2	42.45
14	8	0.59	72.1	4.17	0.01	0.01	0.46	5.9	303.1	37.89
15	9	0.58	73.4	2.45	0.00	0.01	0.47	3.3	306.4	34.05


Regeneration 17
pH
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume


Regeneration 17
Conductivity (mS./cm.)
100
50
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

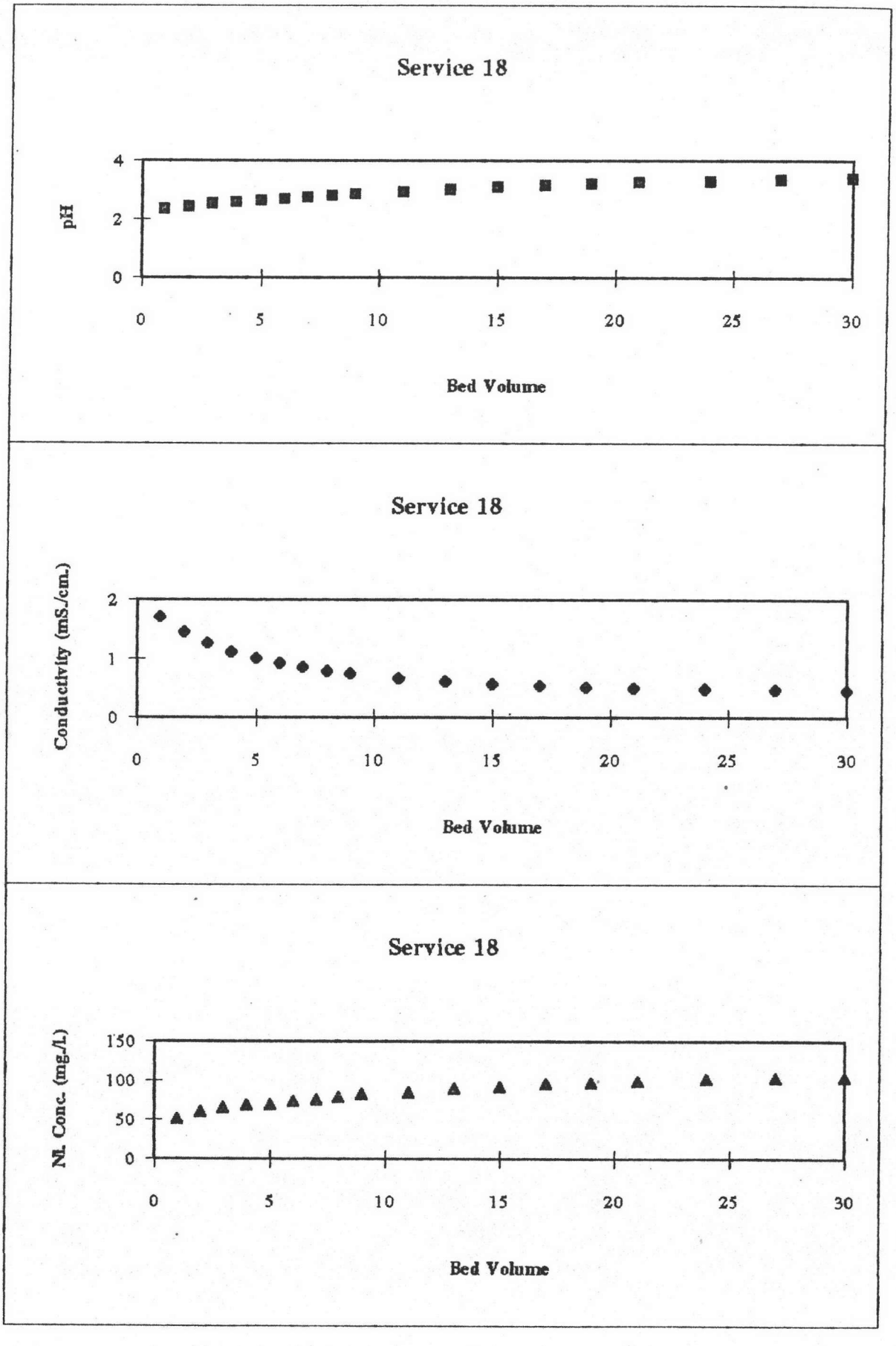

Regeneration 17
NL Conc. (mg./L)
100
50
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

EXPERIMENT 18 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	6	6.35	0.337	109.5

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Cono. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l resin)
					Value	Average	Value	Cumulation	
1	1	2.34	1.715	50.6	0.46	0.23	0.77	0.77	84.20
2	2	2.43	1.45	60	0.55	0.51	0.49	1.26	138.40
3	3	2.52	1.261	65.2	0.60	0.57	0.43	1.69	185.30
4	4	2.59	1.11	68	0.62	0.61	0.39	2.08	228.20
5	5	2.65	1.007	69.8	0.64	0.63	0.37	2.45	268.80
6	6	2.7	0.928	73.2	0.67	0.65	0.35	2.80	306.80
7	7	2.76	0.854	75.2	0.69	0.68	0.32	3.12	342.10
8	8	2.81	0.793	78.8	0.72	0.70	0.30	3.42	374.60
9	9	2.86	0.747	82.7	0.76	0.74	0.26	3.68	403.35
10	11	2.95	0.666	85	0.78	0.77	0.47	4.15	454.65
11	13	3.03	0.612	89.3	0.82	0.80	0.41	4.56	499.35
12	15	3.1	0.573	92.3	0.84	0.83	0.34	4.90	536.75
13	17	3.16	0.544	96.1	0.88	0.86	0.28	5.18	567.35
14	19	3.21	0.519	97.4	0.89	0.88	0.23	5.41	592.85
15	21	3.26	0.503	98.8	0.90	0.90	0.21	5.62	615.85
16	24	3.3	0.487	101.7	0.93	0.92	0.25	5.88	643.40
17	27	3.36	0.47	103.5	0.95	0.94	0.19	6.06	664.10
18	30	3.4	0.459	103.8	0.95	0.95	0.16	6.23	681.65

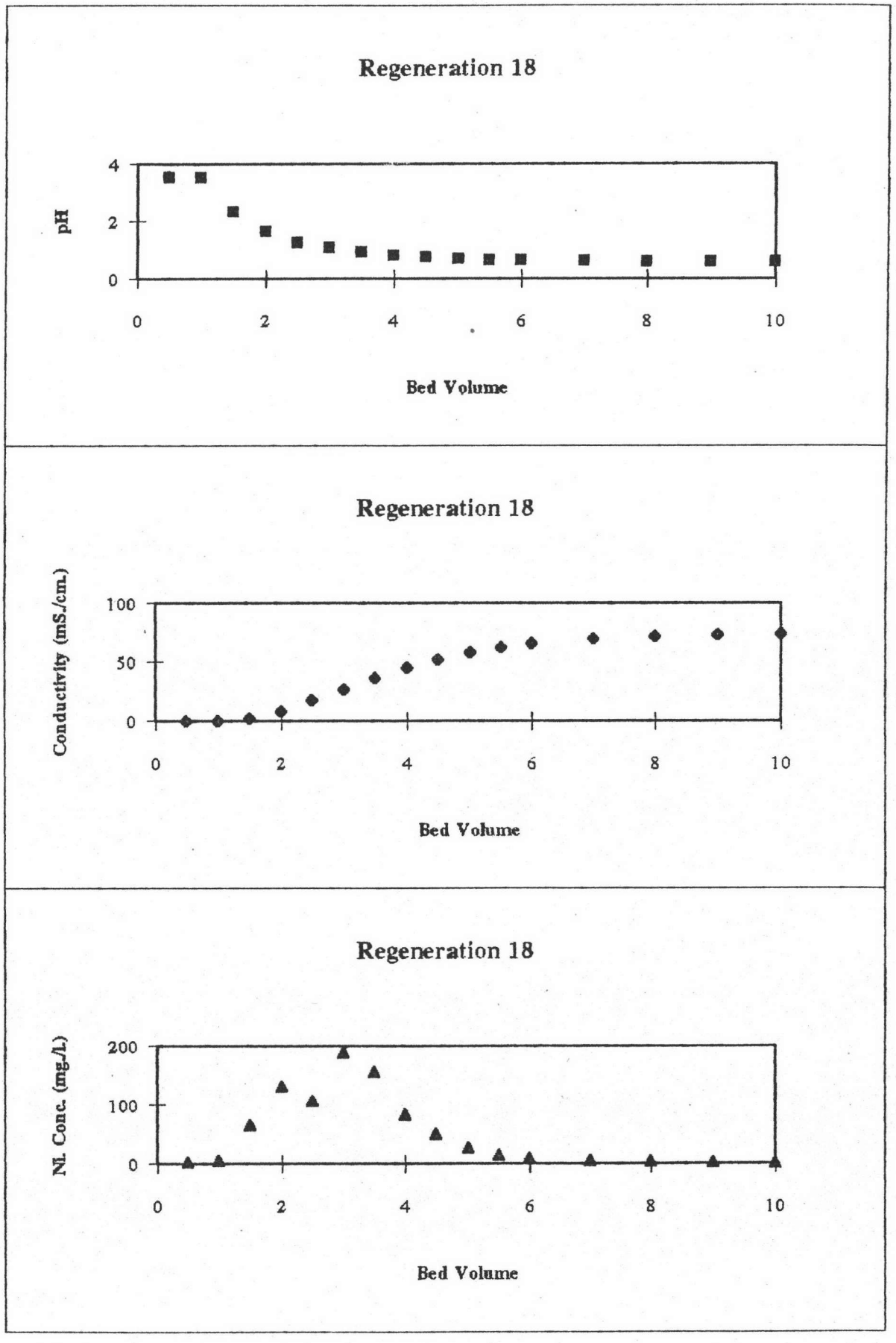

Service 18
pH
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 18
Conductivity (mS./cm.)
2
1
0
0
5
10
15
20
25
30
Bed Volume
Service 18
NL Conc. (mg./L)
150
100
50
0
0
5
10
15
20
25
30
Bed Volume

EXPERIMENT 18 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV/Hr.)	pH	Conductivity (mS/cm.)	Conc (Normal)
HCl	6	0.57	74.3	0.25

Effluent NO.	Bed Volume	pH	Conductivity (mS/cm.)	Ni reg. Conc (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.53	0.1371	2.71	0.00	0.00	0.00	0.68	0.68	1.36
2	1	3.53	0.1363	5.33	0.00	0.00	0.00	2.0	2.7	2.69
3	1.5	2.32	1.954	65.1	0.05	0.03	0.03	17.6	20.3	13.53
4	2	1.63	8.23	131.1	0.10	0.07	0.10	49.1	69.3	34.67
5	2.5	1.26	17.47	106.9	0.08	0.09	0.19	59.5	128.8	51.54
6	3	1.07	26.5	189.1	0.14	0.11	0.30	74.0	202.8	67.62
7	3.5	0.92	36.3	156	0.11	0.13	0.42	86.3	289.1	82.61
8	4	0.81	45.3	84	0.06	0.09	0.51	60.0	349.1	87.28
9	4.5	0.74	52	51.2	0.04	0.05	0.56	33.8	382.9	85.09
10	5	0.69	58.3	27.4	0.02	0.03	0.59	19.7	402.6	80.51
11	5.5	0.65	62.5	14.56	0.01	0.02	0.61	10.5	413.1	75.10
12	6	0.63	65.8	9.53	0.01	0.01	0.61	6.0	419.1	69.85
13	7	0.6	69.7	5.86	0.01	0.01	0.62	7.7	426.8	60.97
14	8	0.58	71.9	3.74	0.01	0.01	0.63	4.8	431.6	53.95
15	9	0.58	73.2	2.45	0.00	0.00	0.63	3.1	434.7	48.30
16	10	0.57	73.7	1.66	0.00	0.00	0.64	2.1	436.7	43.67

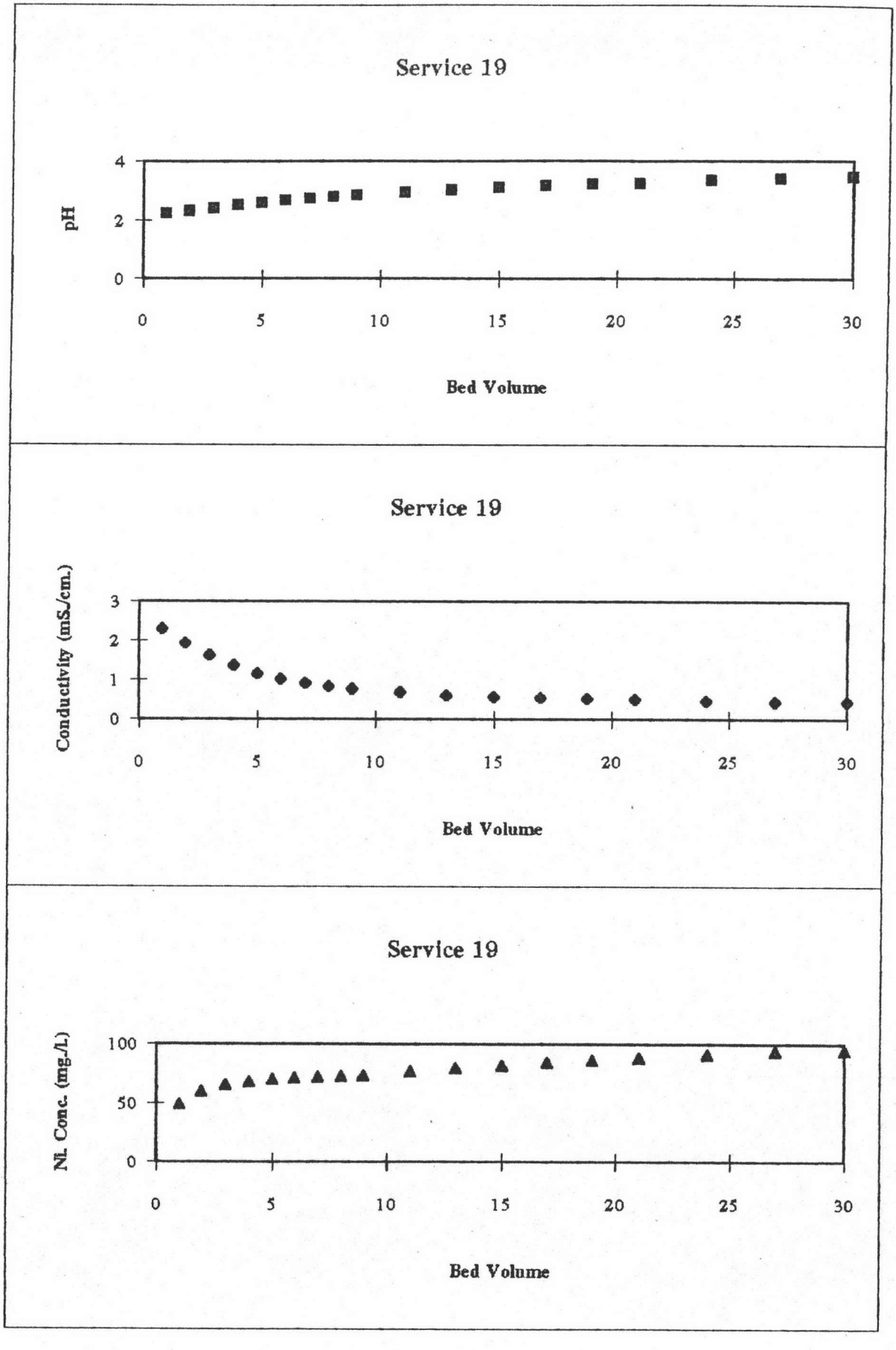

Regeneration 18
pH
4
2
0
0
2
4
6
8
10
Bed Volume
Regeneration 18
Conductivity (mS./cm.)
100
50
0
0
2
4
6
8
10
Bed Volume
Regeneration 18
Ni. Conc. (mg./L)
200
100
0
0
2
4
6
8
10
Bed Volume

EXPERIMENT 19 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni. in conc. (mg./l.)
synthetic	6	6.42	0.339	98.8

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni.eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l resin)
					Value	Average	Value	Cumulation	
1	1	2.22	2.31	48.7	0.49	0.25	0.75	0.75	74.45
2	2	2.31	1.94	60	0.61	0.55	0.45	1.20	118.90
3	3	2.4	1.642	65.5	0.66	0.64	0.36	1.57	154.95
4	4	2.5	1.361	67.8	0.69	0.67	0.33	1.89	187.10
5	5	2.58	1.171	69.8	0.71	0.70	0.30	2.20	217.10
6	6	2.66	1.03	71.4	0.72	0.71	0.29	2.48	245.30
7	7	2.72	0.922	72.4	0.73	0.73	0.27	2.76	272.20
8	8	2.78	0.843	73	0.74	0.74	0.26	3.02	298.30
9	9	2.83	0.781	73.6	0.74	0.74	0.26	3.28	323.80
10	11	2.94	0.686	76.8	0.78	0.76	0.48	3.76	371.00
11	13	3.03	0.612	79.5	0.80	0.79	0.42	4.17	412.30
12	15	3.09	0.578	81.9	0.83	0.82	0.37	4.54	448.50
13	17	3.16	0.542	84.3	0.85	0.84	0.32	4.86	479.90
14	19	3.21	0.523	86.3	0.87	0.86	0.27	5.13	506.90
15	21	3.25	0.506	88.2	0.89	0.88	0.23	5.36	530.00
16	24	3.36	0.479	91.3	0.92	0.91	0.27	5.64	557.15
17	27	3.41	0.459	93.7	0.95	0.94	0.19	5.83	576.05
18	30	3.46	0.446	94.3	0.95	0.95	0.15	5.98	590.45

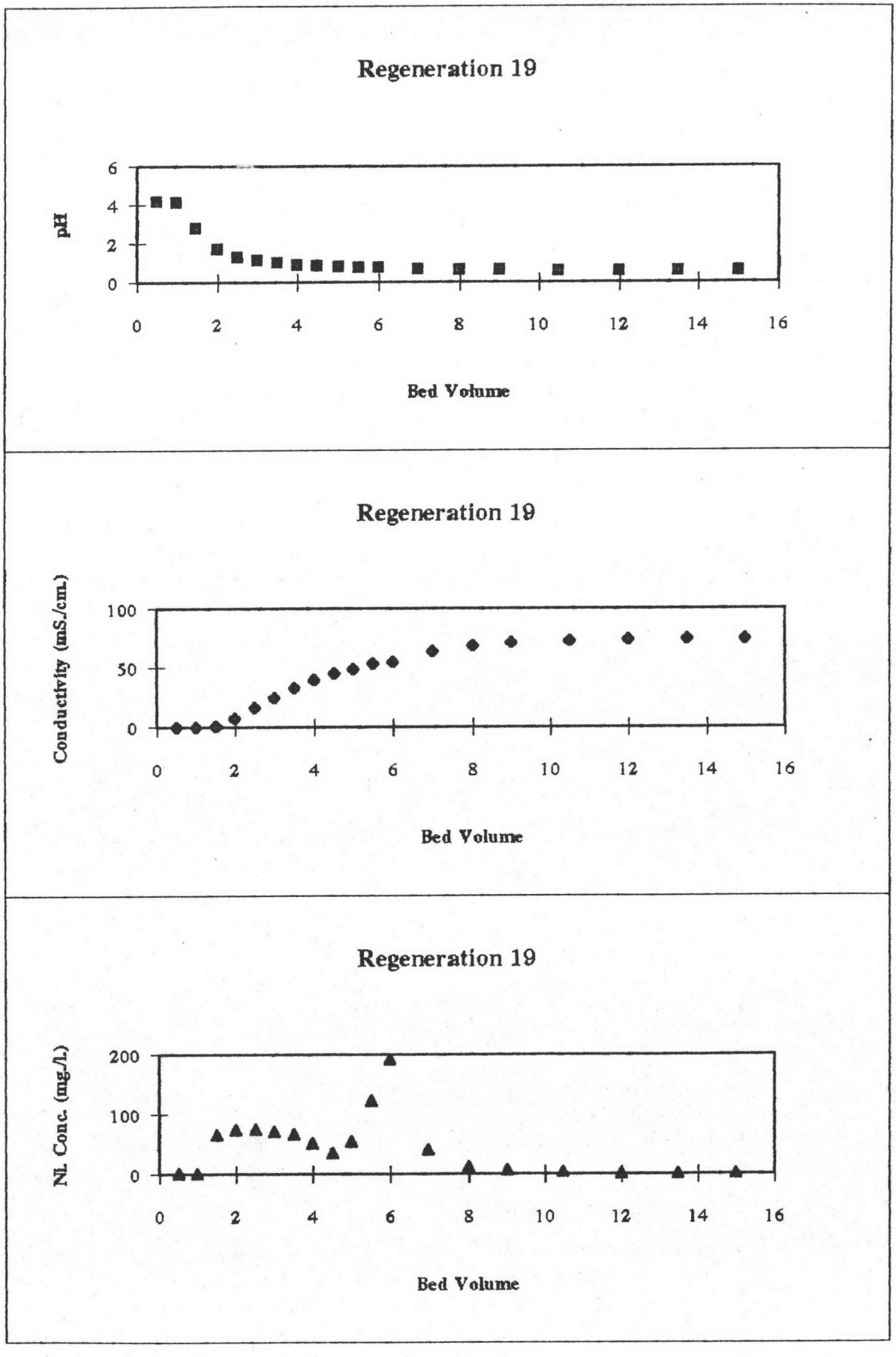

Service 19
pH
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 19
Conductivity (mS/cm.)
3
2
1
0
0
5
10
15
20
25
30
Bed Volume
Service 19
NL Conc. (mg/L)
100
50
0
0
5
10
15
20
25
30
Bed Volume

EXPERIMENT 19 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV /Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	9	0.58	74.6	0.25

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	4.18	0.0485	1.94	0.00	0.00	0.00	0.49	0.49	0.97
2	1	4.12	0.0478	1.88	0.00	0.00	0.00	1.0	1.4	1.44
3	1.5	2.8	0.922	65.8	0.06	0.03	0.03	16.9	18.4	12.24
4	2	1.7	7.28	73.9	0.06	0.06	0.09	34.9	53.3	26.64
5	2.5	1.3	16.43	74.8	0.06	0.06	0.15	37.2	90.5	36.18
6	3	1.11	24.9	70.5	0.06	0.06	0.21	36.3	126.8	42.26
7	3.5	0.98	32.7	66.1	0.06	0.06	0.27	34.2	160.9	45.98
8	4	0.89	39.4	51.2	0.04	0.05	0.32	29.3	190.3	47.57
9	4.5	0.83	45	35.7	0.03	0.04	0.36	21.7	212.0	47.11
10	5	0.79	48.9	54.6	0.05	0.04	0.40	22.6	234.6	46.91
11	5.5	0.75	53.2	122.6	0.10	0.08	0.47	44.3	278.9	50.70
12	6	0.73	54.8	192	0.16	0.13	0.61	78.7	357.5	59.59
13	7	0.66	63.8	40.5	0.07	0.12	0.72	116.3	473.8	67.68
14	8	0.62	68.5	12.11	0.02	0.04	0.77	26.3	500.1	62.51
15	9	0.61	71	6.44	0.01	0.02	0.78	9.3	509.3	56.59
16	10.5	0.59	72.8	3.54	0.01	0.01	0.79	7.5	516.8	49.22
17	12	0.59	73.8	2.04	0.01	0.01	0.80	4.2	521.0	43.42
18	13.5	0.58	74.4	1.34	0.00	0.00	0.80	2.5	523.5	38.78
19	15	0.58	74.6	1.01	0.00	0.00	0.81	1.8	525.3	35.02

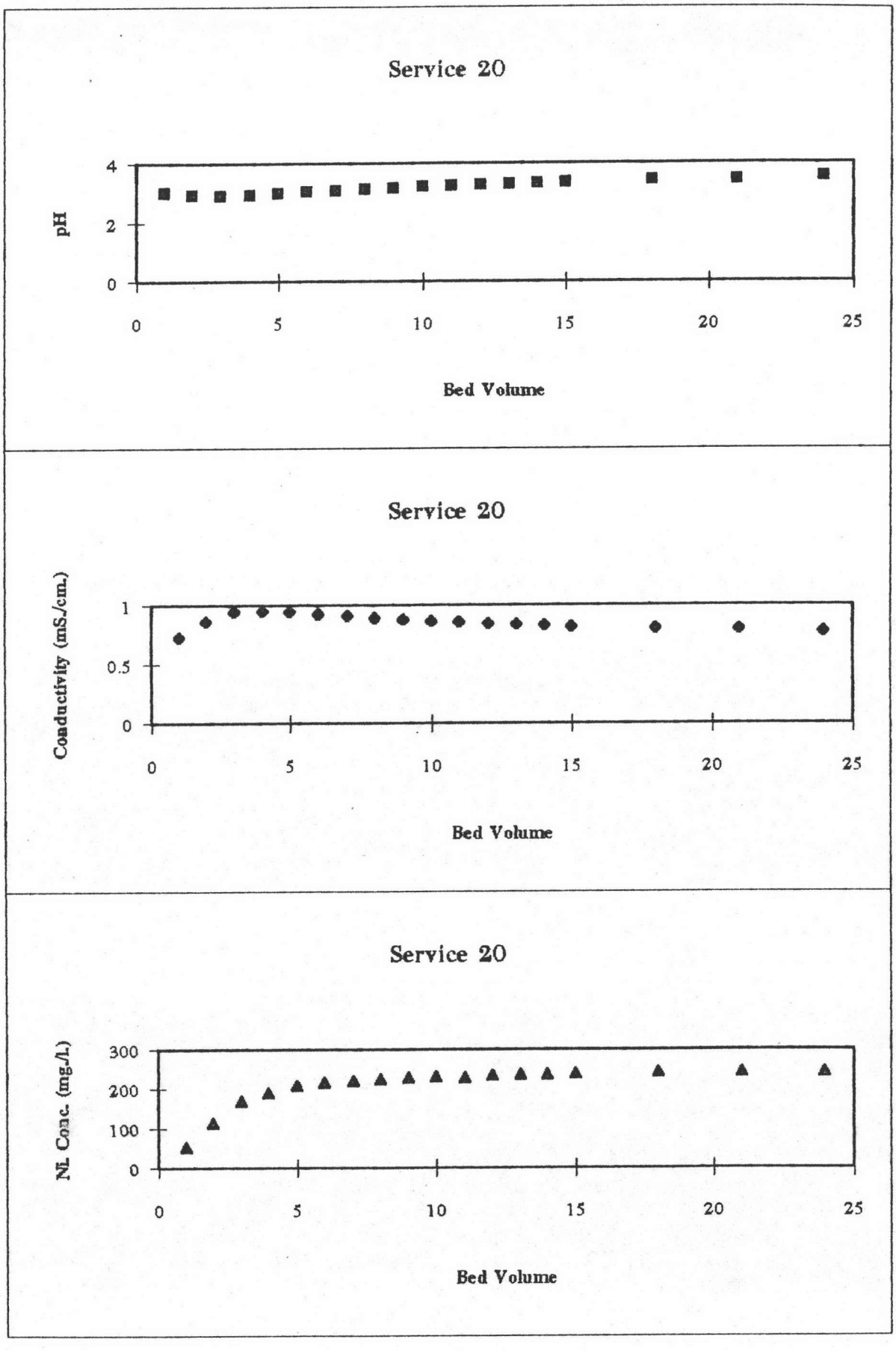

Regeneration 19
pH
6
4
2
0
0
2
4
6
8
10
12
14
16
Bed Volume
Regeneration 19
Conductivity (mS./cm.)
100
50
0
0
2
4
6
8
10
12
14
16
Bed Volume
Regeneration 19
NL Conc. (mg./L)
200
100
0
0
2
4
6
8
10
12
14
16
Bed Volume

