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DEVELOPMENT AND OPERATIONAL PERFORMANCE OF THE CENTRAL POLLUTION CONTROL FACILITY II/S-3 LIQUID TREATMENT FACILITY

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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ABSTRACT

This report describes process development studies and plant performance data for the treatment of wastewater at the temporary treatment facility known as CPCF II/S-3 LTF (Central Pollution Control Facility II/S-3 Ponds Liquid Treatment Facility) and the future West End Treatment Facility (WETF). This report also describes biotest results using demineralized water containing chemicals commonly used to treat wastewater (e.g., sodium bicarbonate, sodium sulfate, etc).

The first CPCF II/S-3 LTF process produced an effluent that contained uranium at a nominal concentration of 77 mg/L. This amount of uranium significantly increased the uranium level in East Fork Poplar Creek. A new treatment process was developed and used to treat some of the water. In laboratory tests, the new process produced water containing uranium at <<5 mg/L and had a biotest (*Ceriodaphnia*) with an NOEC (no observed effect concentration) of 10% effluent in laboratory tests.

Laboratory tests show that the treatment process planned for the future WETF will meet the specified chemical discharge limits; however, the uranium removal may not be as good as the second process used at the CPCF II/S-3 LTF. The average uranium concentration in the wastewater was 11 mg/L in laboratory tests and had a biotest NOEC of 3%.

Specific chemicals in water are being biotested to determine their toxicity to *Ceriodaphnia*. Tests have shown that a uranium concentration of 0.1 to 0.5 mg/L reduced the reproduction rate of *Ceriodaphnia*, while 3 to 7 mg/L caused their death. Moderate amounts of sodium sulfate (2200 mg/L) reduced reproduction, as did a 1095-mg/L concentration of sodium bicarbonate. A 3300-mg/L concentration of sodium chloride killed them, and 1650 mg/L of sodium chloride reduced their reproduction rate. Potassium chloride (960 mg/L) also killed them, but 190 mg/L was not toxic. Lithium nitrate (200 mg/L) killed them within the seven-day test. The NOEC for these chemicals has not yet been established. Data obtained to date clearly indicate that all of these common chemicals are toxic at moderate concentrations, and significant improvements in the biotest results may not be possible until they are removed from the treated water.

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SUMMARY

Development studies have investigated unit operations for the treatment of nitrate wastes from Oak Ridge Y-12 Plant. The studies have examined the chemical purity of the wastewater and evaluated the toxicity. This report also documents the results obtained from the operation of the CPCF II/S-3 LTF (Central Pollution Control Facility II/S-3 Ponds Liquid Treatment Facility). This is an interim facility that has been used for the treatment and discharge of more than 1.5 million gal of liquid waste from the Plant.

Briefly, the process development tests have shown that waters containing 7 mg/L of uranium killed *Ceriodaphnia* and that concentration of 0.1 to 0.5 mg/L of uranium reduced their reproduction rate. Tests also show that several common chemicals will kill *Ceriodaphnia* at moderate concentrations (200- to 4000-mg/L range). Tests have shown that 3300 mg/L of sodium chloride killed all of the *Ceriodaphnia* in seven days. A concentration of 1650 mg/L of sodium chloride significantly reduced their reproduction rate. Pure water containing 1095 mg/L of sodium bicarbonate also reduced the reproduction rate of *Ceriodaphnia*. Potassium chloride killed them at a concentration of 960 mg/L but was not toxic at 190 mg/L. Lithium nitrate killed them at concentrations of 1000 and 200 mg/L. Sodium sulfate was toxic at 4400 mg/L and reduced the reproduction rate at 2220 mg/L. Additional tests are required because the lowest toxic levels of these common chemicals have not yet been determined.

The first process used at the CPCF II/S-3 LTF (Process No. 1) produced treated water containing uranium concentrations of 77 mg/L. This water had a *Ceriodaphnia* NOEC (no observed effect concentration) of 0.1%. A second process, called Modified Process No. 2, was developed and used to test some of the water. The water from this process had a significantly lower amount of uranium [4 mg/L vs 77 mg/L obtained in the first DTF (Decant Treatment Facility) process]. The biotest results from the laboratory tests also increased from 3% NOEC for the first process to 10% NOEC for the second process.

A new facility, the WETF (West End Treatment Facility), was designed in 1984. Its construction is expected to be complete in March 1987 and its operation is currently scheduled to begin in July 1987. The unit operations for the WETF are similar to the CPCF II/S-3 LTF Process No. 1. One difference is that the neutralization operation in the WETF uses sodium hydroxide in the effluent polishing step, whereas Process No. 1 uses calcium hydroxide.

Laboratory tests have shown that the WETF process may produce water containing uranium at an average of 11 mg/L. Process No. 1 produced water with an average uranium concentration of 77 mg/L. The biotest results for the WETF and the CPCF II/S-3 LTF Process No. 1 are about the same (3% NOEC) as modifying it to be the same as the CPCF II/S-3 LTF Process No. 2, because this process produced water containing <5 mg/L of uranium with a NOEC of 10%.

INTRODUCTION

Liquid wastes containing >100 mg/L of nitrate ions are presently being biologically treated in 500,000-gal (2 × 106 L), stirred-tank to bioreactors and chemically treated in a temporary waste treatment facility (the DTF). The treatment process involves several unit operations:

neutralization,
addition of neutralized acetic acid,
biodenitrification,
bio-oxidation,
separation of solids and liquids by settling and decanting, flocculation and removal of solids, and
carbon absorption.