EXPERIMENT 20 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	9	6.82	0.686	255.6

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	3.01	0.73	52.7	0.21	0.10	0.90	0.90	229.25
2	2	2.93	0.866	114.7	0.45	0.33	0.67	1.57	401.15
3	3	2.91	0.944	170.4	0.67	0.56	0.44	2.01	514.20
4	4	2.95	0.954	190.5	0.75	0.71	0.29	2.31	589.35
5	5	2.99	0.943	208.6	0.82	0.78	0.22	2.53	645.40
6	6	3.04	0.925	216.3	0.85	0.83	0.17	2.69	688.55
7	7	3.08	0.909	220	0.86	0.85	0.15	2.84	726.00
8	8	3.12	0.892	223.6	0.87	0.87	0.13	2.97	758.80
9	9	3.16	0.879	229	0.90	0.89	0.11	3.09	789.10
10	10	3.2	0.864	231.5	0.91	0.90	0.10	3.19	814.45
11	11	3.24	0.856	229.5	0.90	0.90	0.10	3.28	839.55
12	12	3.27	0.841	234.6	0.92	0.91	0.09	3.38	863.10
13	13	3.3	0.834	236.7	0.93	0.92	0.08	3.45	883.05
14	14	3.32	0.828	235.8	0.92	0.92	0.08	3.53	902.40
15	15	3.35	0.819	239	0.94	0.93	0.07	3.60	920.60
16	18	3.42	0.806	243.4	0.95	0.94	0.17	3.77	963.80
17	21	3.43	0.793	241.9	0.95	0.95	0.15	3.92	1002.65
18	24	3.54	0.777	243.6	0.95	0.95	0.15	4.07	1041.20

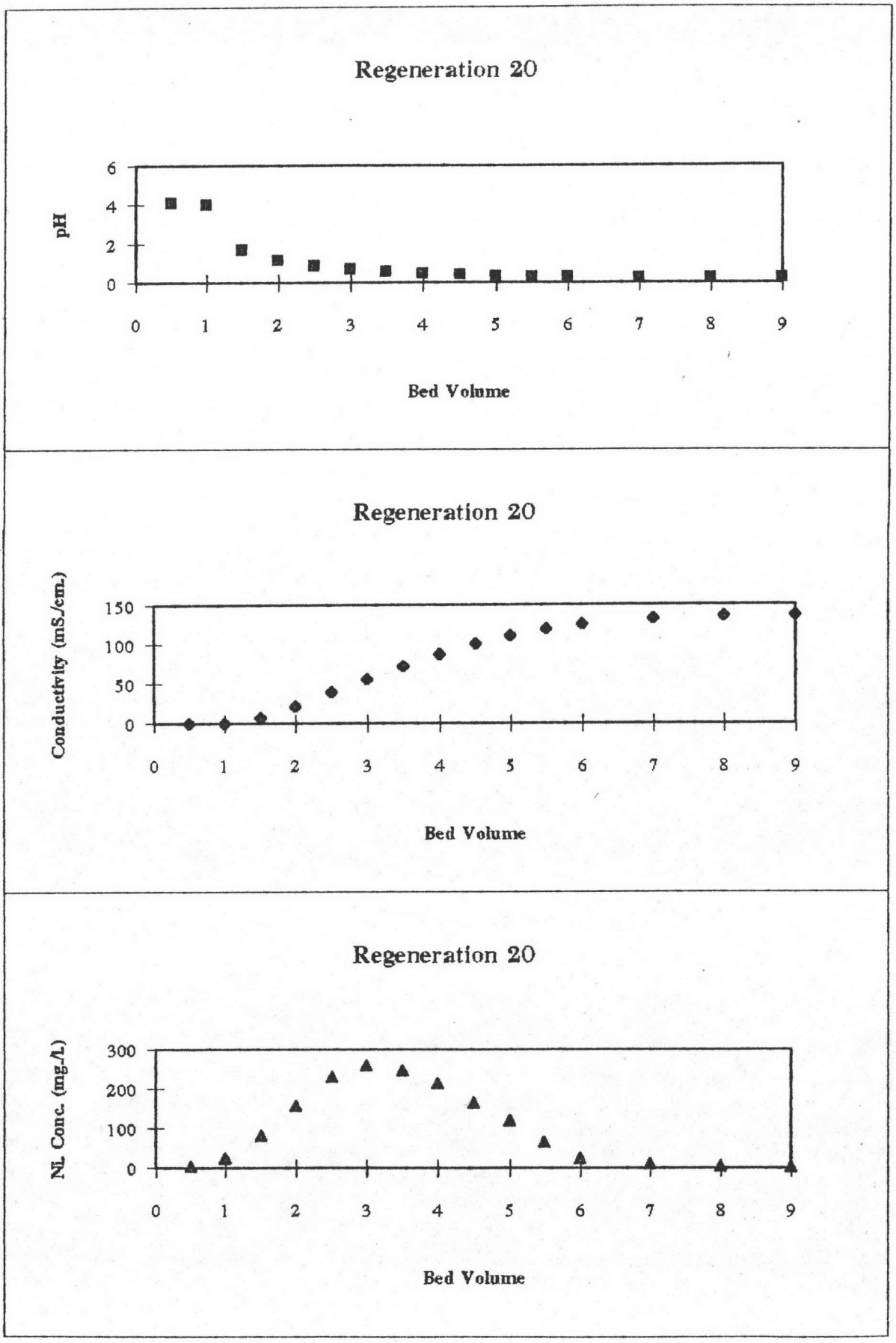

Service 20
pH
4
2
0
0
5
10
15
20
25
Bed Volume
Service 20
Conductivity (mS/cm)
1
0.5
0
0
5
10
15
20
25
Bed Volume
Service 20
NL Conc. (mg/L)
300
200
100
0
0
5
10
15
20
25
Bed Volume

EXPERIMENT 20 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	3	0.23	137.9	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni.reg Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	4.11	0.0467	3.08	0.00	0.00	0.00	0.77	0.77	1.54
2	1	4	0.1426	23.7	0.01	0.01	0.01	6.7	7.5	7.47
3	1.5	1.7	6.72	82.4	0.04	0.03	0.03	26.5	34.0	22.66
4	2	1.16	21.3	158.1	0.08	0.06	0.09	60.1	94.1	47.06
5	2.5	0.87	39.3	230.4	0.11	0.09	0.18	97.1	191.2	76.50
6	3	0.69	56.6	259.5	0.12	0.12	0.30	122.5	313.7	104.57
7	3.5	0.56	72.8	246.5	0.12	0.12	0.42	126.5	440.2	125.78
8	4	0.47	88.2	213.8	0.10	0.11	0.53	115.1	555.3	138.82
9	4.5	0.4	101.3	166.2	0.08	0.09	0.62	95.0	650.3	144.51
10	5	0.35	111.6	120.2	0.06	0.07	0.69	71.6	721.9	144.38
11	5.5	0.31	119.6	66	0.03	0.04	0.74	46.6	768.4	139.72
12	6	0.29	125.6	24.9	0.01	0.02	0.76	22.7	791.2	131.86
13	7	0.26	132.3	9.2	0.01	0.01	0.77	17.1	808.2	115.46
14	8	0.25	135.8	4.81	0.00	0.01	0.78	7.0	815.2	101.90
15	9	0.25	137.1	2.87	0.00	0.00	0.78	3.8	819.1	91.01

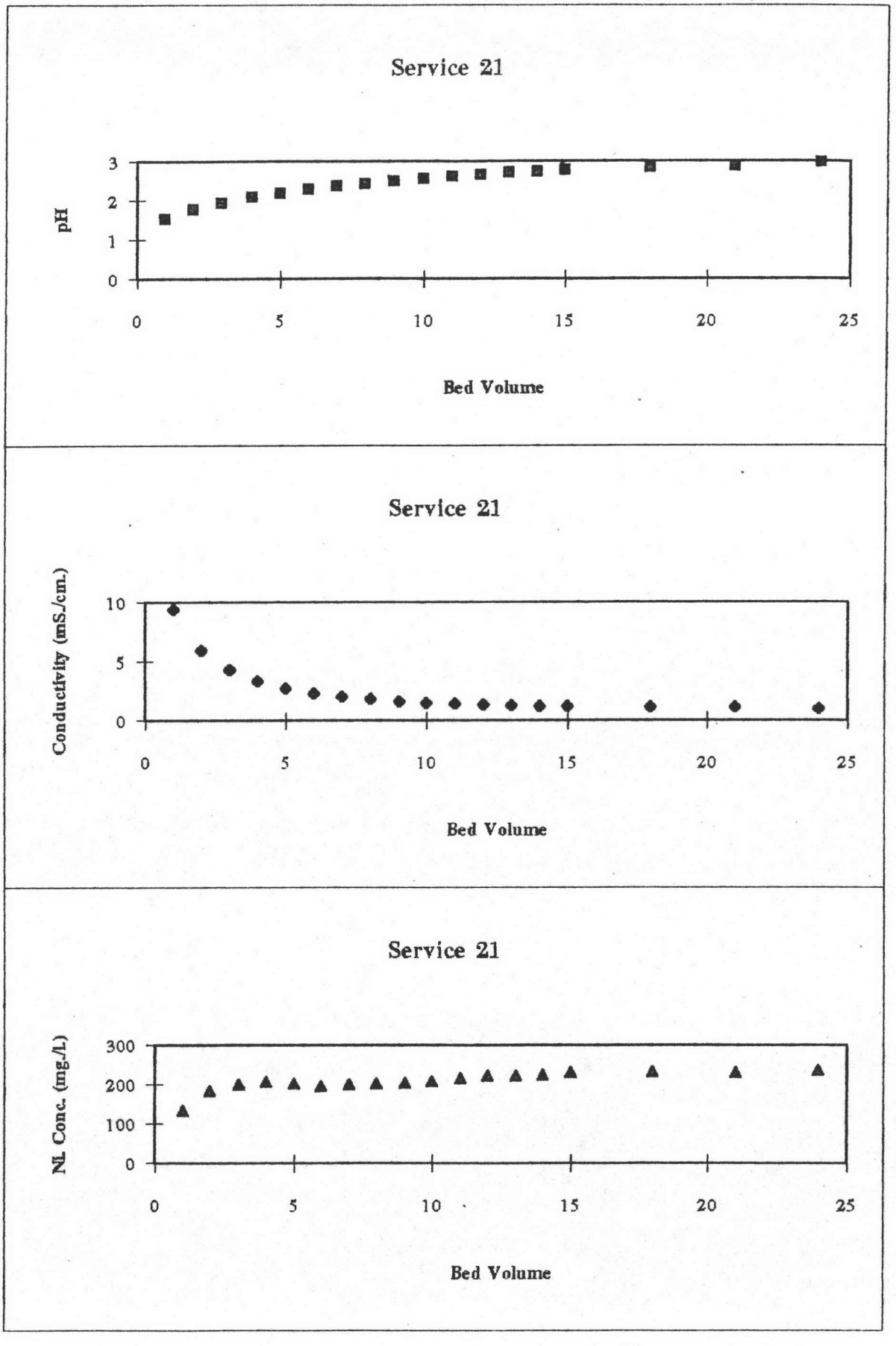

Regeneration 20
pH
6
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume
Regeneration 20
Conductivity (mS/cm.)
150
100
50
0
0 1 2 3 4 5 6 7 8 9
Bed Volume
Regeneration 20
NL Conc. (mg/L)
300
200
100
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

EXPERIMENT 21 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	9	6.76	0.688	253.8

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	1.54	9.39	133.5	0.53	0.26	0.74	0.74	187.05
2	2	1.77	5.94	184.5	0.73	0.63	0.37	1.11	281.85
3	3	1.94	4.26	199.9	0.79	0.76	0.24	1.35	343.45
4	4	2.08	3.32	205.7	0.81	0.80	0.20	1.55	394.45
5	5	2.19	2.69	201.7	0.79	0.80	0.20	1.75	444.55
6	6	2.29	2.28	195.4	0.77	0.78	0.22	1.97	499.80
7	7	2.36	2.02	200.9	0.79	0.78	0.22	2.19	555.45
8	8	2.43	1.807	201.1	0.79	0.79	0.21	2.40	608.25
9	9	2.5	1.642	205.1	0.81	0.80	0.20	2.60	658.95
10	10	2.56	1.522	209.1	0.82	0.82	0.18	2.78	705.65
11	11	2.61	1.434	215.6	0.85	0.84	0.16	2.94	747.10
12	12	2.66	1.361	222.2	0.88	0.86	0.14	3.08	782.00
13	13	2.71	1.296	222.9	0.88	0.88	0.12	3.20	813.25
14	14	2.74	1.254	224.1	0.88	0.88	0.12	3.32	843.55
15	15	2.78	1.21	231.1	0.91	0.90	0.10	3.43	869.75
16	18	2.84	1.155	232.3	0.92	0.91	0.26	3.69	936.05
17	21	2.87	1.128	231.6	0.91	0.91	0.26	3.95	1001.60
18	24	2.97	1.042	237.2	0.93	0.92	0.23	4.18	1059.80

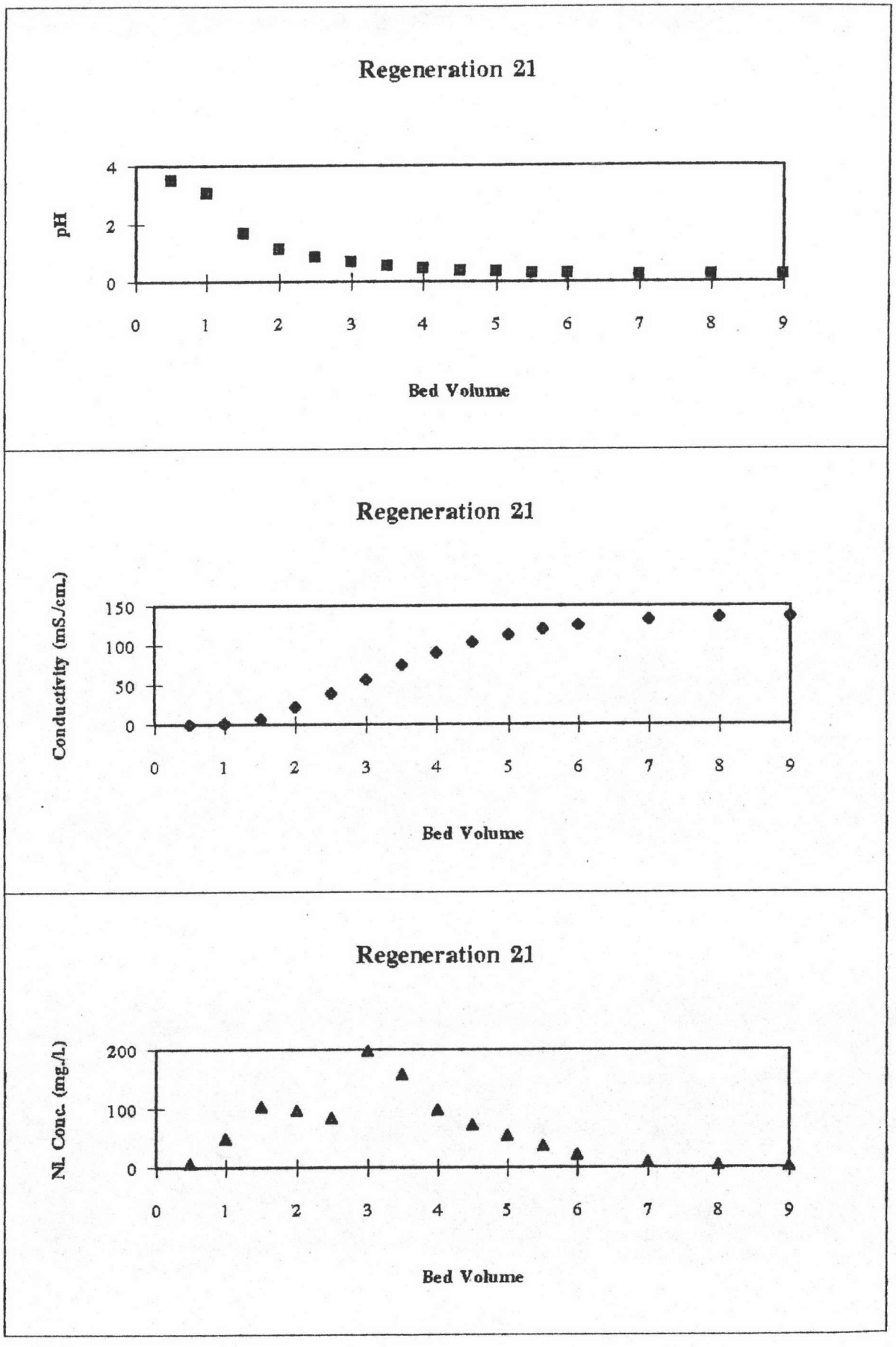

Service 21
pH
3
2
1
0
0
5
10
15
20
25
Bed Volume
Service 21
Conductivity (mS./cm.)
10
5
0
0
5
10
15
20
25
Bed Volume
Service 21
NL Conc. (mg./L)
300
200
100
0
0
5
10
15
20
25
Bed Volume

EXPERIMENT 21 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV /Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	6	0.25	138.5	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni.reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.5	0.1509	7.09	0.00	0.00	0.00	1.77	1.77	3.55
2	1	3.07	0.513	49.4	0.02	0.01	0.01	14.1	15.9	15.90
3	1.5	1.67	7.46	103.7	0.05	0.04	0.05	38.3	54.2	36.11
4	2	1.14	22.5	96.2	0.05	0.05	0.10	50.0	104.1	52.07
5	2.5	0.86	39.9	84.3	0.04	0.04	0.14	45.1	149.3	59.71
6	3	0.69	57.5	196.7	0.09	0.07	0.21	70.3	219.5	73.17
7	3.5	0.56	75.1	158.3	0.07	0.08	0.29	88.8	308.3	88.08
8	4	0.46	91.3	98.5	0.05	0.06	0.35	64.2	372.5	93.12
9	4.5	0.39	103.8	72.5	0.03	0.04	0.39	42.8	415.2	92.27
10	5	0.35	113.6	54.1	0.03	0.03	0.42	31.7	446.9	89.37
11	5.5	0.31	120.1	36.4	0.02	0.02	0.44	22.6	469.5	85.36
12	6	0.29	126	21.33	0.01	0.01	0.46	14.4	483.9	80.65
13	7	0.26	132.3	8.89	0.01	0.01	0.47	15.1	499.0	71.29
14	8	0.25	136	4.39	0.00	0.01	0.47	6.6	505.7	63.21
15	9	0.25	137.1	2.53	0.00	0.00	0.48	3.5	509.1	56.57

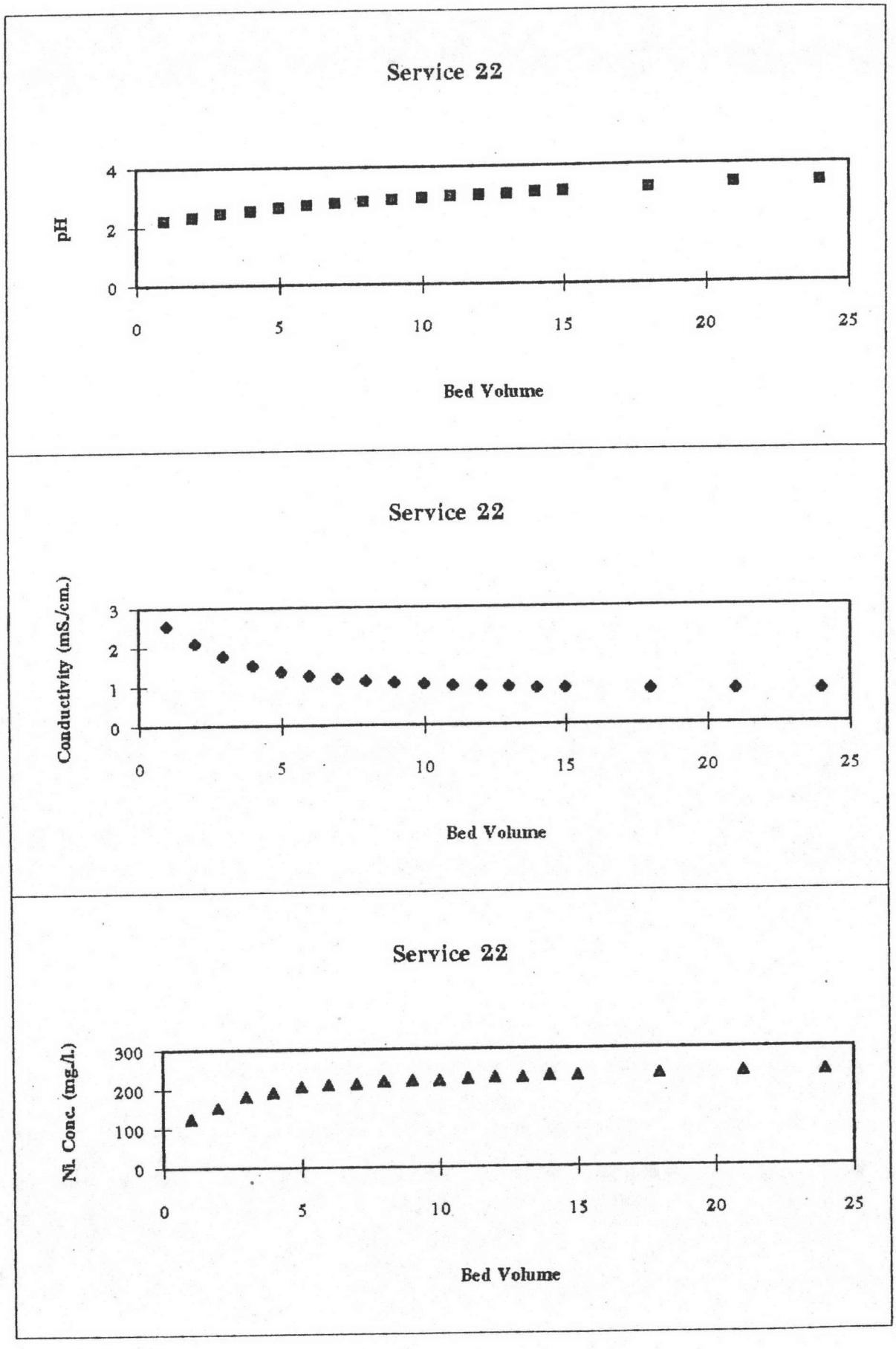

Regeneration 21
pH
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume
Regeneration 21
Conductivity (mS./cm.)
150
100
50
0
0 1 2 3 4 5 6 7 8 9
Bed Volume
Regeneration 21
NL Conc. (mg./L)
200
100
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

EXPERIMENT 22 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	9	7.04	0.692	248.7

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2.2	2.56	125.4	0.50	0.25	0.75	0.75	186.00
2	2	2.32	2.1	153.8	0.62	0.56	0.44	1.19	295.10
3	3	2.44	1.783	181.8	0.73	0.67	0.33	1.51	376.00
4	4	2.54	1.533	192.2	0.77	0.75	0.25	1.76	437.70
5	5	2.63	1.373	205.7	0.83	0.80	0.20	1.96	487.45
6	6	2.71	1.269	209.5	0.84	0.83	0.17	2.13	528.55
7	7	2.77	1.186	211.3	0.85	0.85	0.15	2.28	566.85
8	8	2.83	1.126	218.3	0.88	0.86	0.14	2.42	600.75
9	9	2.88	1.074	220.7	0.89	0.88	0.12	2.53	629.95
10	10	2.93	1.038	219.7	0.88	0.89	0.11	2.65	658.45
11	11	2.98	1.003	224.7	0.90	0.89	0.11	2.75	684.95
12	12	3.02	0.973	225.6	0.91	0.91	0.09	2.85	708.50
13	13	3.06	0.949	227.2	0.91	0.91	0.09	2.94	730.80
14	14	3.09	0.928	231.5	0.93	0.92	0.08	3.02	750.15
15	15	3.13	0.915	230.4	0.93	0.93	0.07	3.09	767.90
16	18	3.22	0.882	235.4	0.95	0.94	0.19	3.28	815.30
17	21	3.35	0.86	239.4	0.96	0.95	0.14	3.41	849.20
18	24	3.37	0.838	239.8	0.96	0.96	0.11	3.52	876.50

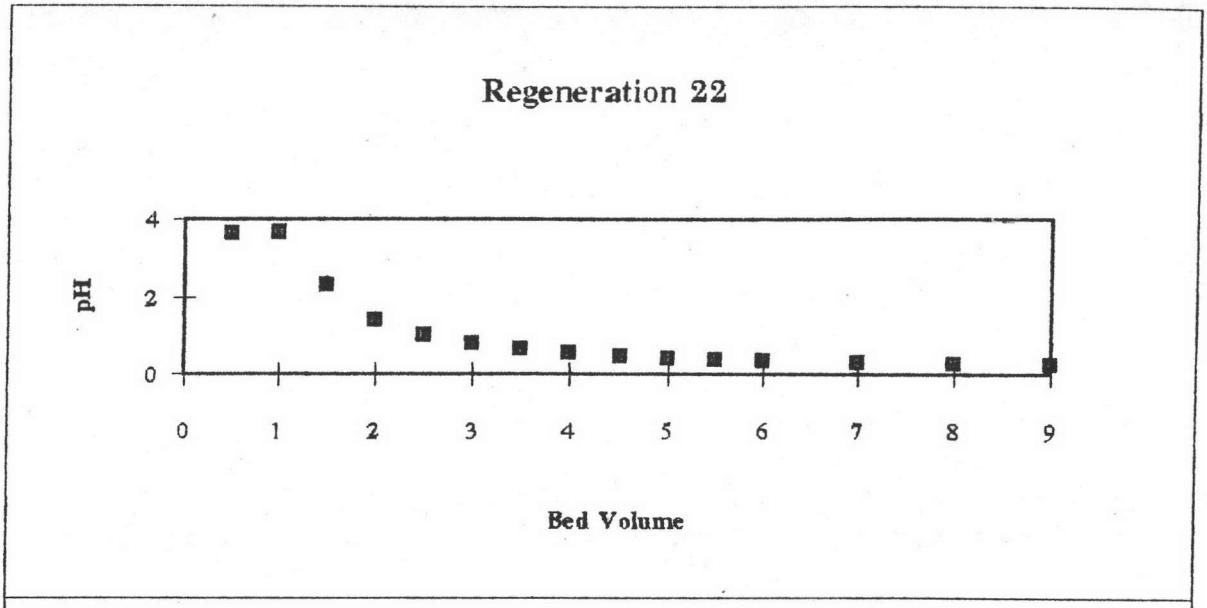

Service 22
pH
4
2
0
0
5
10
15
20
25
Bed Volume
Service 22
Conductivity (mS/cm.)
3
2
1
0
0
5
10
15
20
25
Bed Volume
Service 22
Ni. Conc. (mg/L)
300
200
100
0
0
5
10
15
20
25
Bed Volume

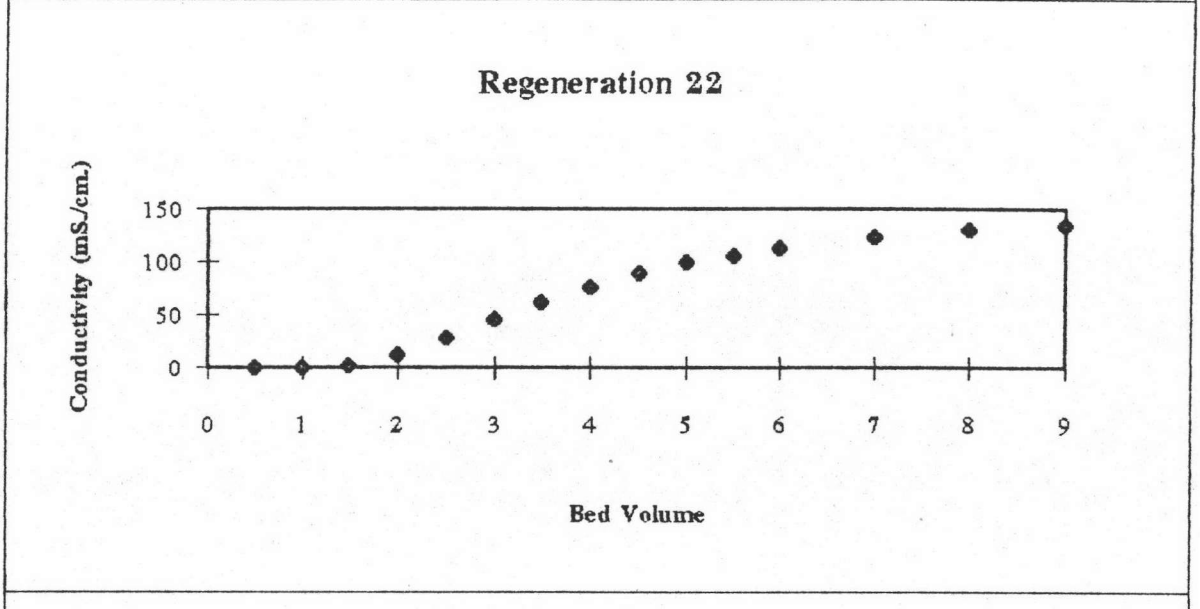
EXPERIMENT 22 Regeneration

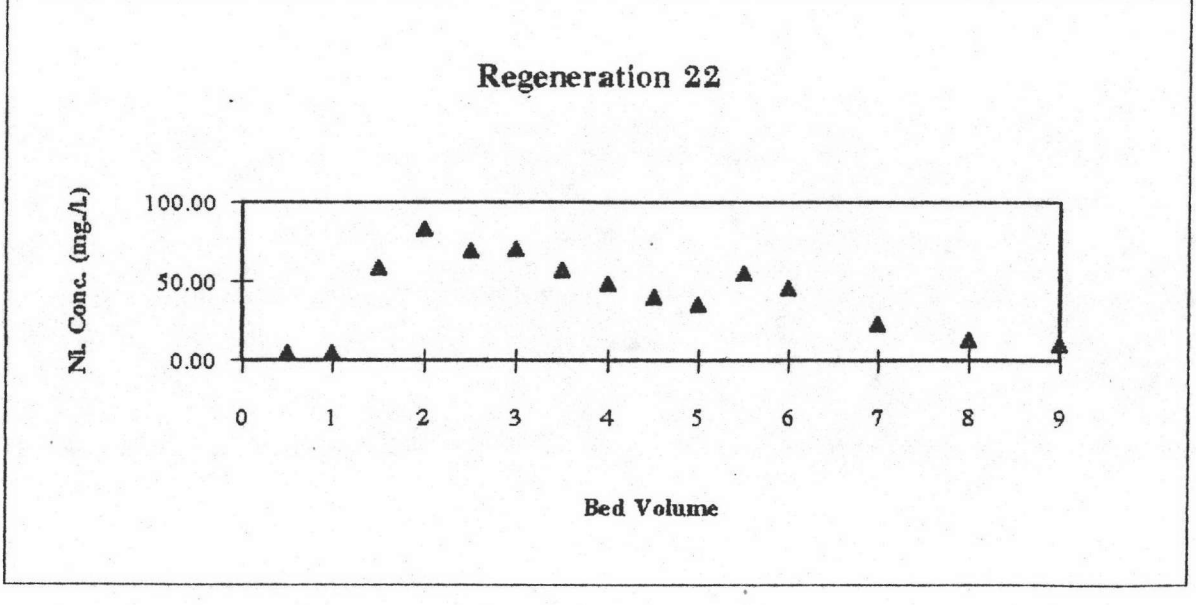
Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	9	0.25	137.8	0.5

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc (mg./l.)	Total Regenerated Nickel / Total exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.64	0.1172	4.80	0.00	0.00	0.00	1.20	1.20	2.40
2	1	3.68	0.1109	4.81	0.00	0.00	0.00	2.4	3.6	3.61
3	1.5	2.33	2.02	58.5	0.03	0.02	0.02	15.8	19.4	12.95
4	2	1.42	12.64	82.7	0.05	0.04	0.06	35.3	54.7	27.36
5	2.5	1.03	28.6	69.2	0.04	0.04	0.11	38.0	92.7	37.07
6	3	0.81	45.9	70.2	0.04	0.04	0.15	34.8	127.5	42.51
7	3.5	0.66	61.9	56.9	0.03	0.04	0.18	31.8	159.3	45.51
8	4	0.56	76.3	48.4	0.03	0.03	0.21	26.3	185.6	46.40
9	4.5	0.48	89.4	39.9	0.02	0.03	0.24	22.1	207.7	46.16
10	5	0.42	99.8	35.4	0.02	0.02	0.26	18.8	226.5	45.31
11	5.5	0.39	105.8	55.4	0.03	0.03	0.28	22.7	249.2	45.31
12	6	0.36	113.1	45.3	0.03	0.03	0.31	25.2	274.4	45.73
13	7	0.31	123.5	23.1	0.03	0.03	0.34	34.2	308.6	44.09
14	8	0.28	130.2	12.74	0.01	0.02	0.36	17.9	326.5	40.82
15	9	0.26	134.9	10.19	0.01	0.01	0.37	11.5	338.0	37.56


Regeneration 22
pH
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume


Regeneration 22
Conductivity (mS./cm.)
150
100
50
0
0 1 2 3 4 5 6 7 8 9
Bed Volume


Regeneration 22
NL Conc. (mg/L)
100.00
50.00
0.00
0 1 2 3 4 5 6 7 8 9
Bed Volume

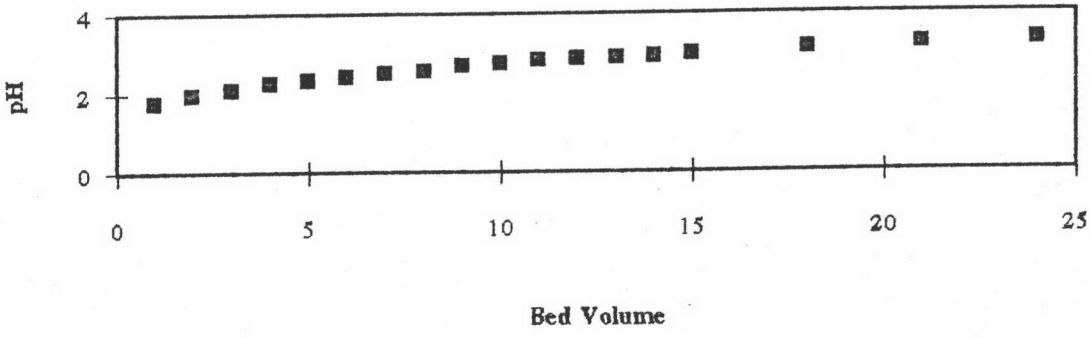
EXPERIMENT 23 Service

Column Size ∅ 6.75*100 cm.

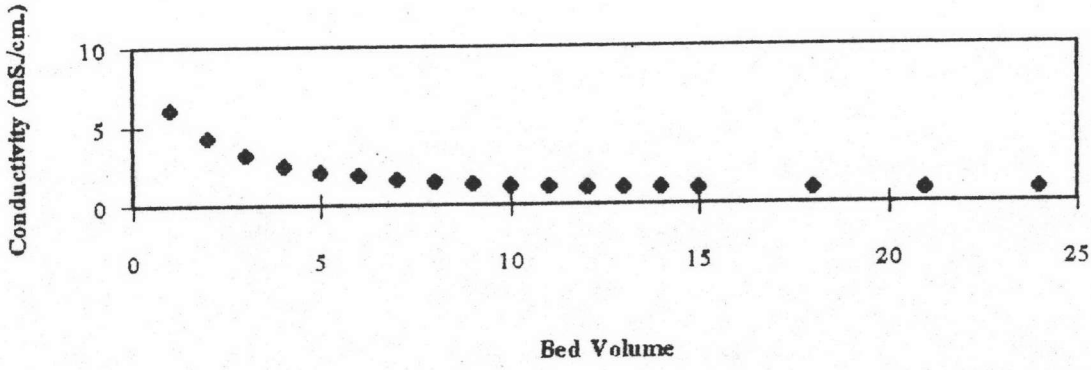
Influent Waste	flow (BV /Hr.)	pH	Conductivity (mS /cm)	Ni in conc. (mg./l.)
synthetic	9	6.66	0.686	246.2

Effluent NO	Bed Volume	pH	Conductivity (mS /cm)	Ni eff Conc (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./Lresin)
					Value	Average	Value	Cumulation	
1	1	1.77	6.04	111.7	0.45	0.23	0.77	0.77	190.35
2	2	1.95	4.29	156.2	0.63	0.54	0.46	1.23	302.60
3	3	2.1	3.23	181.1	0.74	0.69	0.31	1.54	380.15
4	4	2.25	2.49	192.6	0.78	0.76	0.24	1.79	439.50
5	5	2.35	2.1	197.7	0.80	0.79	0.21	1.99	490.55
6	6	2.43	1.88	196.3	0.80	0.80	0.20	2.19	539.75
7	7	2.5	1.662	199.9	0.81	0.80	0.20	2.39	587.85
8	8	2.56	1.522	203.7	0.83	0.82	0.18	2.57	632.25
9	9	2.69	1.392	206.7	0.84	0.83	0.17	2.73	673.25
10	10	2.76	1.232	214	0.87	0.85	0.15	2.88	709.10
11	11	2.82	1.157	217.3	0.88	0.88	0.12	3.00	739.65
12	12	2.87	1.104	222.1	0.90	0.89	0.11	3.11	766.15
13	13	2.88	1.062	222.7	0.90	0.90	0.10	3.21	789.95
14	14	2.92	1.056	223.6	0.91	0.91	0.09	3.30	813.00
15	15	2.97	1.021	227.5	0.92	0.92	0.08	3.39	833.65
16	18	3.1	0.951	233.4	0.95	0.94	0.19	3.58	880.90
17	21	3.21	0.904	237.1	0.96	0.96	0.13	3.71	913.75
18	24	3.3	0.881	242.5	0.98	0.97	0.08	3.79	932.95

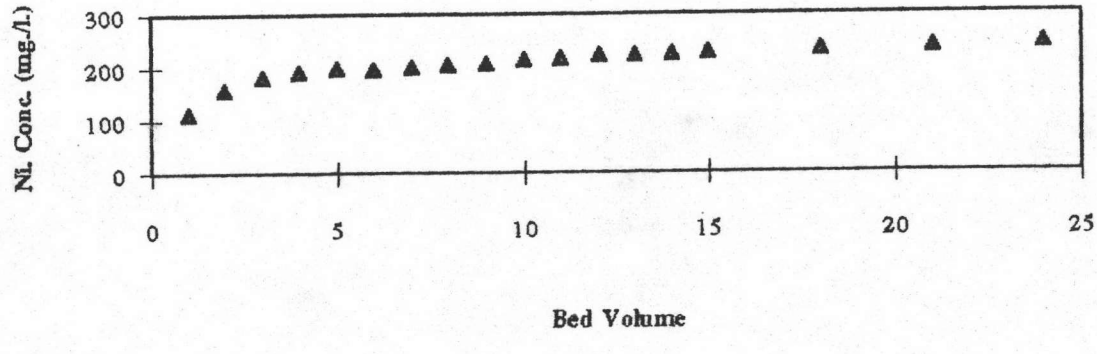
Service 23



Service 23



Service 23

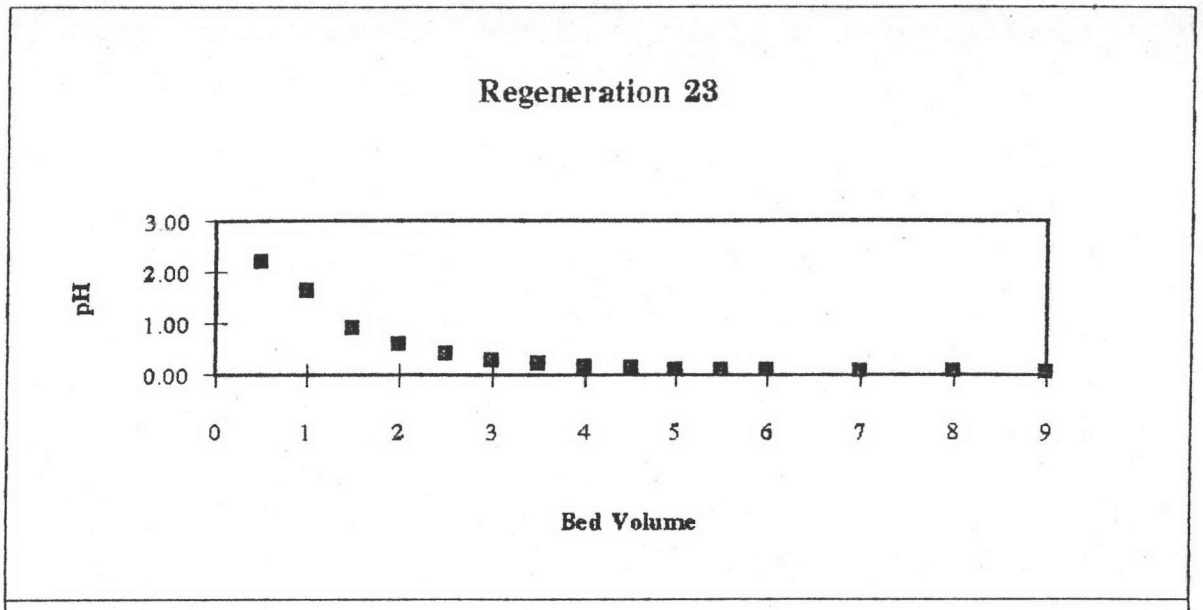


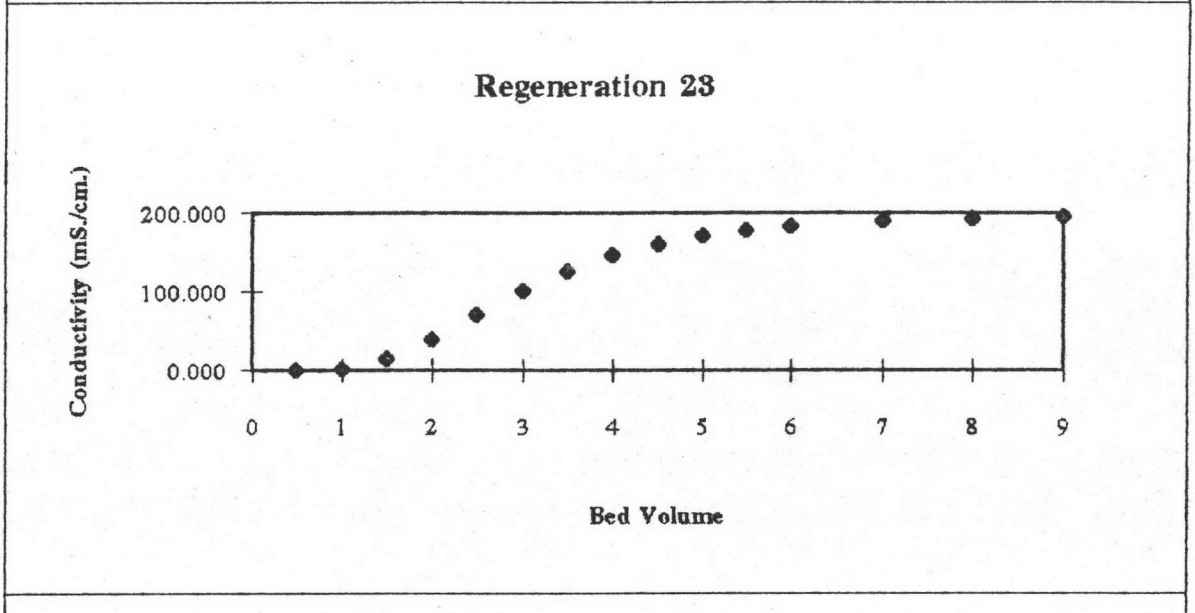
EXPERIMENT 23 Regeneration

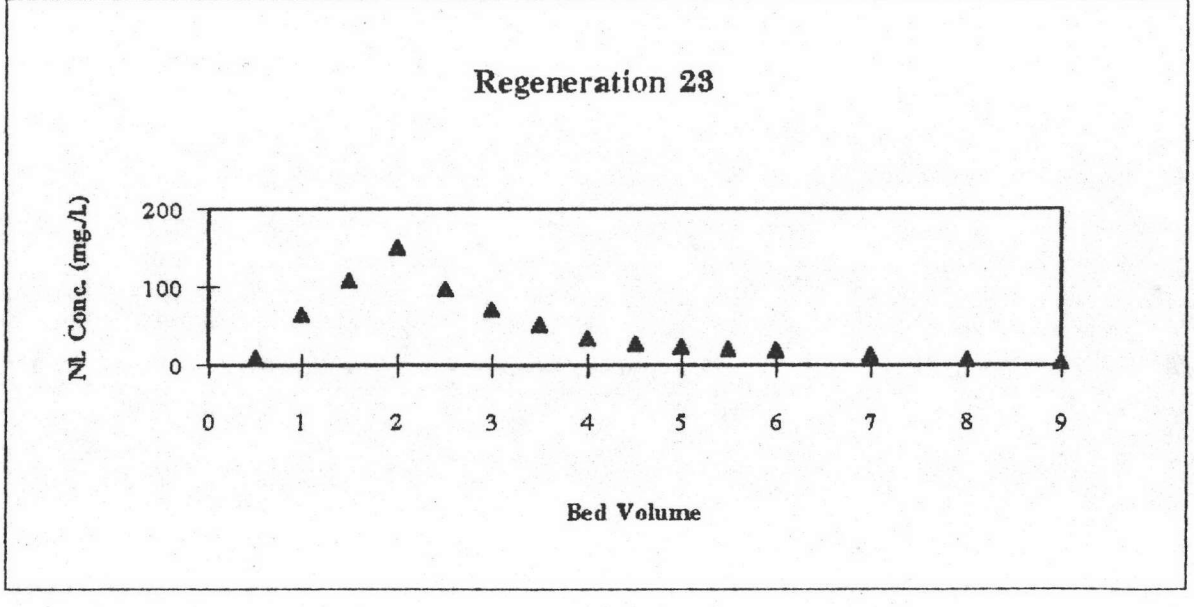
Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)
HCl	3	0.0603	195.8	0.75

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	2.22	0.242	9.09	0.00	0.00	0.00	2.27	2.27	4.55
2	1	1.64	1.647	65	0.03	0.02	0.02	18.5	20.8	20.80
3	1.5	0.92	15.06	108.2	0.06	0.05	0.07	43.3	64.1	42.73
4	2	0.61	39.4	151.1	0.08	0.07	0.14	64.8	128.9	64.46
5	2.5	0.42	71.4	97.7	0.05	0.07	0.20	62.2	191.1	76.45
6	3	0.30	100.9	71.5	0.04	0.05	0.25	42.3	233.4	77.81
7	3.5	0.22	126.7	52.4	0.03	0.03	0.28	31.0	264.4	75.54
8	4	0.17	146.9	33.9	0.02	0.02	0.31	21.6	286.0	71.49
9	4.5	0.14	160.7	27.7	0.01	0.02	0.32	15.4	301.4	66.97
10	5	0.11	170.7	22.7	0.01	0.01	0.34	12.6	314.0	62.79
11	5.5	0.10	178.2	20.4	0.01	0.01	0.35	10.8	324.7	59.04
12	6	0.09	183.4	19.3	0.01	0.01	0.36	9.9	334.7	55.78
13	7	0.08	189.8	13.15	0.01	0.01	0.37	16.2	350.9	50.13
14	8	0.07	193.8	6.77	0.01	0.01	0.38	10.0	360.9	45.11
15	9	0.07	196.2	3.46	0.00	0.01	0.39	5.1	366.0	40.66


Regeneration 23
pH
3.00
2.00
1.00
0.00
0
1
2
3
4
5
6
7
8
9
Bed Volume


Regeneration 23
Conductivity (mS./cm.)
200.000
100.000
0.000
0
1
2
3
4
5
6
7
8
9
Bed Volume

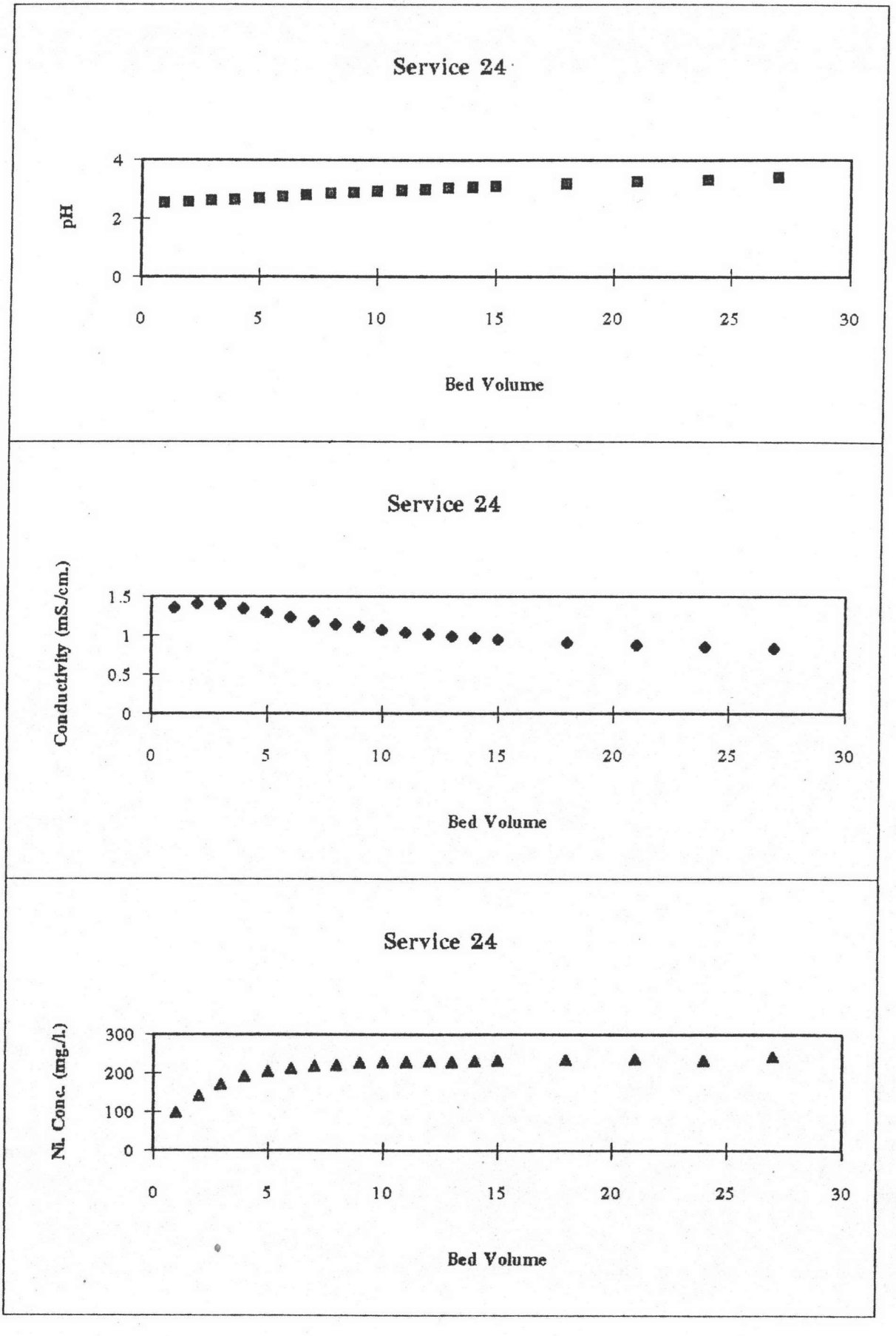

Regeneration 23
NL Conc. (mg/L)
200
100
0
0
1
2
3
4
5
6
7
8
9
Bed Volume

EXPERIMENT 24 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	9	6.74	0.692	251.4

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2.54	1.356	98.2	0.39	0.20	0.80	0.80	202.30
2	2	2.56	1.408	141.7	0.56	0.48	0.52	1.33	333.75
3	3	2.6	1.405	171.6	0.68	0.62	0.38	1.70	428.50
4	4	2.65	1.352	191.1	0.76	0.72	0.28	1.98	498.55
5	5	2.7	1.293	204.6	0.81	0.79	0.21	2.20	552.10
6	6	2.76	1.238	211.6	0.84	0.83	0.17	2.37	595.40
7	7	2.81	1.188	217.7	0.87	0.85	0.15	2.51	632.15
8	8	2.85	1.144	220.3	0.88	0.87	0.13	2.64	664.55
9	9	2.89	1.109	225.9	0.90	0.89	0.11	2.76	692.85
10	10	2.93	1.075	227.9	0.91	0.90	0.10	2.85	717.35
11	11	2.97	1.045	228.1	0.91	0.91	0.09	2.95	740.75
12	12	3	1.017	230	0.91	0.91	0.09	3.04	763.10
13	13	3.04	0.994	229.2	0.91	0.91	0.09	3.12	784.90
14	14	3.07	0.973	230	0.91	0.91	0.09	3.21	806.70
15	15	3.1	0.953	232.8	0.93	0.92	0.08	3.29	826.70
16	18	3.19	0.909	234.6	0.93	0.93	0.21	3.50	879.80
17	21	3.26	0.877	237.4	0.94	0.94	0.18	3.68	926.00
18	24	3.32	0.855	232.8	0.93	0.94	0.19	3.88	974.90
19	27	3.39	0.83	243.70	0.97	0.95	0.16	4.03	1014.35

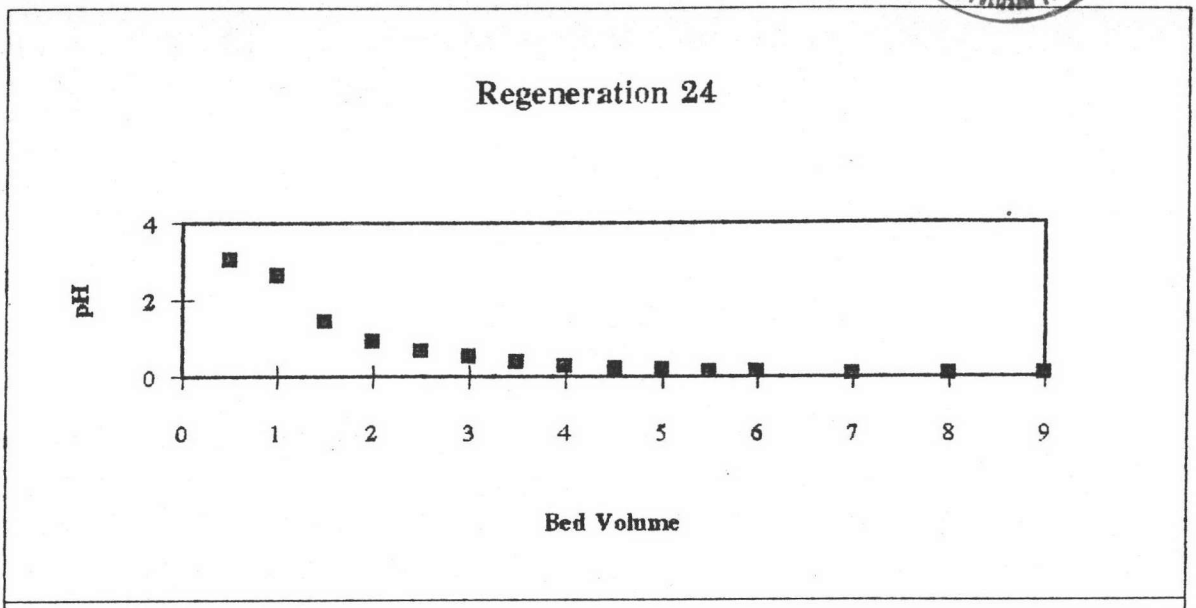

Service 24
pH
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 24
Conductivity (mS./cm.)
1.5
1
0.5
0
0
5
10
15
20
25
30
Bed Volume
Service 24
NL Conc. (mg./L)
300
200
100
0
0
5
10
15
20
25
30
Bed Volume

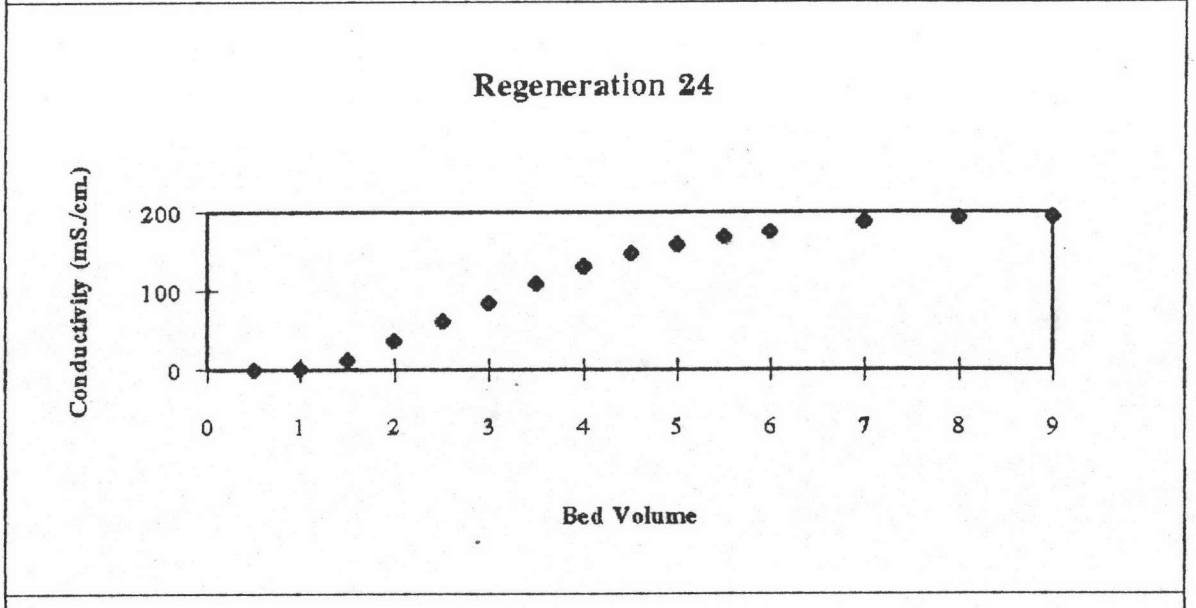
EXPERIMENT 24 Regeneration

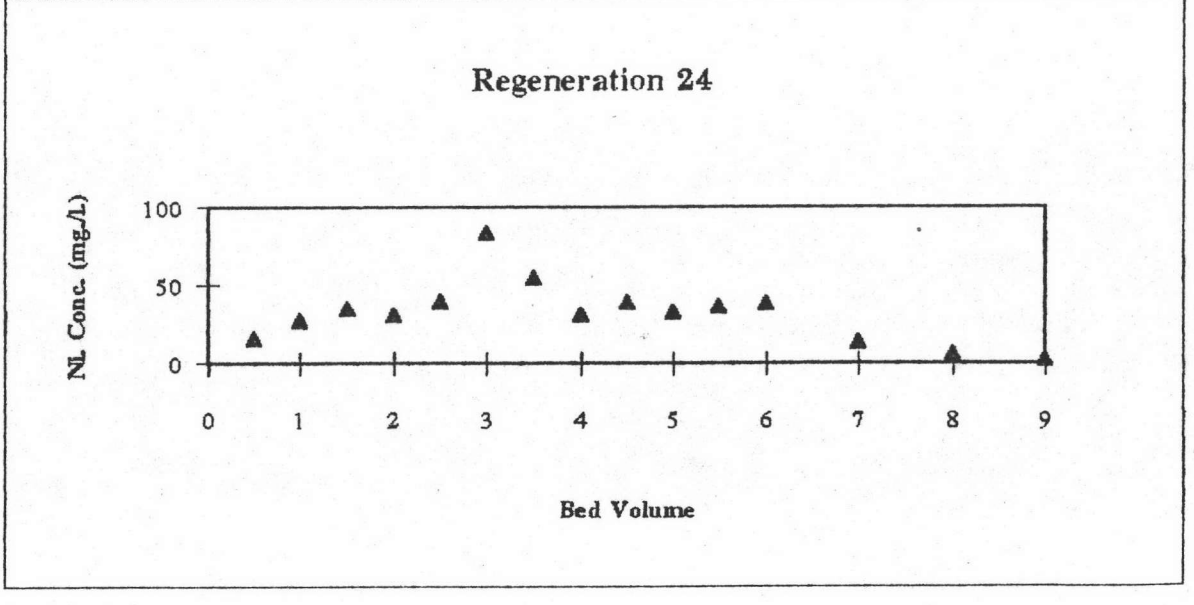
Column Size ∅ 6.75*100 cm

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	6	0.07	194.7	0.75

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni.reg. Conc (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.06	0.4	15.44	0.01	0.00	0.00	3.86	3.86	7.72
2	1	2.63	1.014	27.3	0.01	0.01	0.01	10.7	14.5	14.55
3	1.5	1.44	12.25	34.7	0.02	0.02	0.03	15.5	30.0	20.03
4	2	0.93	36.5	30.7	0.02	0.02	0.05	16.4	46.4	23.20
5	2.5	0.67	62.2	39.7	0.02	0.02	0.06	17.6	64.0	25.60
6	3	0.52	85.1	83.5	0.04	0.03	0.09	30.8	94.8	31.60
7	3.5	0.39	109.9	54.5	0.03	0.03	0.13	34.5	129.3	36.94
8	4	0.29	131.3	30.7	0.02	0.02	0.15	21.3	150.6	37.65
9	4.5	0.23	147.3	38.9	0.02	0.02	0.17	17.4	168.0	37.33
10	5	0.19	159.2	32.9	0.02	0.02	0.18	18.0	185.9	37.19
11	5.5	0.15	168.6	36.6	0.02	0.02	0.20	17.4	203.3	36.97
12	6	0.13	175.2	38.4	0.02	0.02	0.22	18.8	222.1	37.01
13	7	0.09	187.8	13.79	0.01	0.02	0.24	26.1	248.2	35.45
14	8	0.08	192.9	5.85	0.01	0.01	0.24	9.8	258.0	32.25
15	9	0.07	195.2	2.63	0.00	0.00	0.25	4.2	262.2	29.14


Regeneration 24
pH
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume


Regeneration 24
Conductivity (mS./cm.)
200
100
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

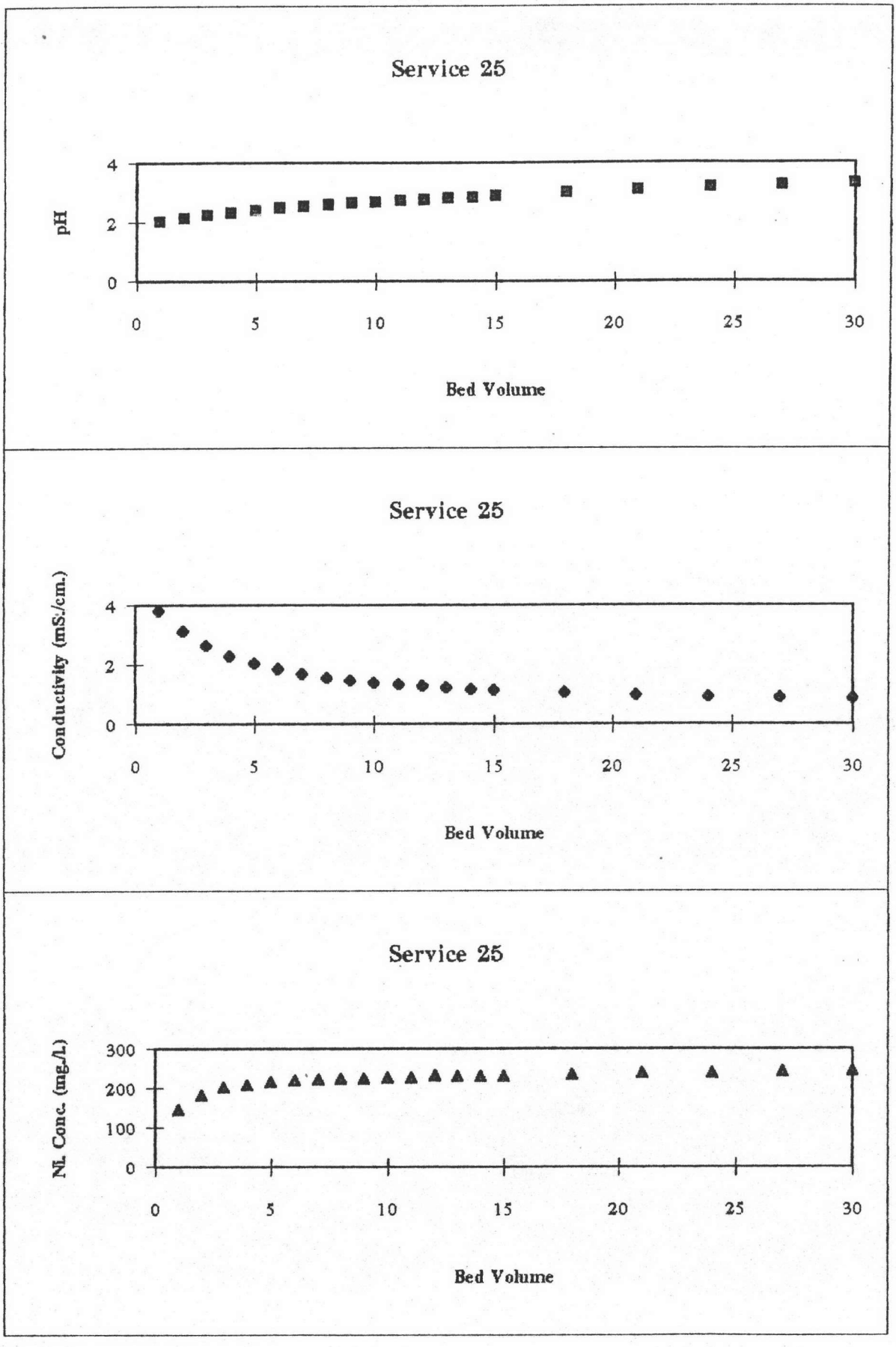

Regeneration 24
NL Conc. (mg/L)
100
50
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

EXPERIMENT 25 Service

Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH.	Conductivity (mS./cm.)	Ni in conc. (mg./l.)
synthetic	9	6.8	0.698	251.5

Effluent NO.	Bed Volume	pH.	Conductivity (mS./cm.)	Ni eff Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2.01	3.82	145.2	0.58	0.29	0.71	0.71	178.90
2	2	2.12	3.14	181.4	0.72	0.65	0.35	1.06	267.10
3	3	2.23	2.65	201.4	0.80	0.76	0.24	1.30	327.20
4	4	2.32	2.29	207.9	0.83	0.81	0.19	1.49	374.05
5	5	2.4	2.03	216.2	0.86	0.84	0.16	1.64	413.50
6	6	2.47	1.84	220.6	0.88	0.87	0.13	1.78	446.60
7	7	2.52	1.681	221.5	0.88	0.88	0.12	1.90	477.05
8	8	2.58	1.556	224.6	0.89	0.89	0.11	2.01	505.50
9	9	2.63	1.469	224.7	0.89	0.89	0.11	2.12	532.35
10	10	2.68	1.396	226.4	0.90	0.90	0.10	2.22	558.30
11	11	2.72	1.325	226.5	0.90	0.90	0.10	2.32	583.35
12	12	2.76	1.268	232.6	0.92	0.91	0.09	2.41	605.30
13	13	2.8	1.227	231.5	0.92	0.92	0.08	2.48	624.75
14	14	2.83	1.179	231	0.92	0.92	0.08	2.56	645.00
15	15	2.88	1.144	229.8	0.91	0.92	0.08	2.65	666.10
16	18	2.98	1.05	234.1	0.93	0.92	0.23	2.88	724.75
17	21	3.07	0.984	238	0.95	0.94	0.18	3.07	771.10
18	24	3.16	0.937	238	0.95	0.95	0.16	3.23	811.60
19	27	3.23	0.904	242.00	0.96	0.95	0.14	3.36	846.10
20	30	3.29	0.877	244.30	0.97	0.97	0.10	3.46	871.15

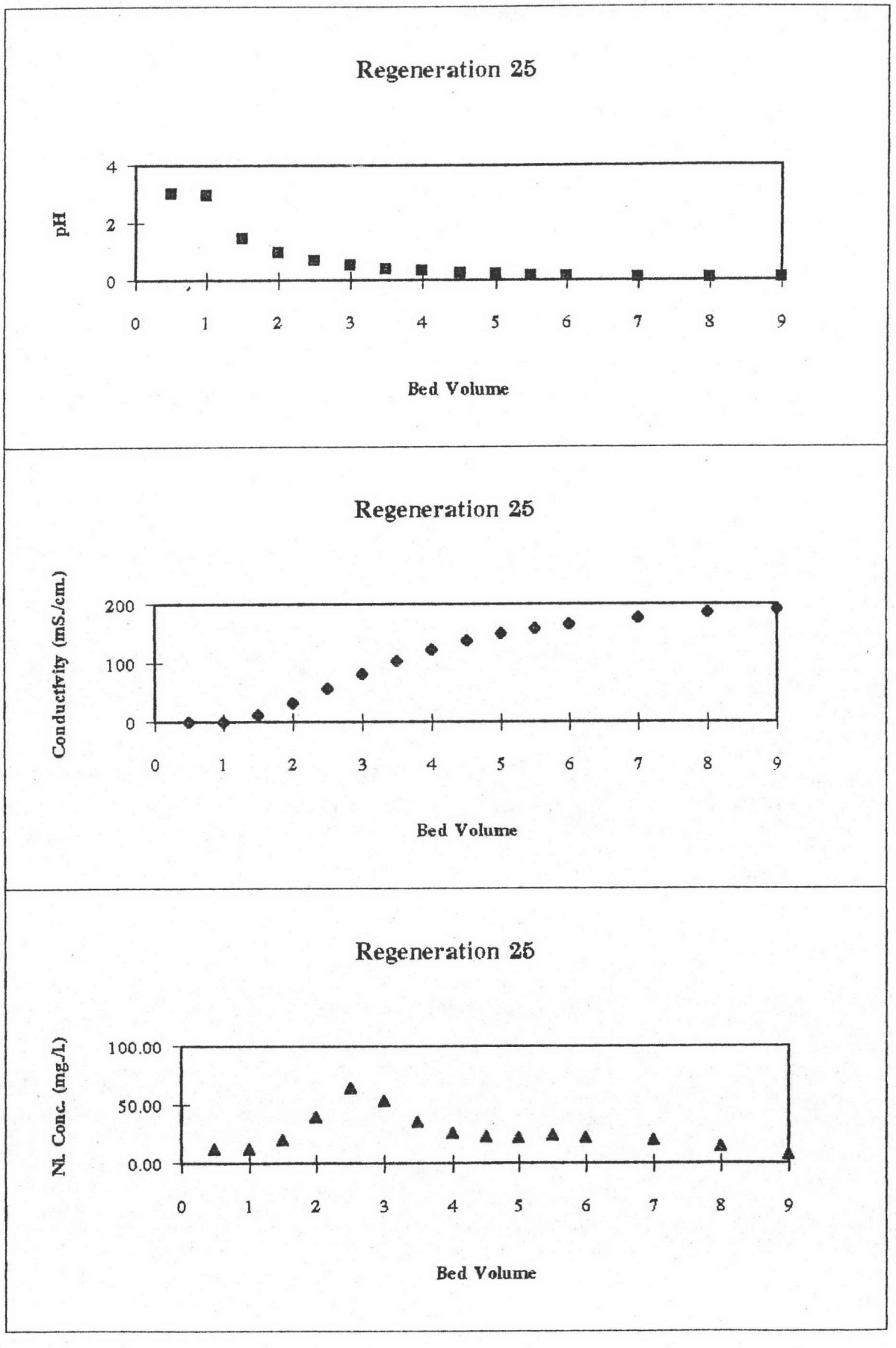

Service 25
pH
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 25
Conductivity (mS/cm.)
4
2
0
0
5
10
15
20
25
30
Bed Volume
Service 25
NL Conc. (mg/L)
300
200
100
0
0
5
10
15
20
25
30
Bed Volume

EXPERIMENT 25 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	9	0.04	198.4	0.75

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.04	0.488	12.08	0.01	0.00	0.00	3.02	3.02	6.04
2	1	2.98	0.508	12.03	0.01	0.01	0.01	6.0	9.0	9.05
3	1.5	1.46	- 11.7	19.78	0.01	0.01	0.02	8.0	17.0	11.33
4	2	0.97	33.1	39.6	0.02	0.02	0.04	14.8	31.8	15.92
5	2.5	0.7	57.7	64.7	0.04	0.03	0.07	26.1	57.9	23.17
6	3	0.52	82.3	53.2	0.03	0.03	0.10	29.5	87.4	29.13
7	3.5	0.4	104.2	35.7	0.02	0.03	0.13	22.2	109.6	31.32
8	4	0.32	122.8	25.7	0.01	0.02	0.14	15.4	125.0	31.25
9	4.5	0.25	138	22.9	0.01	0.01	0.16	12.2	137.1	30.48
10	5	0.21	150.2	22.2	0.01	0.01	0.17	11.3	148.4	29.69
11	5.5	0.17	158.4	23.9	0.01	0.01	0.18	11.5	159.9	29.08
12	6	0.15	166.1	21.9	0.01	0.01	0.20	11.5	171.4	28.57
13	7	0.11	177.3	19.61	0.02	0.02	0.21	20.8	192.2	27.46
14	8	0.08	185.9	14.31	0.02	0.02	0.23	17.0	209.1	26.14
15	9	0.07	191.9	7.39	0.01	0.01	0.25	10.8	220.0	24.44

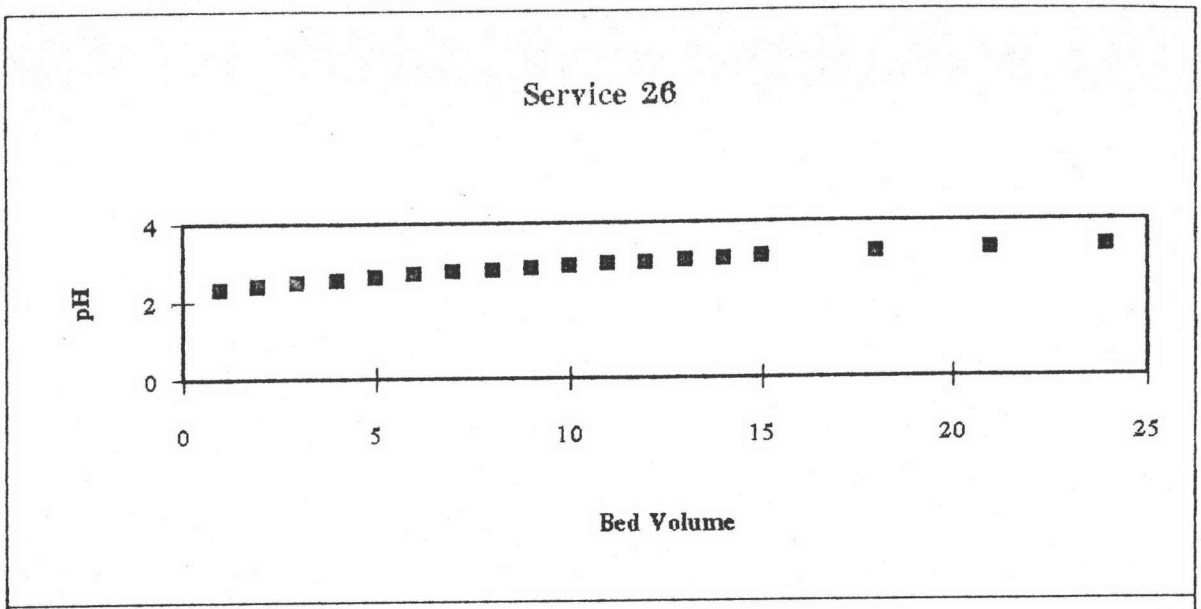

Regeneration 25
pH
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume
Regeneration 25
Conductivity (mS./cm.)
200
100
0
0 1 2 3 4 5 6 7 8 9
Bed Volume
Regeneration 25
NL Conc. (mg./L)
100.00
50.00
0.00
0 1 2 3 4 5 6 7 8 9
Bed Volume

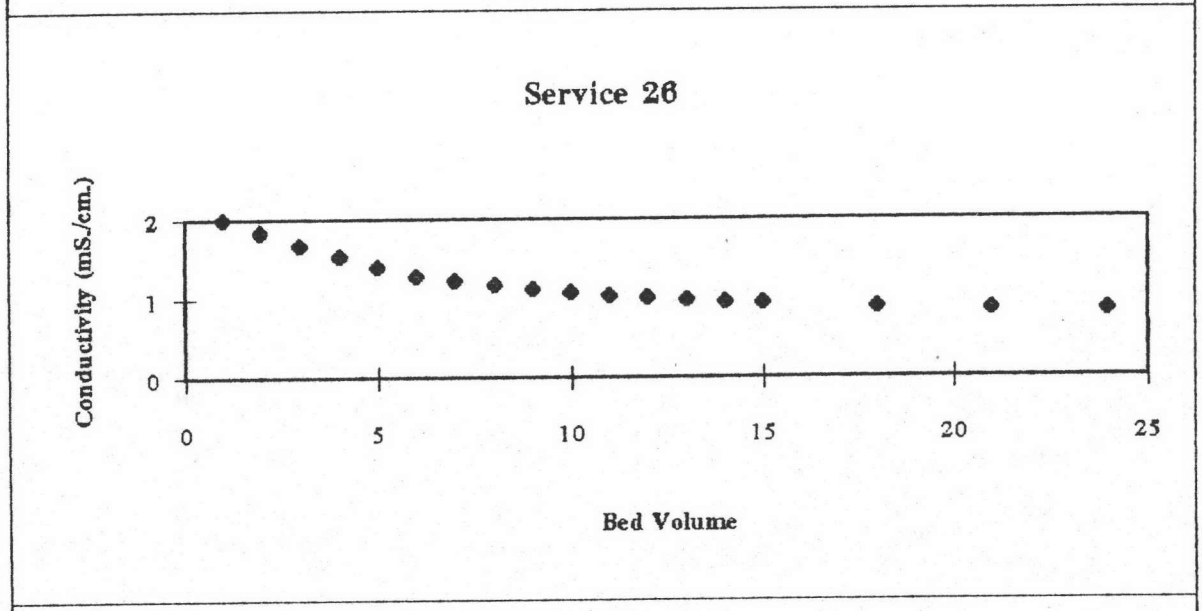
EXPERIMENT 26 Service

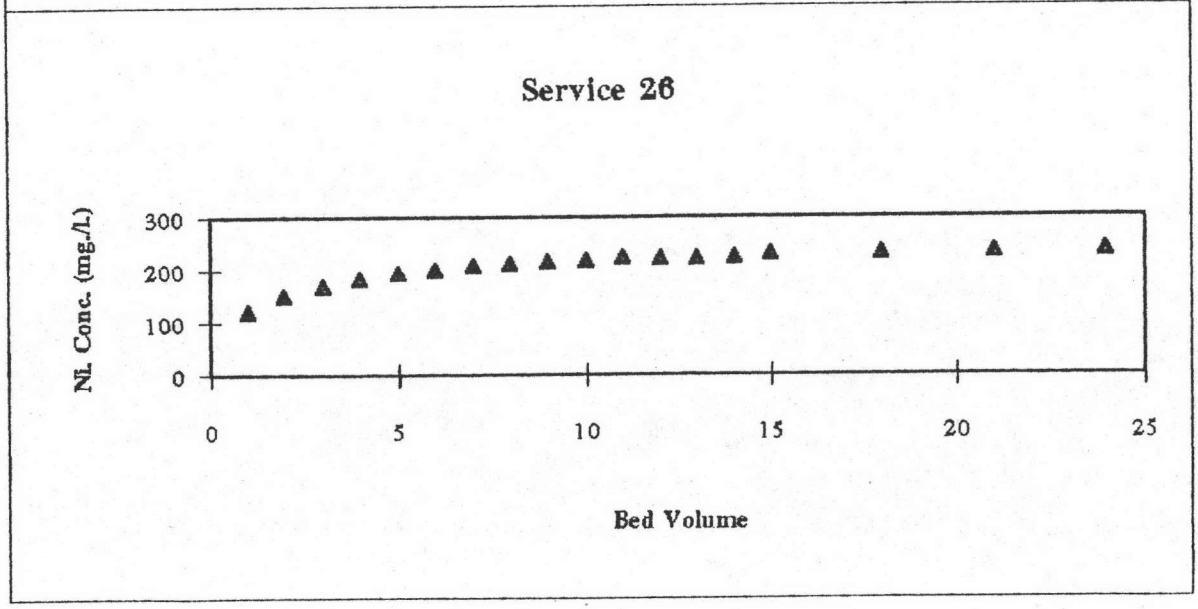
Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV /Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	9	6.3	0.701	247.6

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2.33	2	120.3	0.49	0.24	0.76	0.76	187.45
2	2	2.4	1.83	150.8	0.61	0.55	0.45	1.21	299.50
3	3	2.48	1.669	169.6	0.68	0.65	0.35	1.56	386.90
4	4	2.54	1.541	184.4	0.74	0.71	0.29	1.85	457.50
5	5	2.62	1.4	194.8	0.79	0.77	0.23	2.08	515.50
6	6	2.7	1.283	199.8	0.81	0.80	0.20	2.29	565.80
7	7	2.75	1.219	207.6	0.84	0.82	0.18	2.46	609.70
8	8	2.8	1.164	211.3	0.85	0.85	0.15	2.62	647.85
9	9	2.85	1.119	215.4	0.87	0.86	0.14	2.75	682.10
10	10	2.9	1.077	217.6	0.88	0.87	0.13	2.88	713.20
11	11	2.94	1.035	223.8	0.90	0.89	0.11	2.99	740.10
12	12	2.99	1.002	222.5	0.90	0.90	0.10	3.09	764.55
13	13	3.03	0.974	222.9	0.90	0.90	0.10	3.19	789.45
14	14	3.07	0.955	224.6	0.91	0.90	0.10	3.28	813.30
15	15	3.11	0.937	229.9	0.93	0.92	0.08	3.37	833.65
16	18	3.2	0.891	233.4	0.94	0.94	0.19	3.56	881.50
17	21	3.27	0.861	235.1	0.95	0.95	0.16	3.72	921.55
18	24	3.34	0.837	235.9	0.95	0.95	0.15	3.87	957.85


Service 26
pH
4
2
0
0
5
10
15
20
25
Bed Volume


Service 26
Conductivity (mS./cm.)
2
1
0
0
5
10
15
20
25
Bed Volume

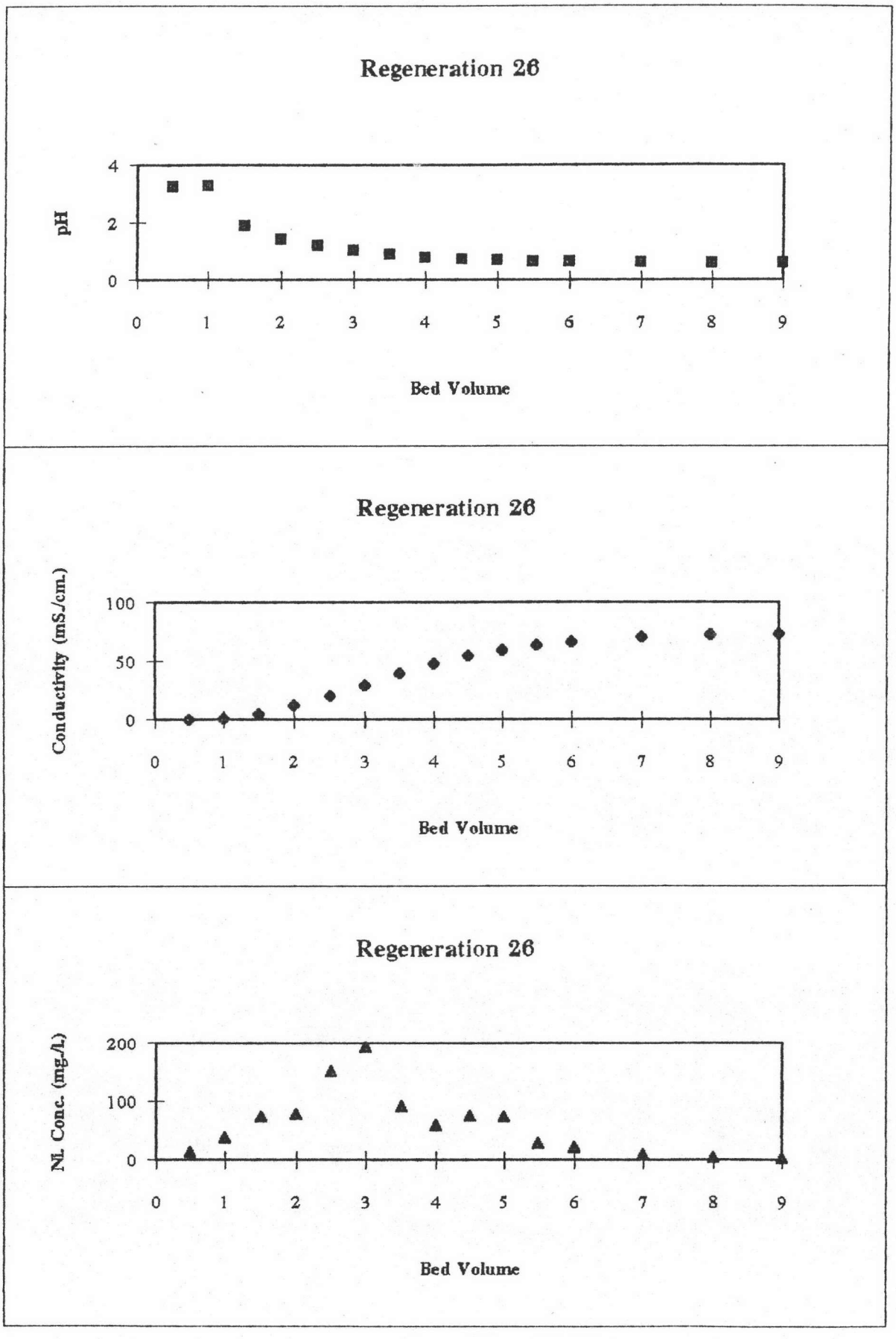

Service 26
Ni. Conc. (mg./L)
300
200
100
0
0
5
10
15
20
25
Bed Volume

EXPERIMENT 26 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	3	0.56	74.1	0.25

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.25	0.265	13.4	0.01	0.00	0.00	3.35	3.35	6.70
2	1	3.27	0.366	37.7	0.02	0.01	0.02	12.8	16.1	16.13
3	1.5	1.9	4.6	74.1	0.04	0.03	0.05	28.0	44.1	29.38
4	2	1.43	12.17	78.6	0.04	0.04	0.09	38.2	82.3	41.13
5	2.5	1.19	20.7	152.1	0.08	0.06	0.15	57.7	139.9	55.97
6	3	1.02	29.5	193.7	0.10	0.09	0.24	86.5	226.4	75.46
7	3.5	0.88	39.8	92.3	0.05	0.07	0.31	71.5	297.9	85.11
8	4	0.78	48.1	58.3	0.03	0.04	0.35	37.7	335.5	83.88
9	4.5	0.72	54.7	74.8	0.04	0.03	0.39	33.3	368.8	81.96
10	5	0.69	59.4	74.3	0.04	0.04	0.42	37.3	406.1	81.22
11	5.5	0.65	63.6	28.8	0.02	0.03	0.45	25.8	431.9	78.52
12	6	0.63	66.3	21.9	0.01	0.01	0.46	12.7	444.5	74.09
13	7	0.6	70.4	9.18	0.01	0.01	0.47	15.5	460.1	65.72
14	8	0.58	72.4	4.16	0.00	0.01	0.48	6.7	466.7	58.34
15	9	0.58	73.5	2.71	0.00	0.00	0.49	3.4	470.2	52.24

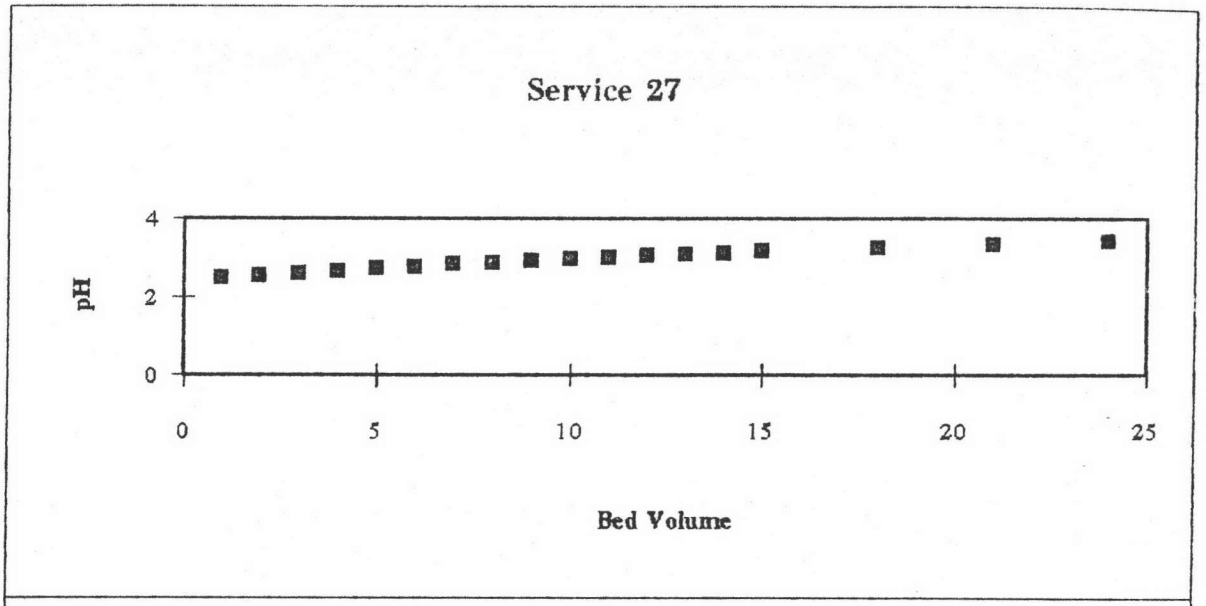

Regeneration 26
pH
4
2
0
0 1 2 3 4 5 6 7 8 9
Bed Volume
Regeneration 26
Conductivity (mS/cm.)
100
50
0
0 1 2 3 4 5 6 7 8 9
Bed Volume
Regeneration 26
NL Conc. (mg/L)
200
100
0
0 1 2 3 4 5 6 7 8 9
Bed Volume

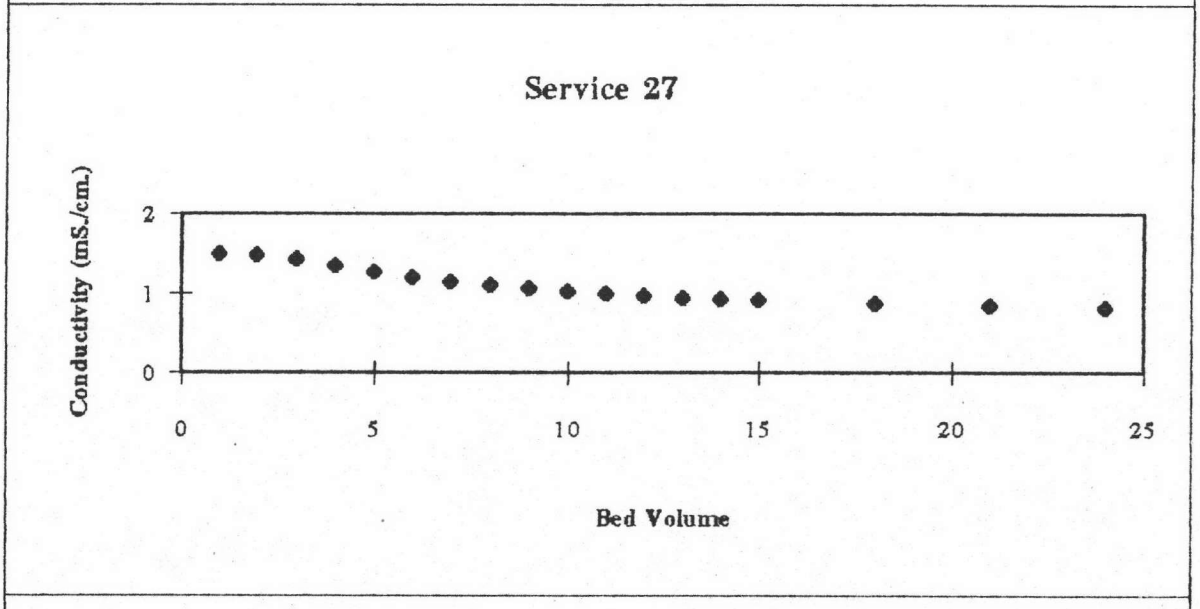
EXPERIMENT 27 Service

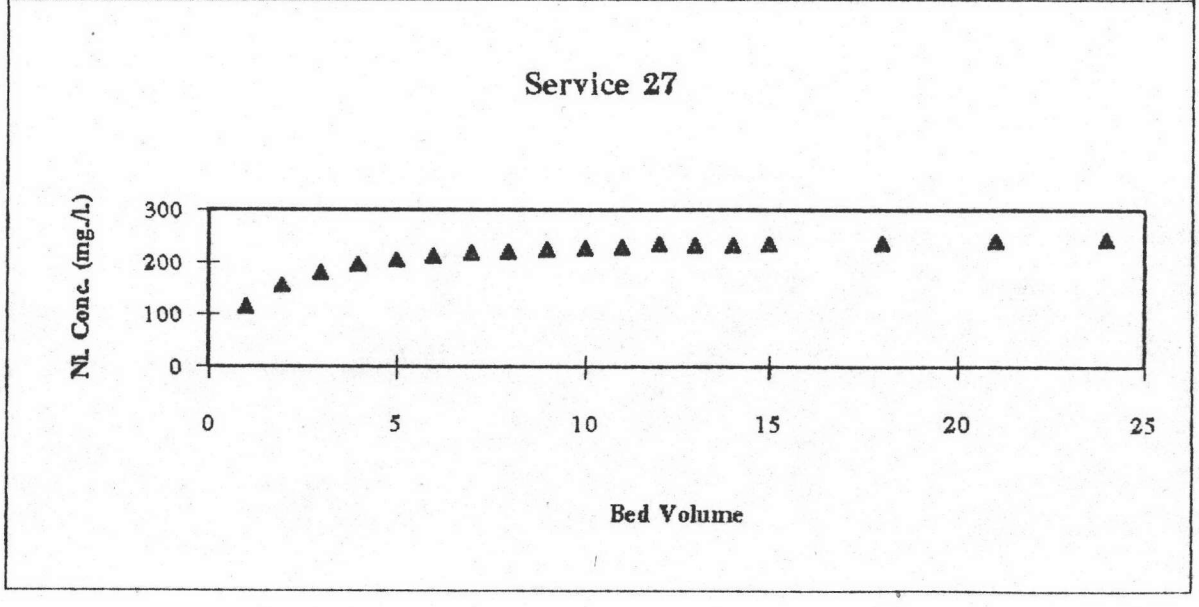
Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV /Hr.)	pH	Conductivity (mS /cm.)	Ni in conc (mg /l.)
synthetic	9	6.79	0.691	251.3

Effluent NO	Bed Volume	pH	Conductivity (mS /cm.)	Ni eff. Conc (mg /l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg/l resin)
					Value	Average	Value	Cumulation	
1	1	2.49	1.502	113.3	0.45	0.23	0.77	0.77	194.65
2	2	2.53	1.489	154.8	0.62	0.53	0.47	1.24	311.90
3	3	2.59	1.427	180.2	0.72	0.67	0.33	1.57	395.70
4	4	2.66	1.345	195.3	0.78	0.75	0.25	1.83	459.25
5	5	2.72	1.267	204.9	0.82	0.80	0.20	2.03	510.45
6	6	2.77	1.203	211.9	0.84	0.83	0.17	2.20	553.35
7	7	2.83	1.147	217.8	0.87	0.85	0.15	2.35	589.80
8	8	2.88	1.098	220.6	0.88	0.87	0.13	2.47	621.90
9	9	2.93	1.058	224	0.89	0.88	0.12	2.59	650.90
10	10	2.97	1.023	226.4	0.90	0.90	0.10	2.69	677.00
11	11	3.01	0.993	228.4	0.91	0.90	0.10	2.79	700.90
12	12	3.05	0.966	234.8	0.93	0.92	0.08	2.87	720.60
13	13	3.09	0.943	232.2	0.92	0.93	0.07	2.94	738.40
14	14	3.13	0.923	233.4	0.93	0.93	0.07	3.01	756.90
15	15	3.16	0.909	234.7	0.93	0.93	0.07	3.08	774.15
16	18	3.26	0.868	237.4	0.94	0.94	0.18	3.26	819.90
17	21	3.35	0.838	241.2	0.96	0.95	0.14	3.41	855.90
18	24	3.42	0.817	242.1	0.96	0.96	0.12	3.52	884.85


Service 27
pH
4
2
0
0
5
10
15
20
25
Bed Volume


Service 27
Conductivity (mS./cm.)
2
1
0
0
5
10
15
20
25
Bed Volume

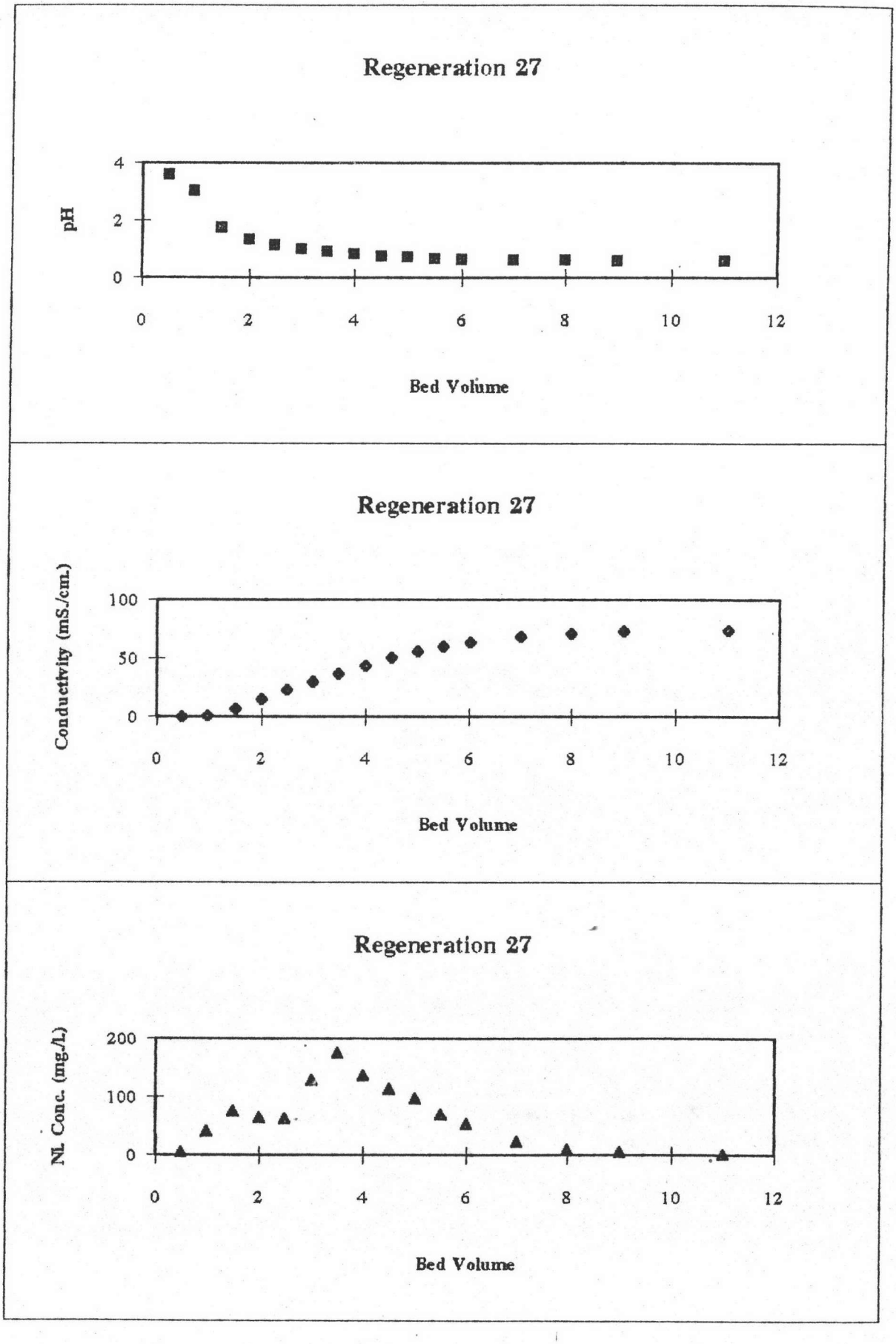

Service 27
NL Conc. (mg./L)
300
200
100
0
0
5
10
15
20
25
Bed Volume

EXPERIMENT 27 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	6	0.58	74.6	0.25

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
1	0.5	3.59	0.1181	5.1	0.00	0.00	0.00	1.28	1.28	2.55
2	1	3.04	0.5	41.6	0.02	0.01	0.01	11.7	13.0	12.95
3	1.5	1.74	6.54	75.4	0.04	0.03	0.05	29.3	42.2	28.13
4	2	1.33	15.21	63.7	0.04	0.04	0.09	34.8	77.0	38.49
5	2.5	1.13	23.3	63	0.04	0.04	0.12	31.7	108.7	43.46
6	3	1.01	30.2	129.3	0.07	0.05	0.18	48.1	156.7	52.24
7	3.5	0.91	37.3	175.4	0.10	0.09	0.26	76.2	232.9	66.54
8	4	0.83	44	136.9	0.08	0.09	0.35	78.1	311.0	77.74
9	4.5	0.76	51	113.2	0.06	0.07	0.42	62.5	373.5	83.00
10	5	0.72	56.1	97.6	0.06	0.06	0.48	52.7	426.2	85.24
11	5.5	0.68	60.5	69.6	0.04	0.05	0.53	41.8	468.0	85.09
12	6	0.65	63.9	53.6	0.03	0.03	0.56	30.8	498.8	83.13
13	7	0.62	68.5	23.5	0.03	0.03	0.59	38.6	537.4	76.76
14	8	0.6	71.5	9.75	0.01	0.02	0.61	16.6	554.0	69.25
15	9	0.59	73.1	4.9	0.01	0.01	0.62	7.3	561.3	62.37
16	11	0.58	74.3	1.97	0.00	0.00	0.62	6.9	568.2	51.65

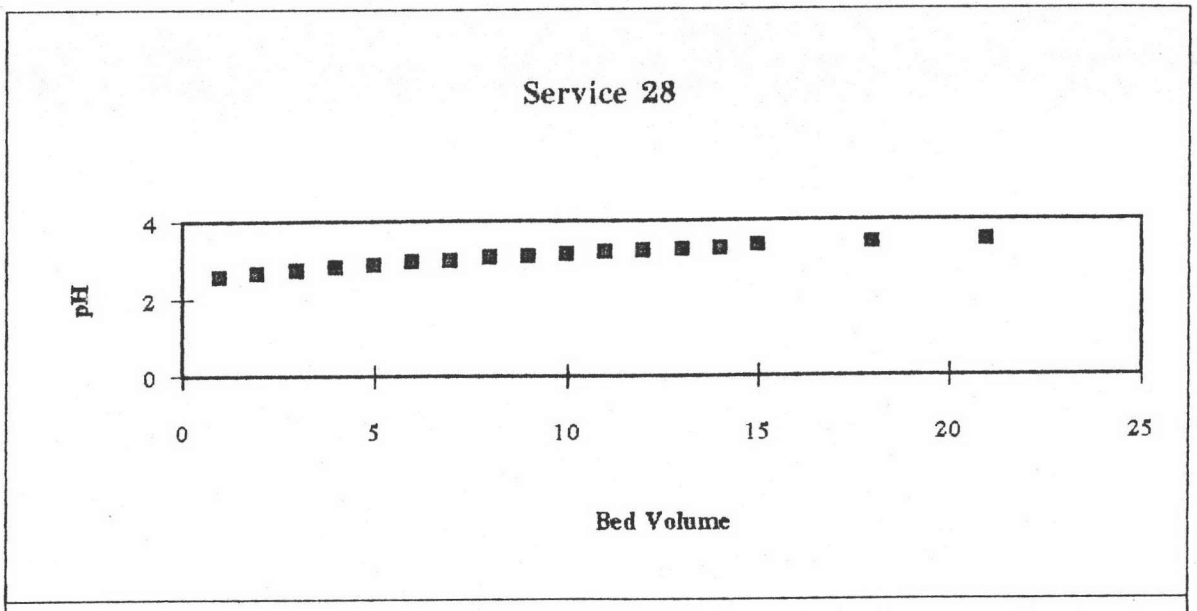

Regeneration 27
pH
4
2
0
0
2
4
6
8
10
12
Bed Volume
Regeneration 27
Conductivity (mS./cm.)
100
50
0
0
2
4
6
8
10
12
Bed Volume
Regeneration 27
NL Conc. (mg./L)
200
100
0
0
2
4
6
8
10
12
Bed Volume

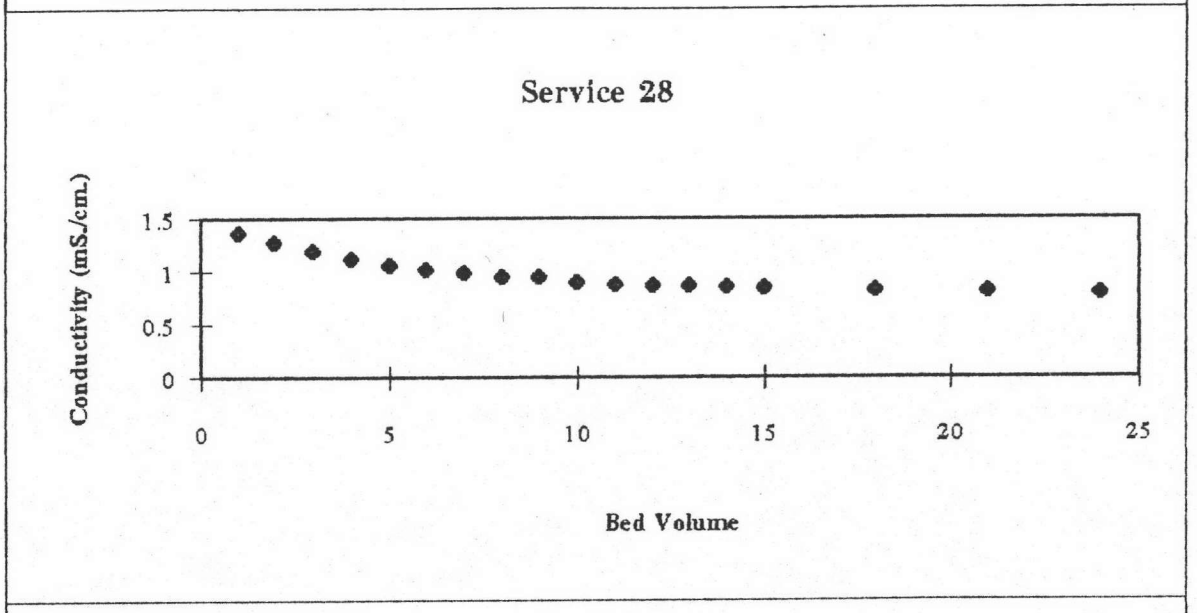
EXPERIMENT 28 Service

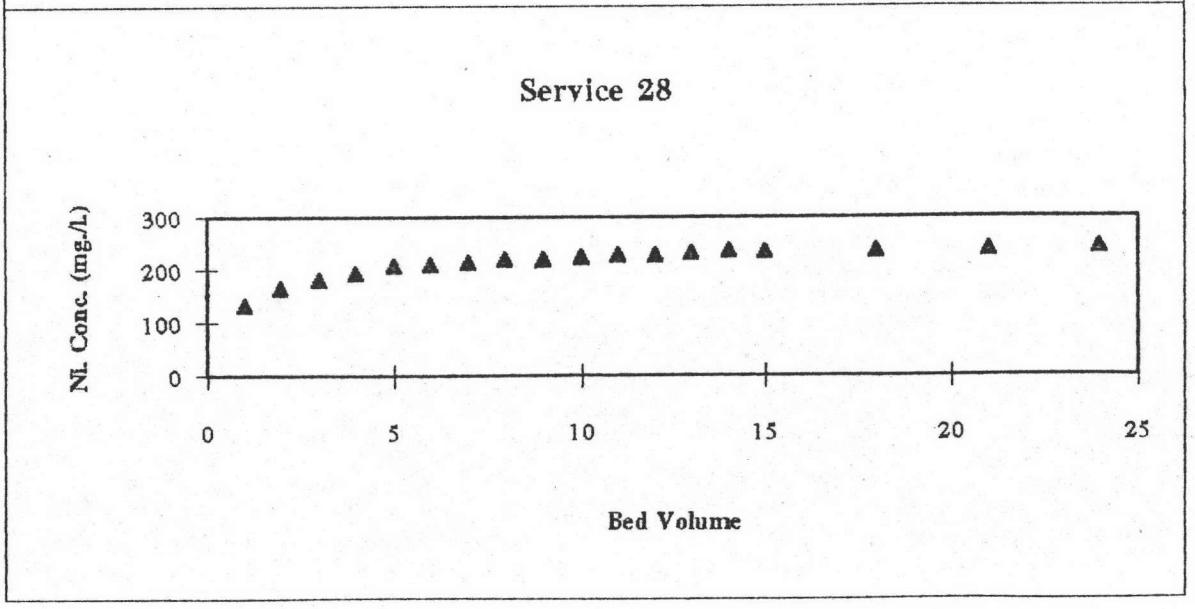
Column Size ∅ 6.75*100 cm.

Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)
synthetic	9	6.68	0.7	256.5

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff. Conc. (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
					Value	Average	Value	Cumulation	
1	1	2.57	1.372	131.7	0.51	0.26	0.74	0.74	190.65
2	2	2.65	1.275	165.8	0.65	0.58	0.42	1.16	298.40
3	3	2.73	1.19	181.3	0.71	0.68	0.32	1.49	381.35
4	4	2.81	1.119	193.2	0.75	0.73	0.27	1.76	450.60
5	5	2.88	1.065	208.8	0.81	0.78	0.22	1.97	506.10
6	6	2.94	1.024	209.8	0.82	0.82	0.18	2.16	553.30
7	7	2.99	0.987	215	0.84	0.83	0.17	2.33	597.40
8	8	3.05	0.952	219.6	0.86	0.85	0.15	2.48	636.60
9	9	3.1	0.952	220.5	0.86	0.86	0.14	2.62	673.05
10	10	3.15	0.898	225.1	0.88	0.87	0.13	2.76	706.75
11	11	3.19	0.88	227.9	0.89	0.88	0.12	2.87	736.75
12	12	3.22	0.871	228.6	0.89	0.89	0.11	2.98	765.00
13	13	3.25	0.865	233.3	0.91	0.90	0.10	3.08	790.55
14	14	3.28	0.857	236.1	0.92	0.92	0.08	3.17	812.35
15	15	3.36	0.851	235.3	0.92	0.92	0.08	3.25	833.15
16	18	3.42	0.829	237.6	0.93	0.92	0.23	3.48	893.30
17	21	3.48	0.813	238.3	0.93	0.93	0.22	3.70	948.95
18	24	3.53	0.801	242.9	0.95	0.94	0.19	3.89	996.65


Service 28
pH
4
2
0
0
5
10
15
20
25
Bed Volume


Service 28
Conductivity (mS./cm.)
1.5
1
0.5
0
0
5
10
15
20
25
Bed Volume

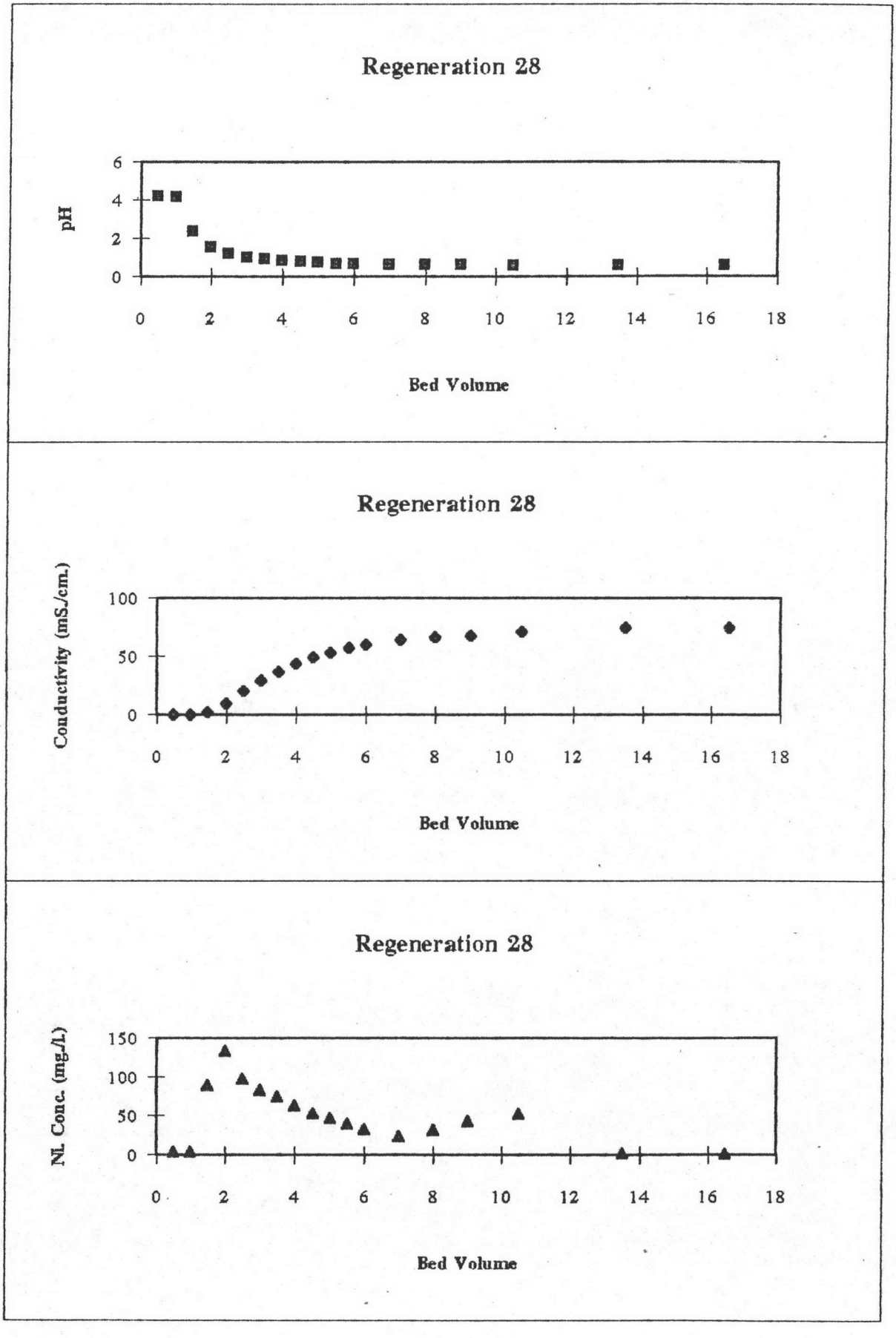

Service 28
Ni. Conc. (mg./L)
300
200
100
0
0
5
10
15
20
25
Bed Volume

EXPERIMENT 28 Regeneration

Column Size ∅ 6.75*100 cm.

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc (Normal)
HCl	9	0.58	74.8	0.25

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Ni.reg. Conc (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc (mg./l.)
					Value	Average	Cumulation			
1	0.5	4.22	0.0507	3.99	0.00	0.00	0.00	1.00	1.00	2.00
2	1	4.15	0.054	4.35	0.00	0.00	0.00	2.1	3.1	3.08
3	1.5	2.38	1.89	89.5	0.04	0.02	0.03	23.5	26.5	17.70
4	2	1.55	9.85	133.8	0.07	0.06	0.08	55.8	82.4	41.19
5	2.5	1.2	20.3	97.9	0.05	0.06	0.14	57.9	140.3	56.12
6	3	1.02	29.7	83.6	0.04	0.05	0.19	45.4	185.7	61.89
7	3.5	0.92	36.7	75	0.04	0.04	0.23	39.7	225.3	64.38
8	4	0.83	44	63.6	0.03	0.03	0.26	34.7	260.0	64.99
9	4.5	0.78	49.3	53.9	0.03	0.03	0.29	29.4	289.3	64.30
10	5	0.74	53.5	46.8	0.02	0.03	0.32	25.2	314.5	62.90
11	5.5	0.68	57.4	39.7	0.02	0.02	0.34	21.6	336.1	61.12
12	6	0.65	60.4	32.9	0.02	0.02	0.36	18.2	354.3	59.05
13	7	0.64	64.5	23.3	0.02	0.02	0.38	28.1	382.4	54.63
14	8	0.63	66.3	32	0.03	0.03	0.40	27.7	410.0	51.26
15	9	0.62	68	43.5	0.04	0.04	0.44	37.8	447.8	49.76
16	10.5	0.6	71	52.9	0.08	0.06	0.50	72.3	520.1	49.53
17	13.5	0.58	74.5	2.54	0.01	0.04	0.55	83.2	603.3	44.69
18	16.5	0.58	75	0.81	0.00	0.01	0.55	5.0	608.3	36.87

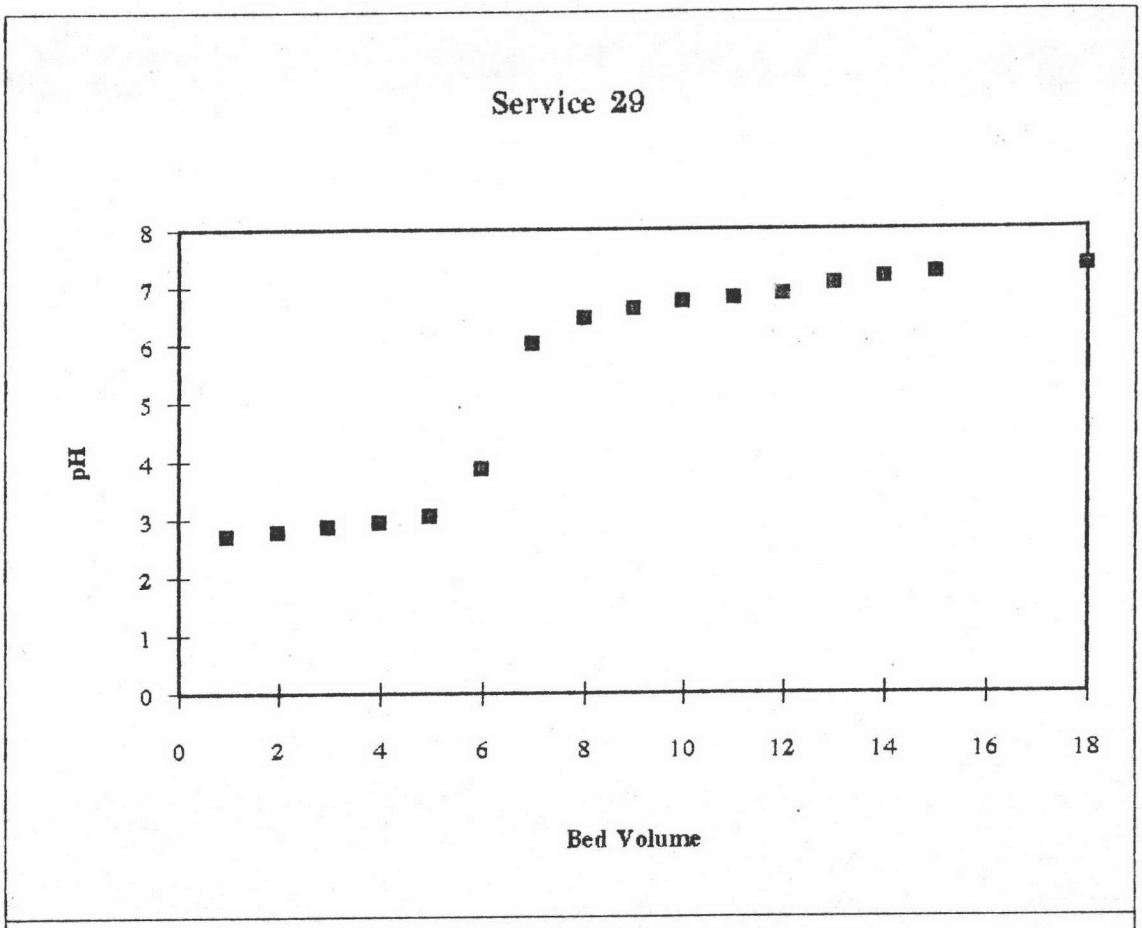

Regeneration 28
pH
6
4
2
0
0
2
4
6
8
10
12
14
16
18
Bed Volume
Regeneration 28
Conductivity (mS./cm.)
100
50
0
0
2
4
6
8
10
12
14
16
18
Bed Volume
Regeneration 28
NL Conc. (mg./L)
150
100
50
0
0
2
4
6
8
10
12
14
16
18
Bed Volume

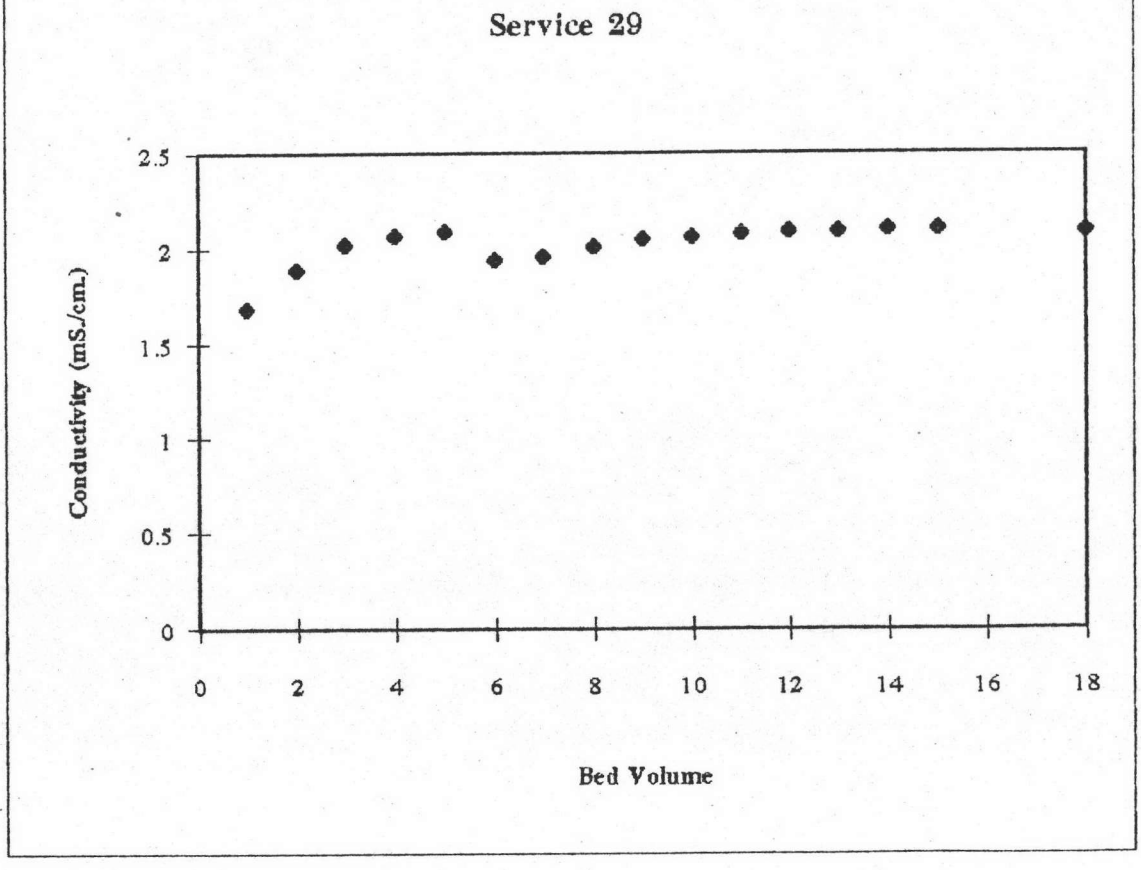
EXPERIMENT 29 Service

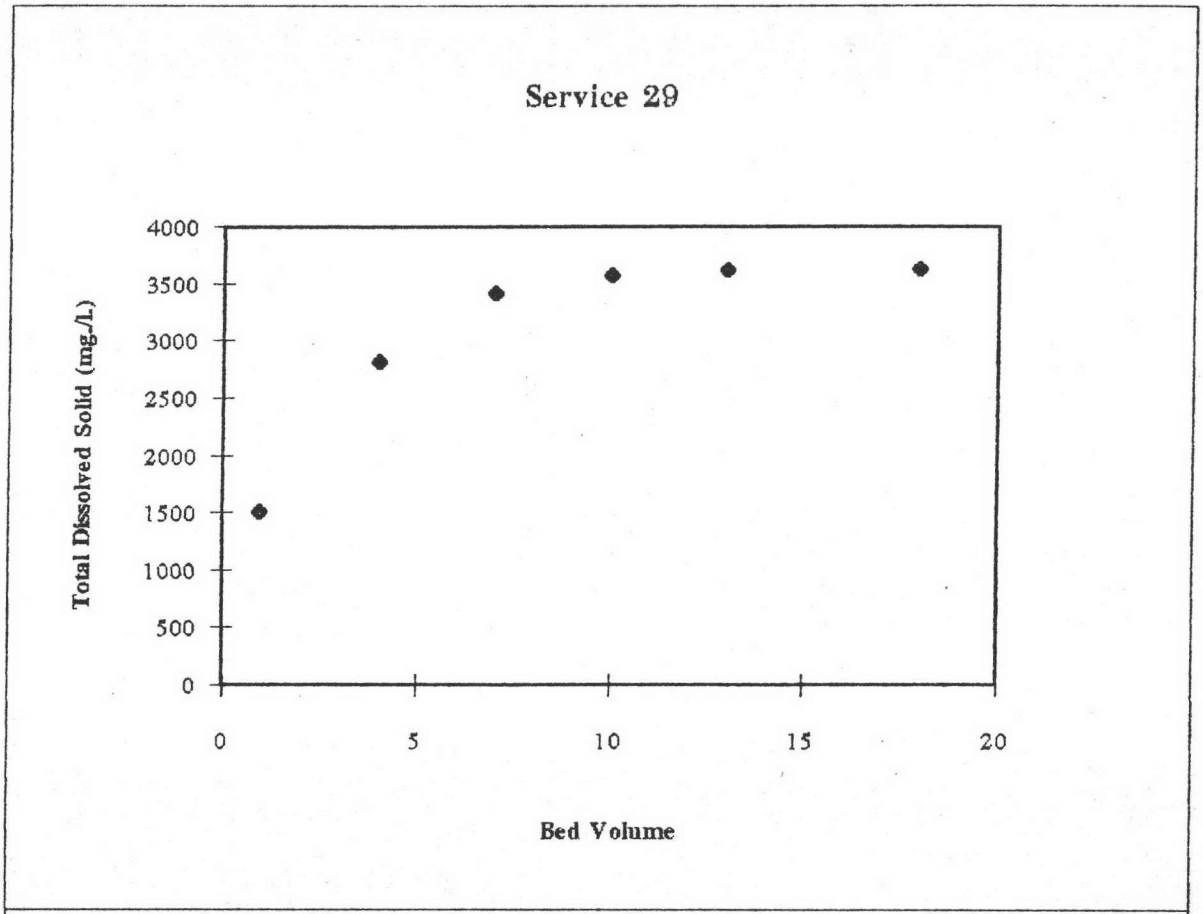
Column Size ∅ 6.75*100 cm.

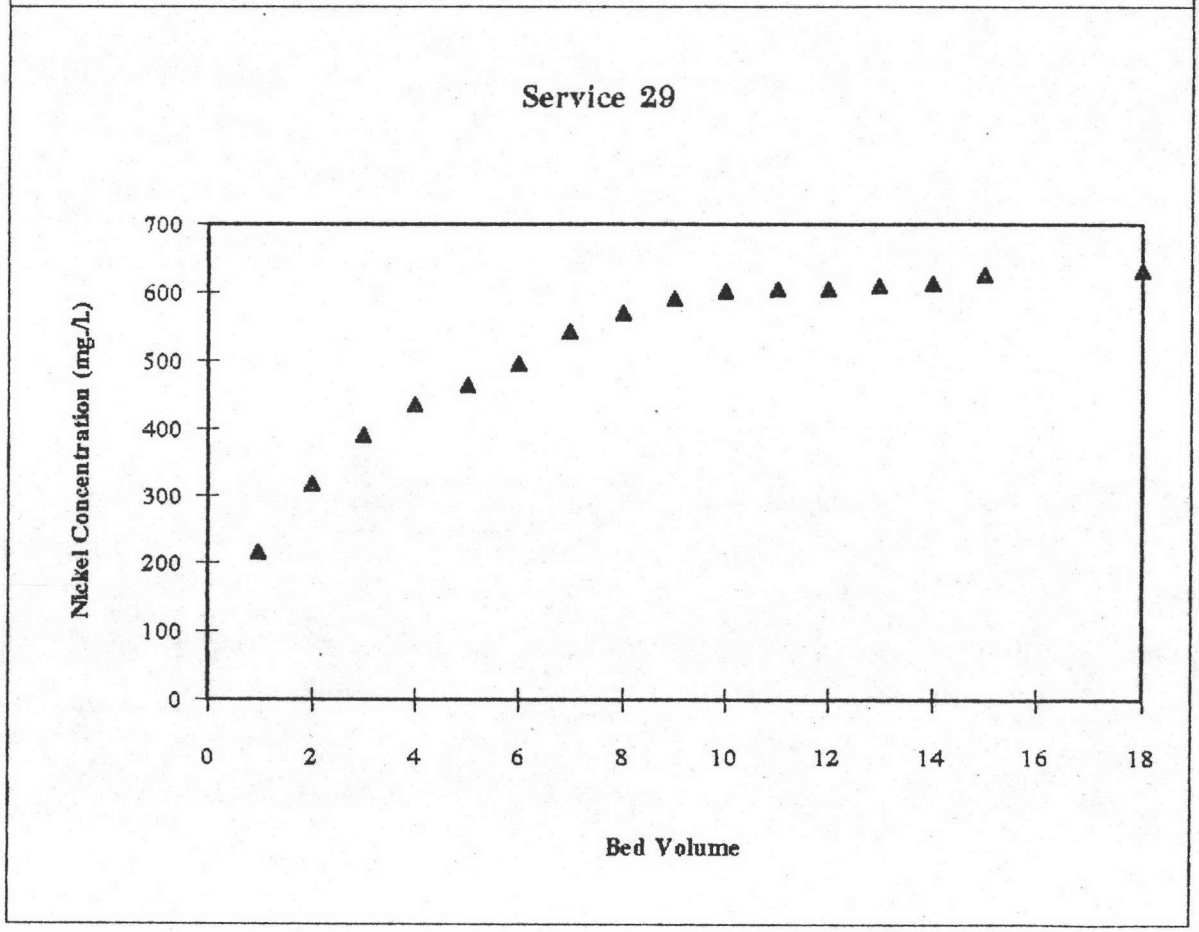
Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)	TDS (mg./l.)
Real	9	7.65	2.14	677	3644

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff Conc (mg./l.)	TDS (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l.resin)
						Value	Average	Value	Cumulation	
1	1	2.69	1.684	217	1513	0.32	0.16	0.84	0.84	568.45
2	2	2.77	1.893	317		0.47	0.39	0.61	1.44	978.20
3	3	2.86	2.02	390		0.58	0.52	0.48	1.92	1301.55
4	4	2.94	2.07	435	2817	0.64	0.61	0.39	2.31	1566.10
5	5	3.05	2.09	463		0.68	0.66	0.34	2.65	1794.10
6	6	3.86	1.94	494		0.73	0.71	0.29	2.94	1992.60
7	7	6.01	1.96	543	3416	0.80	0.77	0.23	3.18	2151.10
8	8	6.45	2.01	569		0.84	0.82	0.18	3.36	2272.10
9	9	6.62	2.05	591		0.87	0.86	0.14	3.50	2369.10
10	10	6.75	2.06	601	3568	0.89	0.88	0.12	3.62	2450.10
11	11	6.79	2.08	605		0.89	0.89	0.11	3.73	2524.10
12	12	6.88	2.09	604		0.89	0.89	0.11	3.84	2596.60
13	13	7.05	2.09	610	3620	0.90	0.90	0.10	3.94	2666.60
14	14	7.16	2.1	613		0.91	0.90	0.10	4.04	2732.10
15	15	7.24	2.1	625		0.92	0.91	0.09	4.12	2790.10
16	18	7.35	2.09	631	3624	0.93	0.93	0.22	4.34	2937.10


Service 29
pH
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
12
14
16
18
Bed Volume


Service 29
Conductivity (mS./cm.)
0
0.5
1
1.5
2
2.5
0
2
4
6
8
10
12
14
16
18
Bed Volume


Service 29
Total Dissolved Solid (mg./L)
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
Bed Volume


Service 29
Nickel Concentration (mg./L)
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
Bed Volume

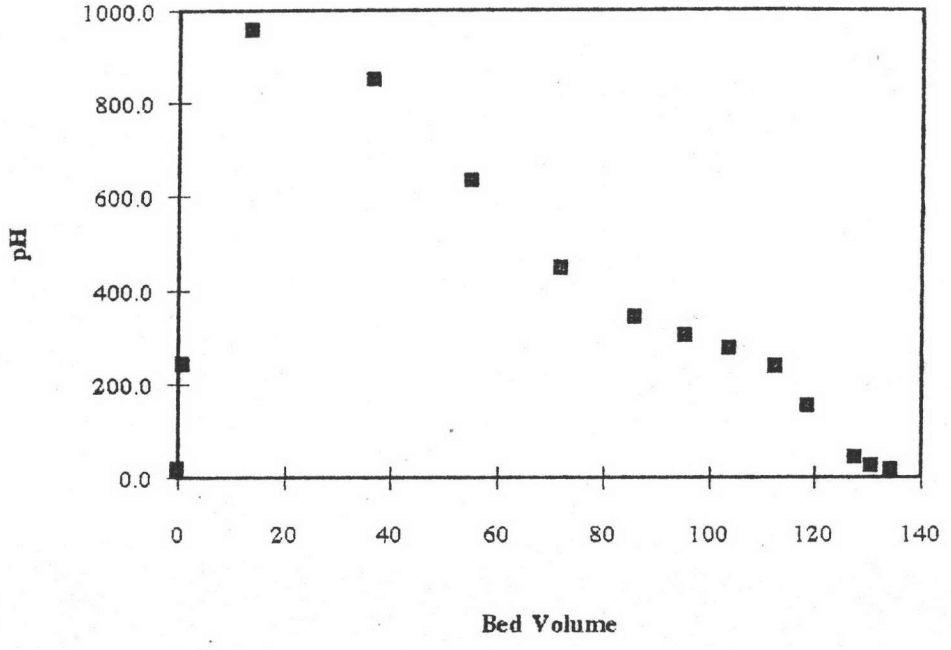
EXPERIMENT 29 Regeneration

Column Size ∅ 6.75*100 cm.

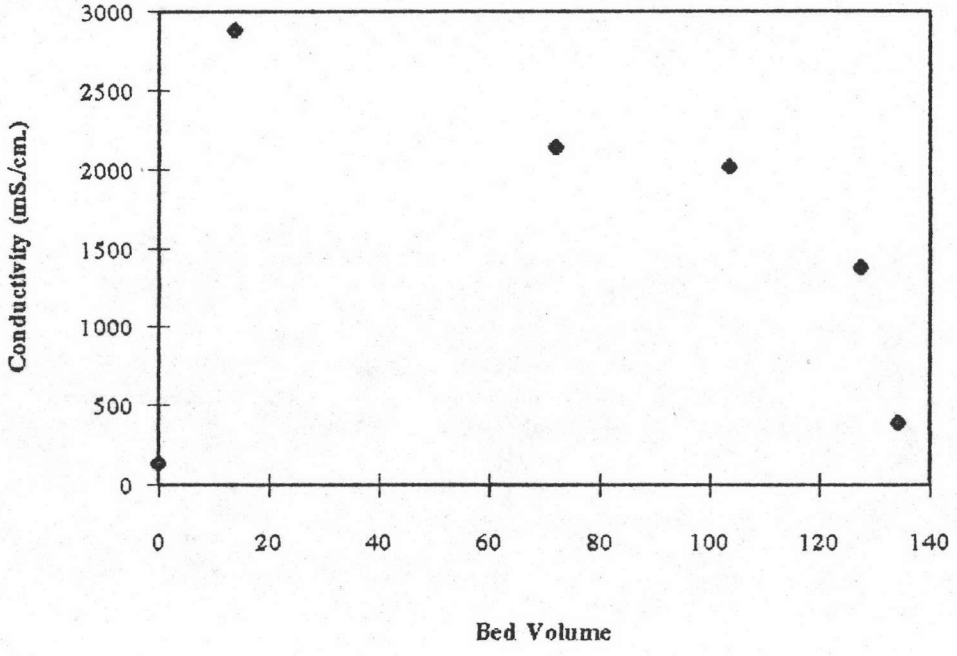
Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)	TDS (mg./l.)
HCl	3	0.18	138.6	0.5	140

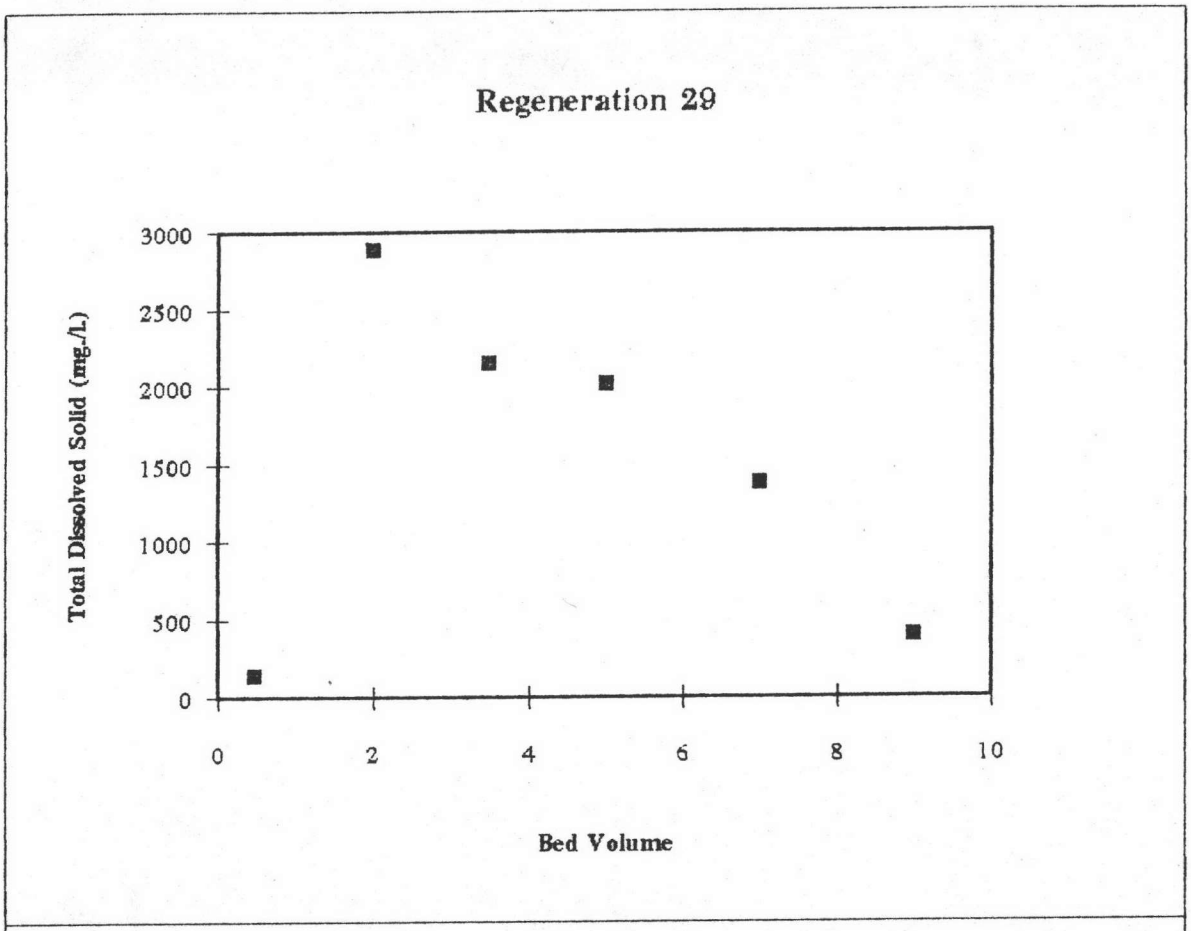
Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	TDS (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
					Value	Average	Cumulation			
0.5	7.16	0.0631	17.4	136	0.00	0.00	0.00	4.35	4.35	8.70
1	7.21	0.0665	18.0		0.00	0.00	0.00	8.9	13.2	13.20
1.5	5.71	0.93	243		0.04	0.02	0.03	65.3	78.5	52.30
2	1.38	13.75	959	2882	0.16	0.10	0.13	300.5	379.0	189.48
2.5	0.86	36.6	851		0.14	0.15	0.28	452.5	831.5	332.58
3	0.65	55	636		0.11	0.13	0.41	371.8	1203.2	401.07
3.5	0.51	71.9	450	2142	0.08	0.09	0.50	271.5	1474.7	421.34
4	0.42	85.7	344		0.06	0.07	0.57	198.5	1673.2	418.30
4.5	0.36	95.5	304		0.05	0.06	0.62	162.0	1835.2	407.82
5	0.32	103.7	277	2016	0.05	0.05	0.67	145.3	1980.5	396.09
5.5	0.28	112.3	238		0.04	0.04	0.72	128.8	2109.2	383.49
6	0.25	118.7	154		0.03	0.03	0.75	98.0	2207.2	367.87
7	0.22	127.5	43.2	1382	0.01	0.02	0.77	98.6	2305.8	329.40
8	0.2	130.8	25.3		0.01	0.01	0.78	34.3	2340.1	292.51
9	0.19	134.4	16.5	392	0.01	0.01	0.79	20.9	2360.9	262.33

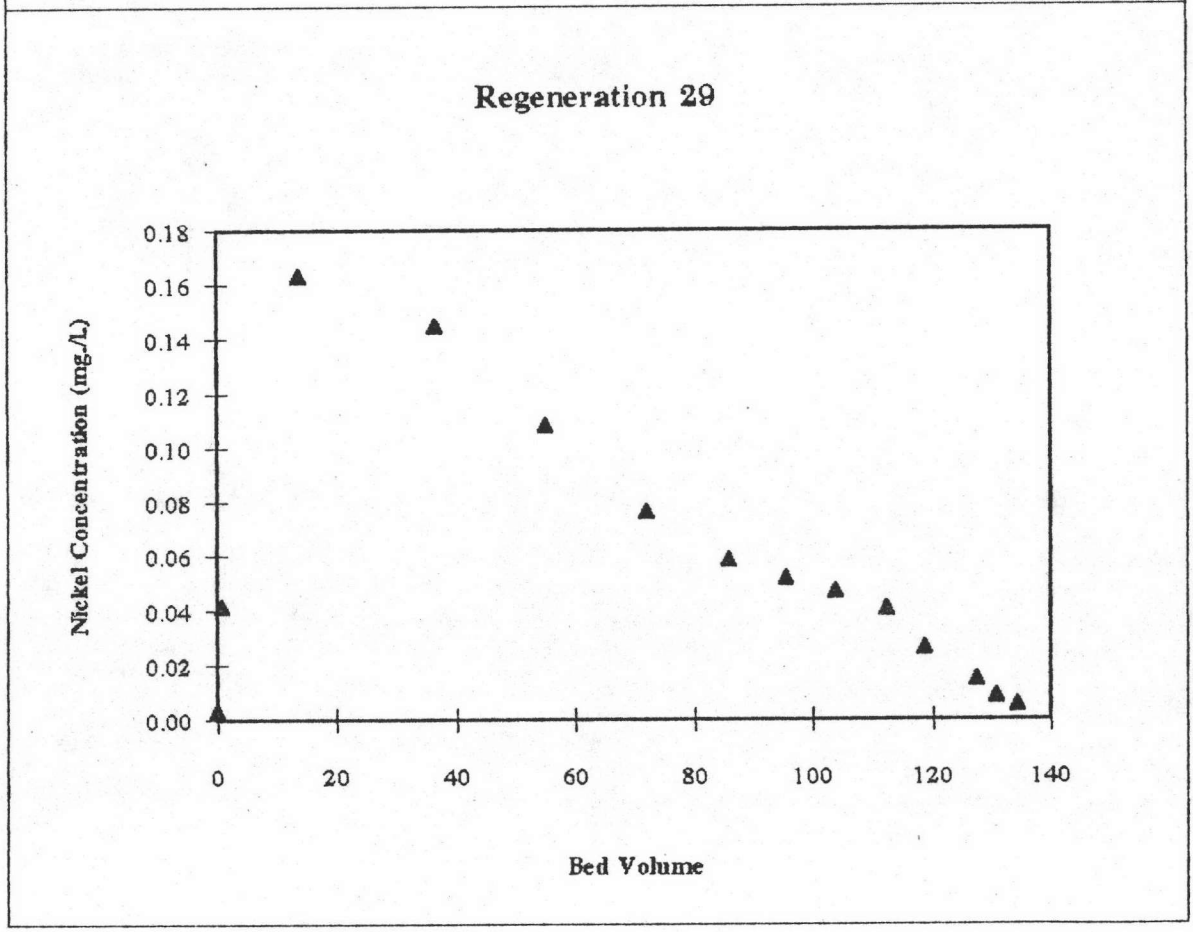
Regeneration 29



Regeneration 29




Regeneration 29
Total Dissolved Solid (mg/L)
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
Bed Volume

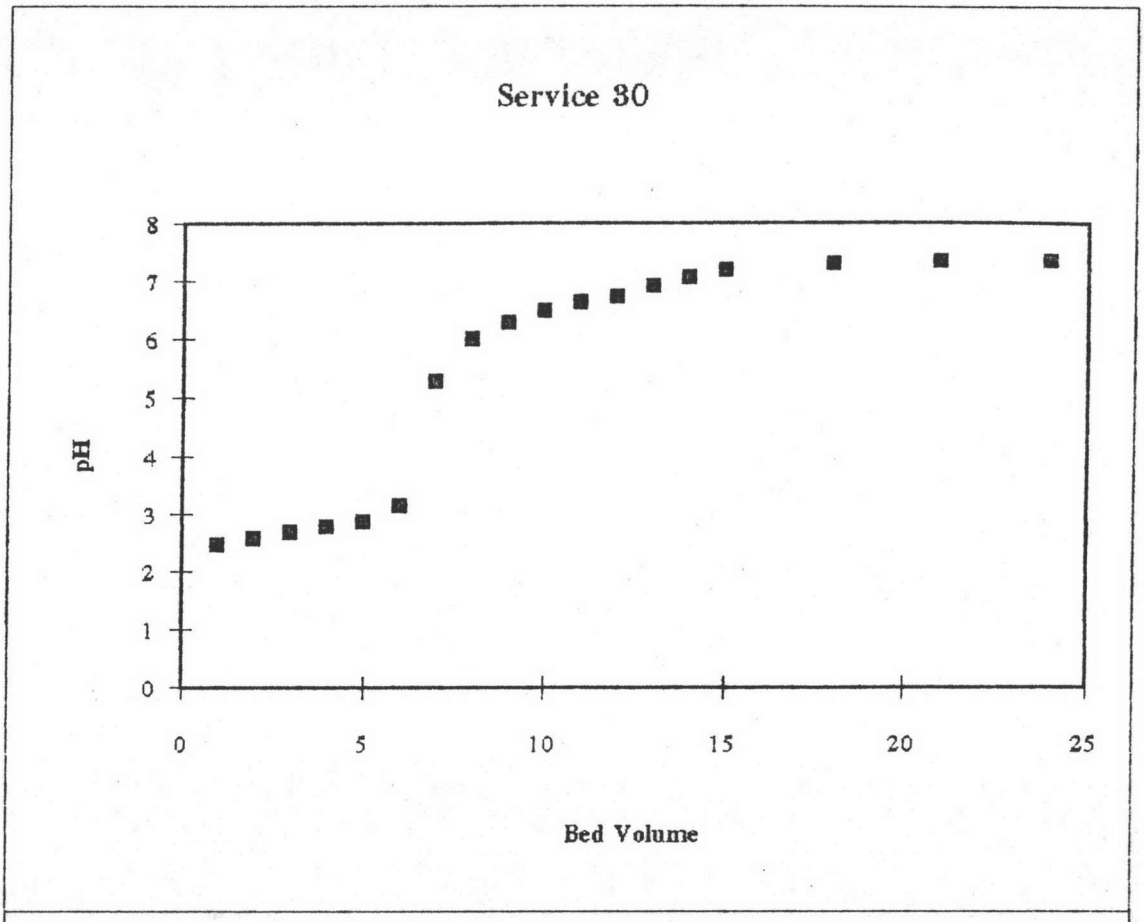

Regeneration 29
Nickel Concentration (mg/L)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
20
40
60
80
100
120
140
Bed Volume

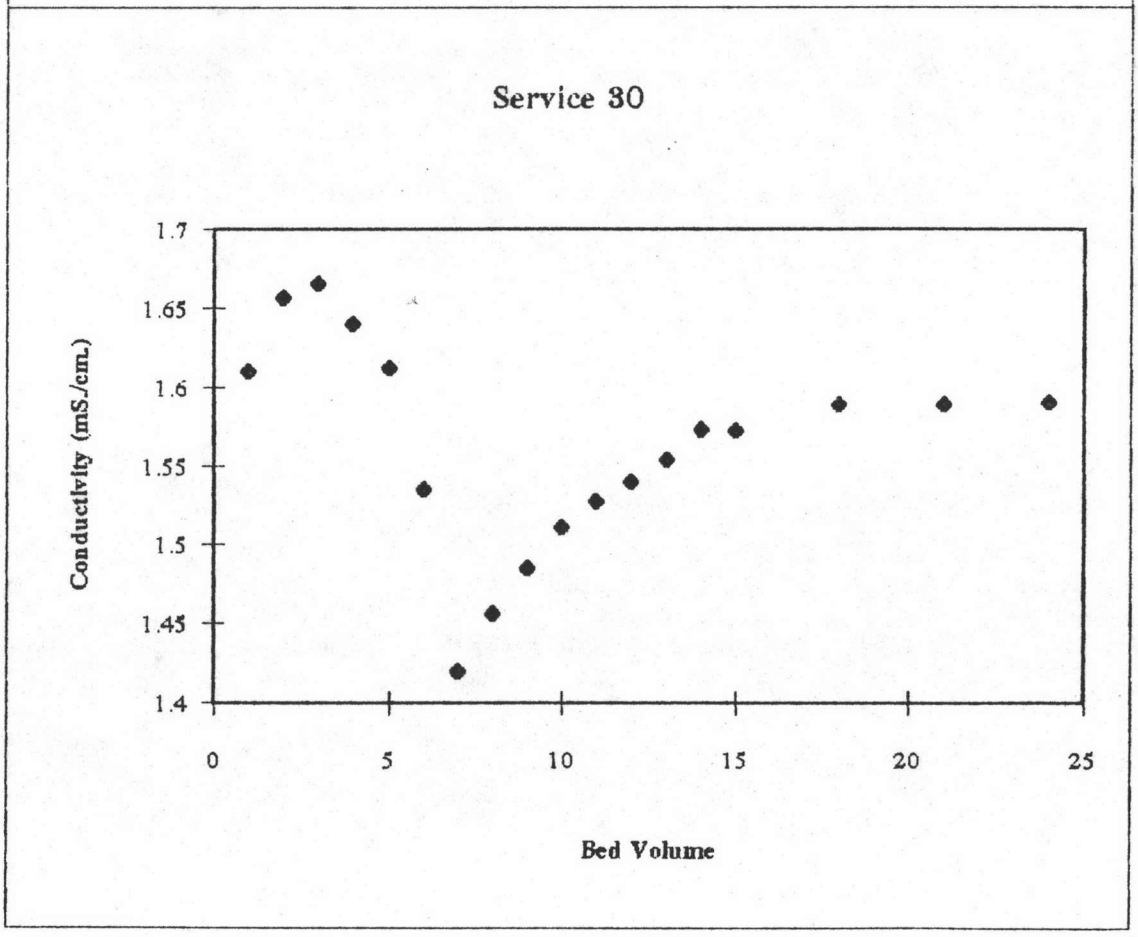
EXPERIMENT 30 Service

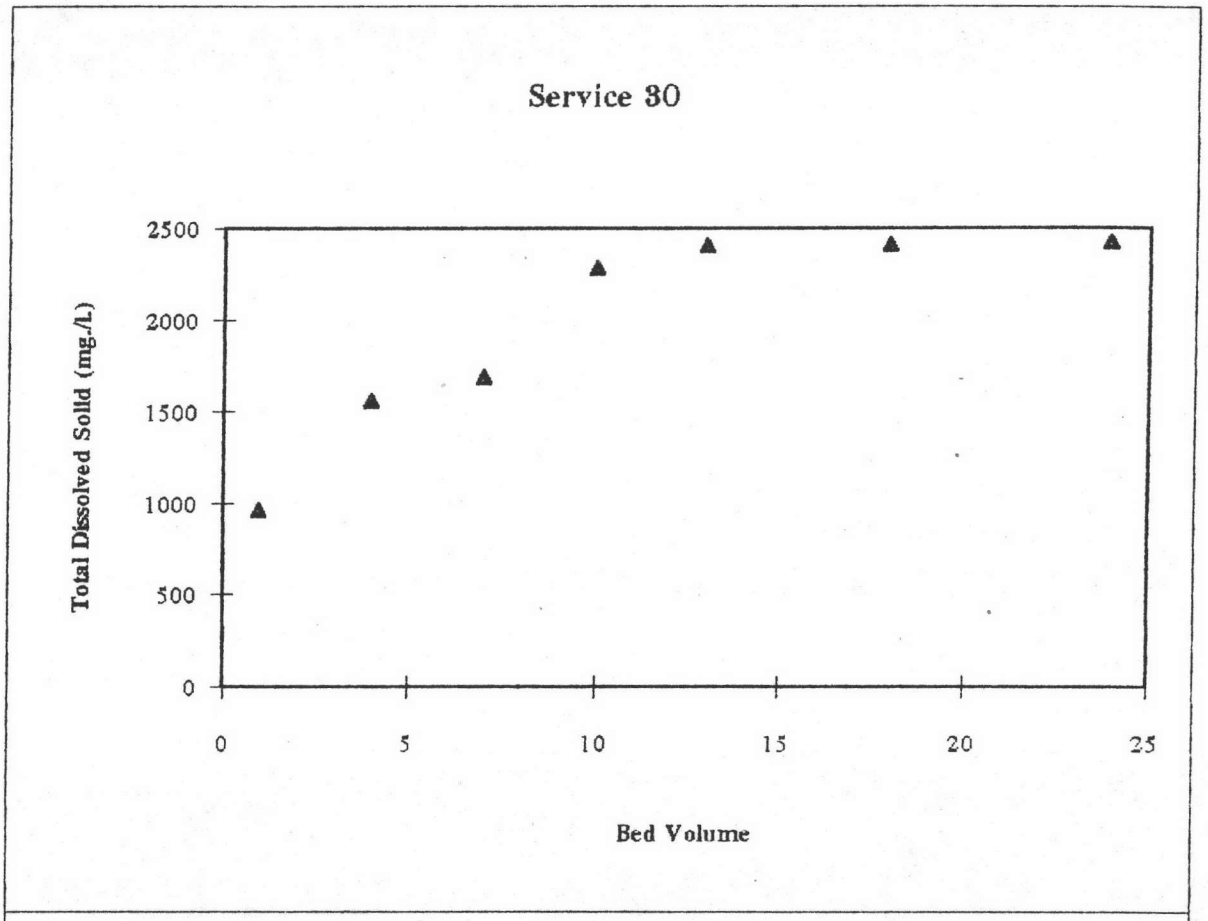
Column Size ∅ 6.75*100 cm.

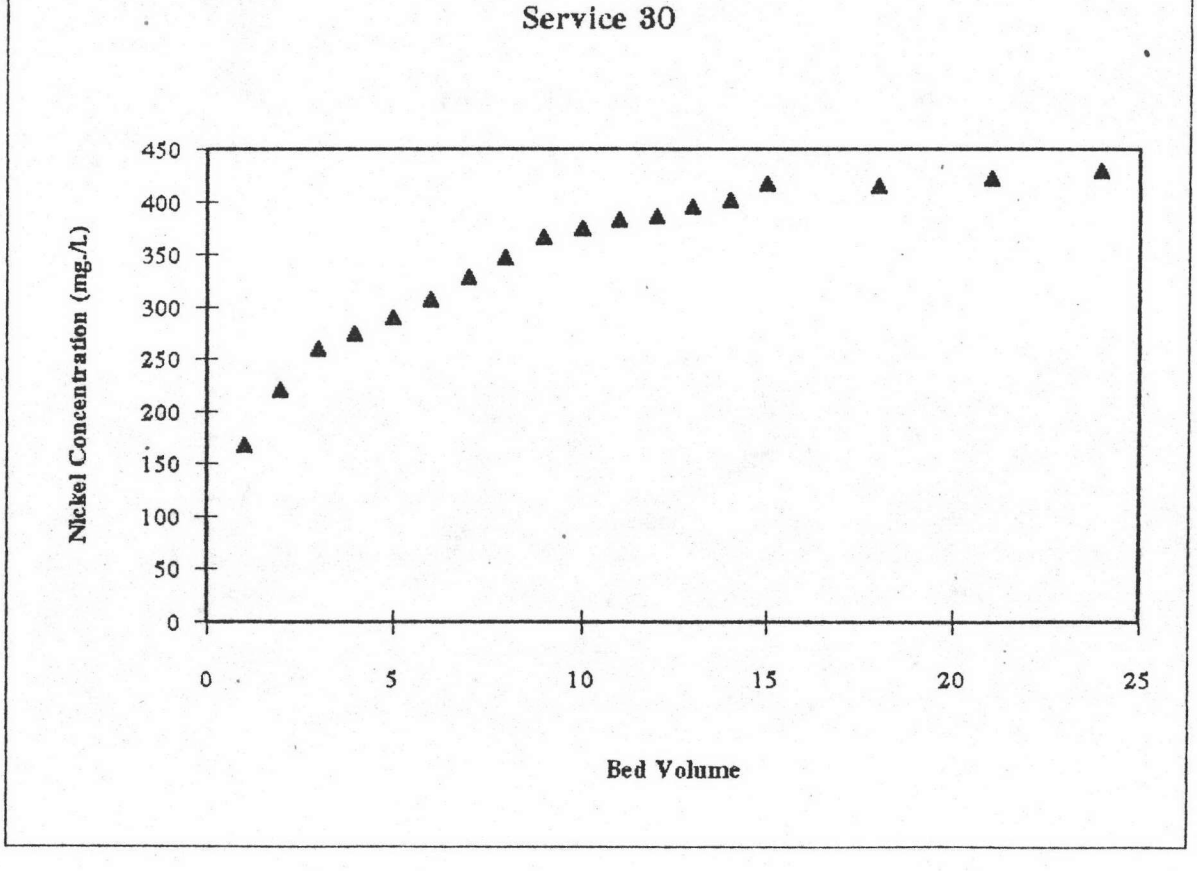
Influent Waste	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Ni in conc (mg./l.)	TDS (mg./l.)
Real	9	7.63	1.593	445	1888

Effluent NO	Bed Volume	pH	Conductivity (mS./cm.)	Ni eff Conc (mg./l.)	TDS (mg./l.)	Effluent Nickel / Influent Nickel		Exchanging Nickel / Influent Nickel		Total Exchanging (mg./l resin)
						Value	Average	Value	Cumulation	
1	1	2.45	1.61	168	966	0.38	0.19	0.81	0.81	361.00
2	2	2.56	1.657	220		0.49	0.44	0.56	1.38	612.00
3	3	2.67	1.666	259		0.58	0.54	0.46	1.84	817.50
4	4	2.77	1.64	274	1558	0.62	0.60	0.40	2.24	996.00
5	5	2.86	1.612	289		0.65	0.63	0.37	2.61	1159.50
6	6	3.15	1.535	307		0.69	0.67	0.33	2.94	1306.50
7	7	5.29	1.42	328	1690	0.74	0.71	0.29	3.22	1434.00
8	8	6	1.456	347		0.78	0.76	0.24	3.46	1541.50
9	9	6.29	1.485	367		0.82	0.80	0.20	3.66	1629.50
10	10	6.48	1.511	375	2284	0.84	0.83	0.17	3.83	1703.50
11	11	6.64	1.528	383		0.86	0.85	0.15	3.98	1769.50
12	12	6.73	1.54	386		0.87	0.86	0.14	4.11	1830.00
13	13	6.91	1.554	395	2404	0.89	0.88	0.12	4.23	1884.50
14	14	7.05	1.573	402		0.90	0.90	0.10	4.34	1931.00
15	15	7.19	1.572	417		0.94	0.92	0.08	4.42	1966.50
16	18	7.3	1.589	415	2414	0.93	0.93	0.20	4.61	2053.50
17	21	7.34	1.589	422.0		0.95	0.94	0.18	4.79	2133
18	24	7.33	1.59	429.0	2426	0.96	0.96	0.13	4.92	2191.5


Service 30
pH
8
7
6
5
4
3
2
1
0
0
5
10
15
20
25
Bed Volume


Service 30
Conductivity (mS./cm.)
1.7
1.65
1.6
1.55
1.5
1.45
1.4
0
5
10
15
20
25
Bed Volume

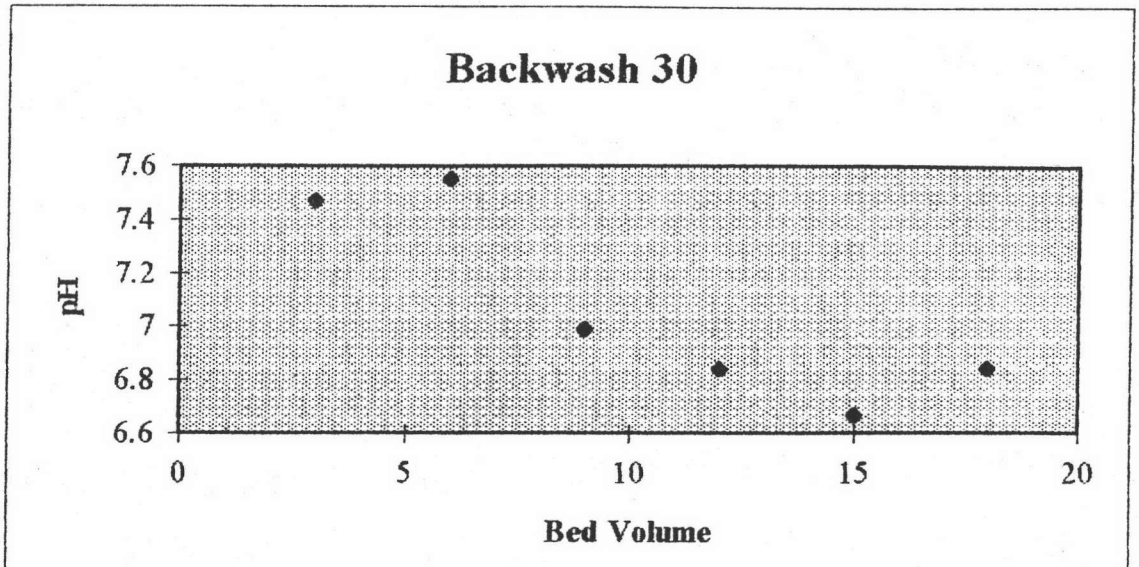

Service 30
Total Dissolved Solid (mg./L)
2500
2000
1500
1000
500
0
0
5
10
15
20
25
Bed Volume

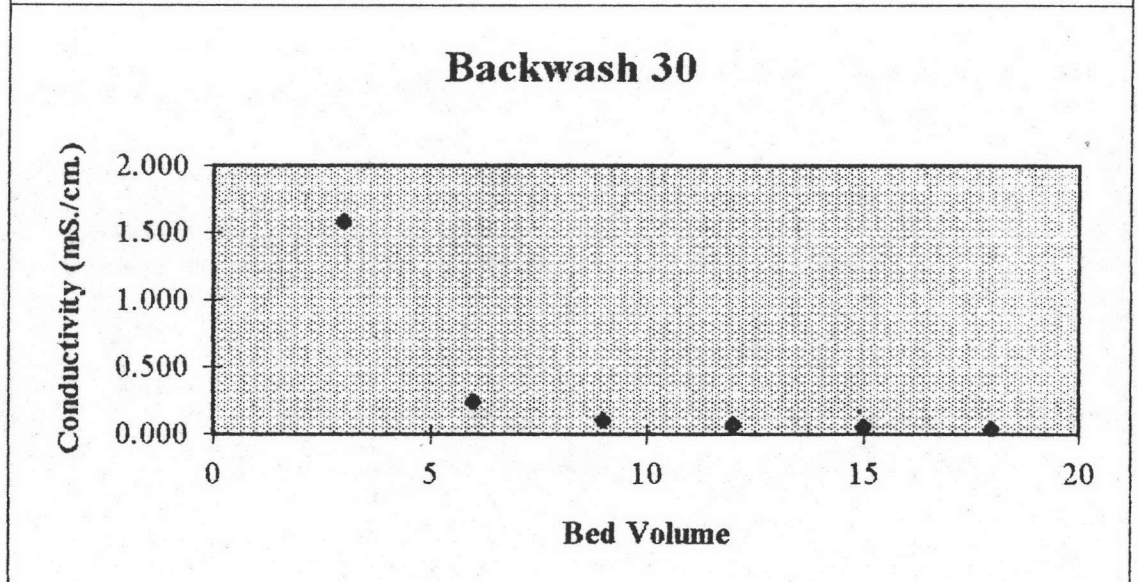

Service 30
Nickel Concentration (mg./L)
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
Bed Volume

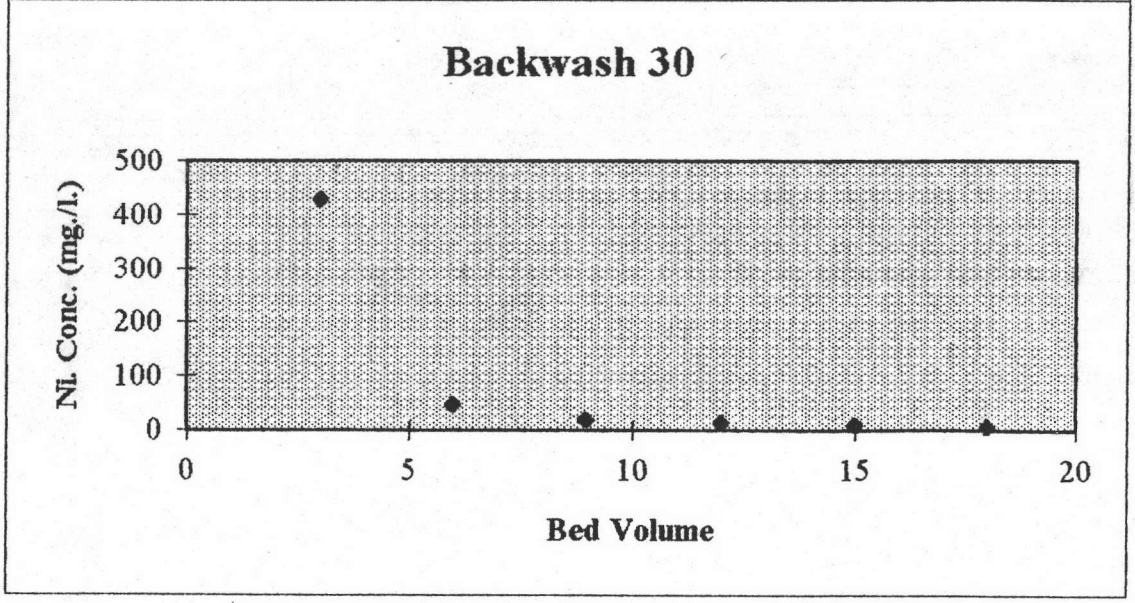
EXPERIMENT 30 Backwash

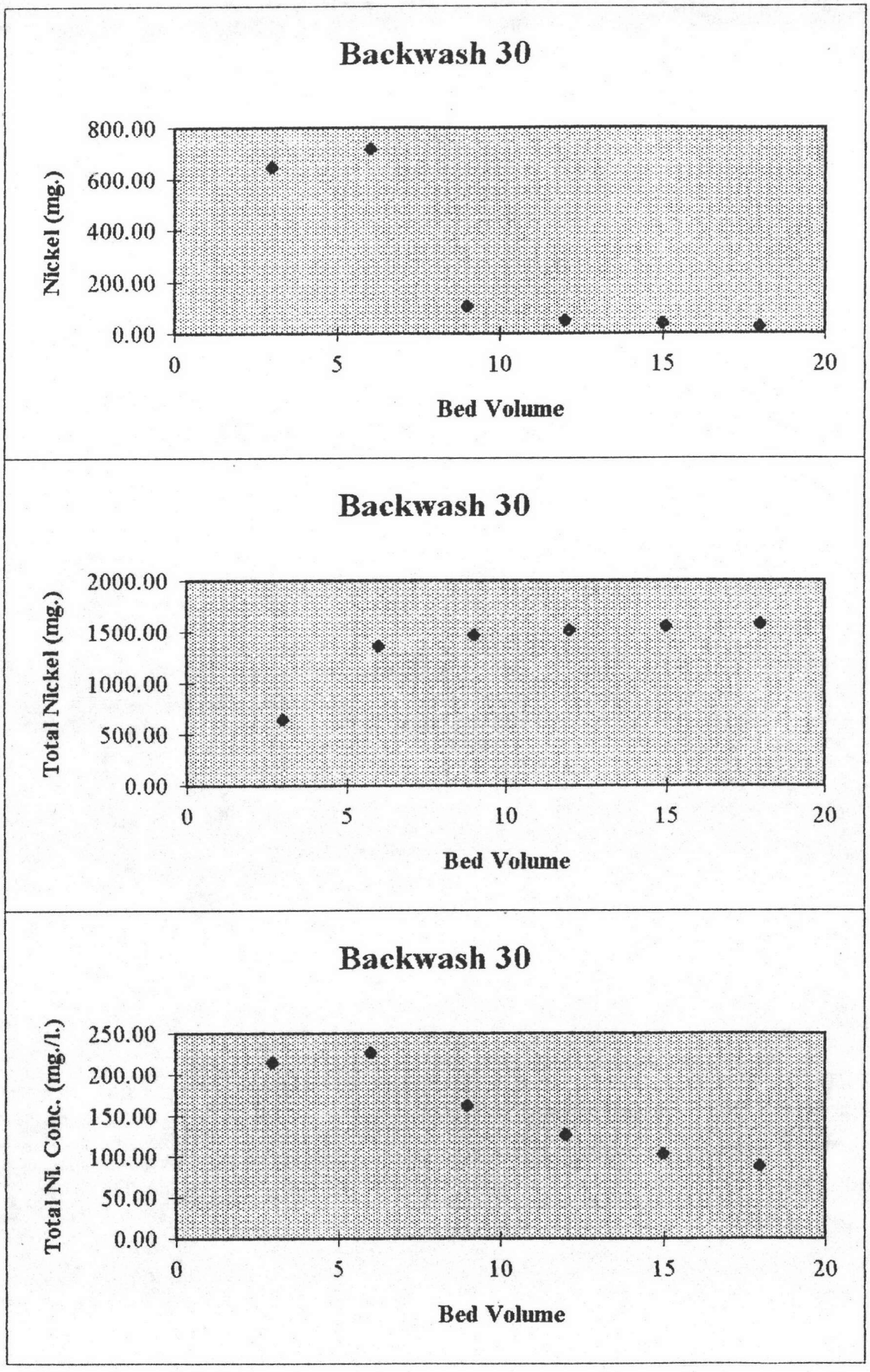
Column Size ∅ 6.75*100 cm.

Effluent NO.	Bed Volume	pH	Conductivity (mS./cm.)	Nickel Conc. (mg./l.)	Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni. Conc. (mg./l.)
1	3	7.47	1.585	430	645.00	645.00	215.00
2	6	7.55	0.243	48.8	718.2	1363.2	227.20
3	9	6.99	0.105	20.9	104.6	1467.8	163.08
4	12	6.84	0.073	14.0	52.4	1520.1	126.68
5	15	6.67	0.057	10.7	37.1	1557.2	103.81
6	18	6.84	0.039	6.9	26.4	1583.6	87.98


Backwash 30
pH
7.6
7.4
7.2
7
6.8
6.6
0
5
10
15
20
Bed Volume


Backwash 30
Conductivity (mS./cm.)
2.000
1.500
1.000
0.500
0.000
0
5
10
15
20
Bed Volume


Backwash 30
Ni. Conc. (mg./l.)
500
400
300
200
100
0
0
5
10
15
20
Bed Volume

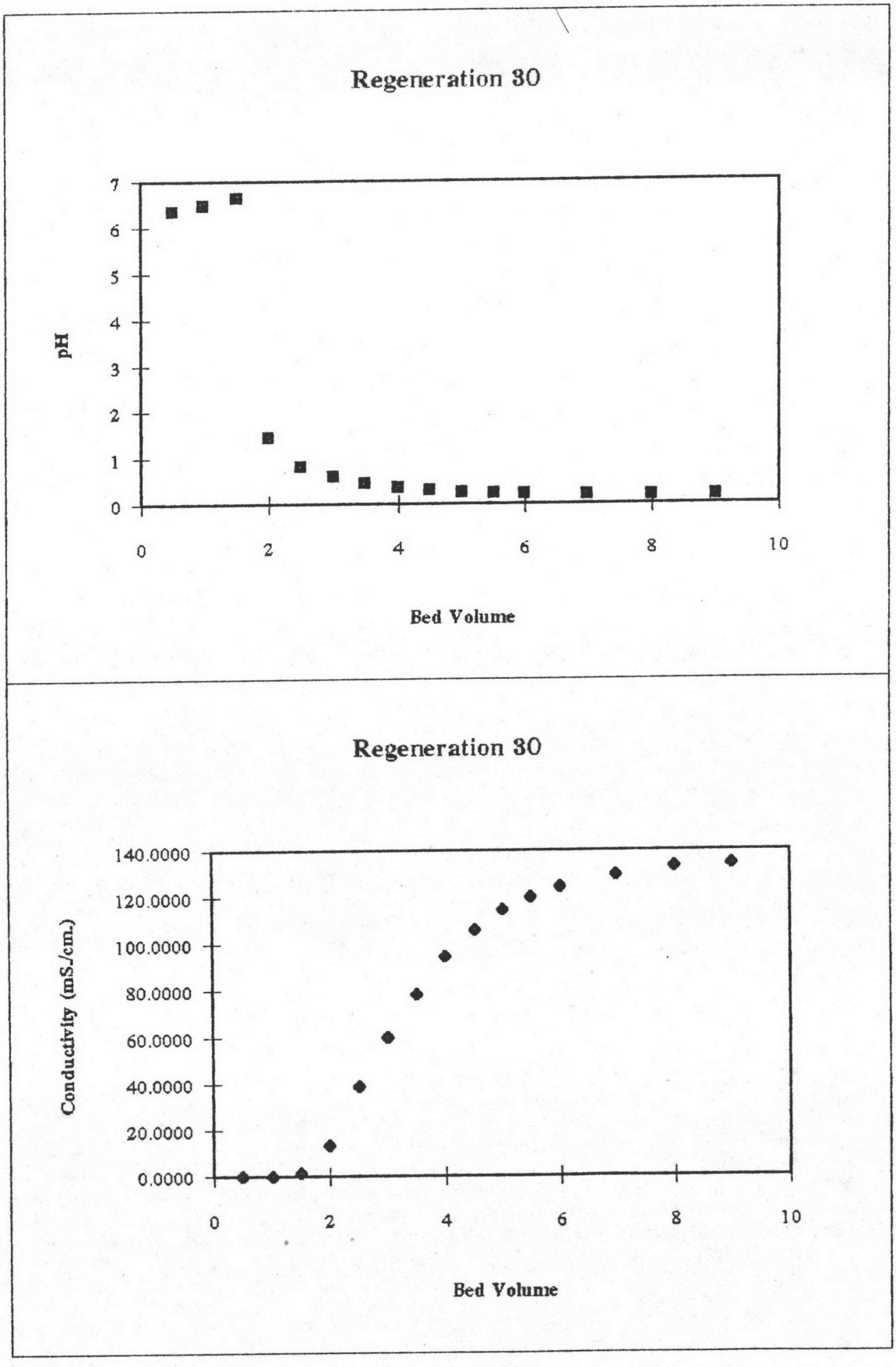

Backwash 30
Nickel (mg.)
800.00
600.00
400.00
200.00
0.00
0
5
10
15
20
Bed Volume
Backwash 30
Total Nickel (mg.)
2000.00
1500.00
1000.00
500.00
0.00
0
5
10
15
20
Bed Volume
Backwash 30
Total Ni. Conc. (mg./l.)
250.00
200.00
150.00
100.00
50.00
0.00
0
5
10
15
20
Bed Volume

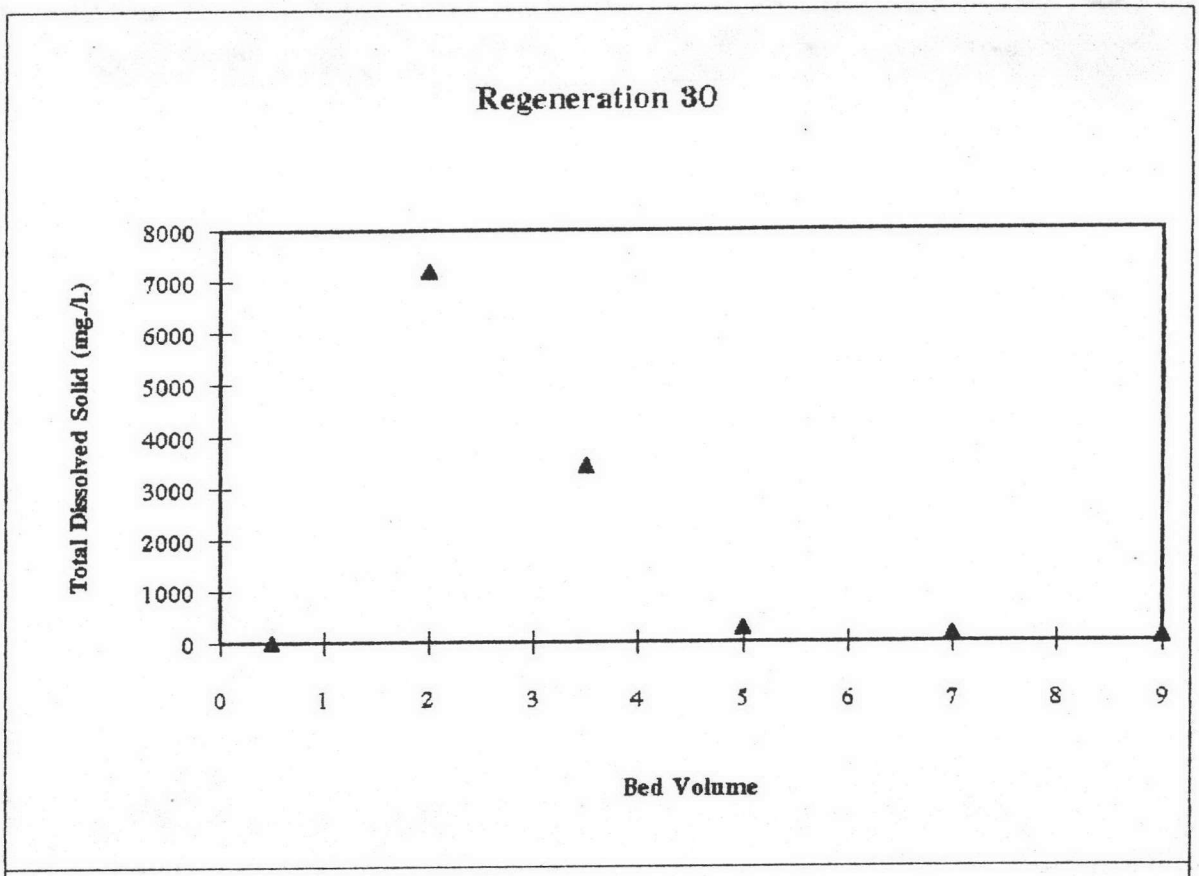
EXPERIMENT 30 Regeneration

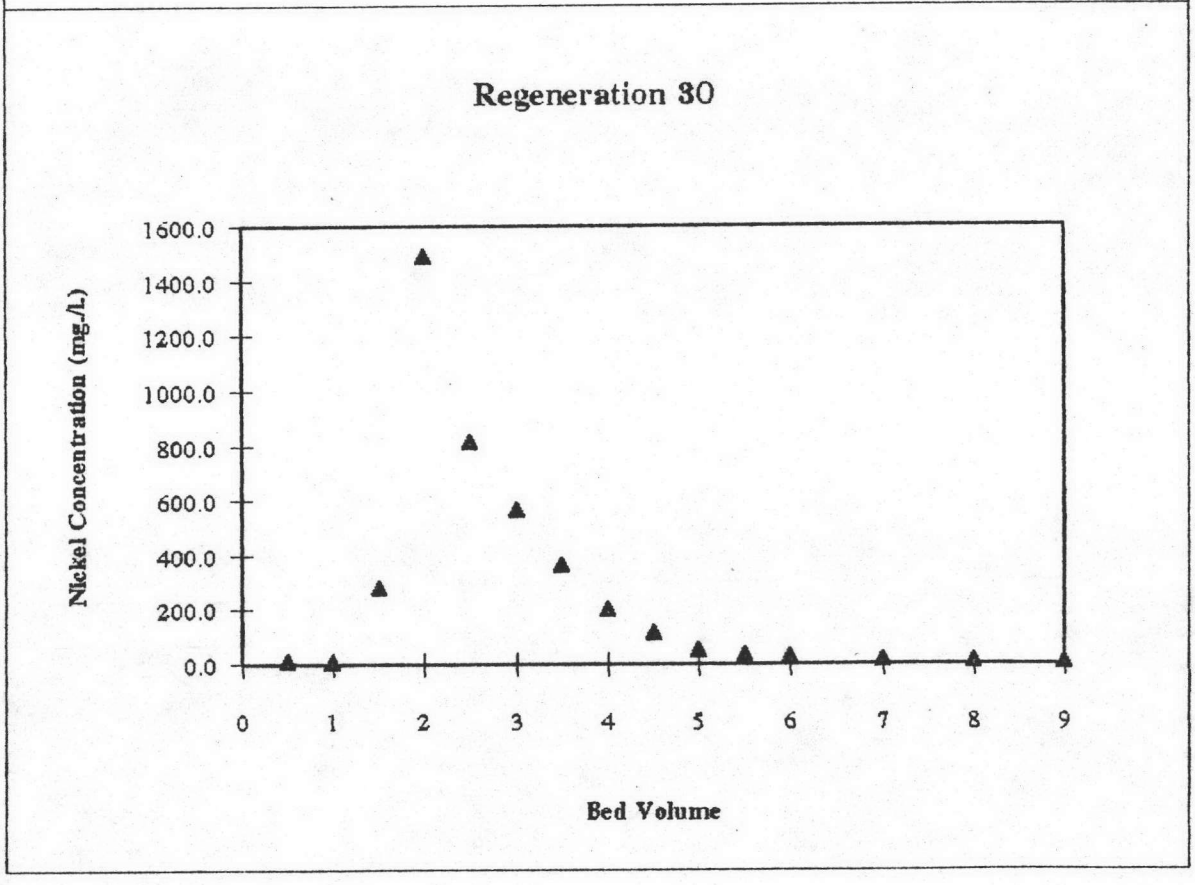
Column Size ∅ 6.75*100 cm

Influent Regenerant	flow (BV./Hr.)	pH	Conductivity (mS./cm.)	Conc. (Normal)	TDS (mg./l.)
HCl	3	0.16	138.4	0.5	42

Bed Volume	pH	Conductivity (mS./cm.)	Ni reg. Conc. (mg./l.)	TDS (mg./l.)	Total Regenerated Nickel / Total Exchanging Nickel			Weight of Nickel (mg.)	Total Nickel (mg.)	Total Ni Conc (mg./l.)
					Value	Average	Cumulation			
0.5	6.34	0.0717	11.0	10	0.00	0.00	0.00	2.74	2.74	5.48
1	6.48	0.0624	9.2		0.00	0.00	0.00	5.0	7.8	7.76
1.5	6.63	1.388	280		0.06	0.03	0.04	72.2	80.0	53.33
2	1.44	13.42	1490	7184	0.34	0.20	0.24	442.4	522.4	261.21
2.5	0.82	38.9	813		0.19	0.26	0.50	575.8	1098.2	439.27
3	0.6	59.9	565		0.13	0.16	0.66	344.4	1442.6	480.87
3.5	0.46	78.3	365	3414	0.08	0.11	0.76	232.3	1674.9	478.55
4	0.36	94.6	203		0.05	0.06	0.83	141.8	1816.7	454.17
4.5	0.3	105.9	116		0.03	0.04	0.87	79.7	1896.4	421.41
5	0.26	114.5	53.2	278	0.01	0.02	0.88	42.4	1938.7	387.74
5.5	0.24	120.2	34.7		0.01	0.01	0.89	22.0	1960.7	356.49
6	0.22	124.6	26		0.01	0.01	0.90	15.2	1975.8	329.31
7	0.2	129.5	16.1	154	0.01	0.01	0.91	21.1	1996.9	285.27
8	0.18	133.1	10.6		0.00	0.01	0.91	13.4	2010.3	251.28
9	0.18	134.1	7.7	74	0.00	0.00	0.92	9.1	2019.4	224.38


Regeneration 30
pH
0
1
2
3
4
5
6
7
0
2
4
6
8
10
Bed Volume
Regeneration 30
Conductivity (mS./cm.)
0.0000
20.0000
40.0000
60.0000
80.0000
100.0000
120.0000
140.0000
0
2
4
6
8
10
Bed Volume


Regeneration 30
Total Dissolved Solid (mg./L)
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9
Bed Volume


Regeneration 30
Nickel Concentration (mg./L)
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
0 1 2 3 4 5 6 7 8 9
Bed Volume

ประวัติผู้เขียน

นายขจรศักดิ์ โกศลมนตรี เกิดเมื่อวันที่ 1 สิงหาคม พ.ศ. 2511 ณ. กรุงเทพมหานคร สำเร็จการศึกษาระดับปริญญาตรีวิศวกรรมศาสตรบัณฑิต สาขาวิชาวิศวกรรมสิ่งแวดล้อม ภาควิชาวิศวกรรมสิ่งแวดล้อม คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย ในปีการศึกษา 2534 และเข้าศึกษาต่อในหลักสูตรวิศวกรรมศาสตรมหาบัณฑิต สาขาวิชาวิศวกรรมสุขาภิบาล ภาควิชาวิศวกรรมสิ่งแวดล้อม คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย ในปีการศึกษา 2536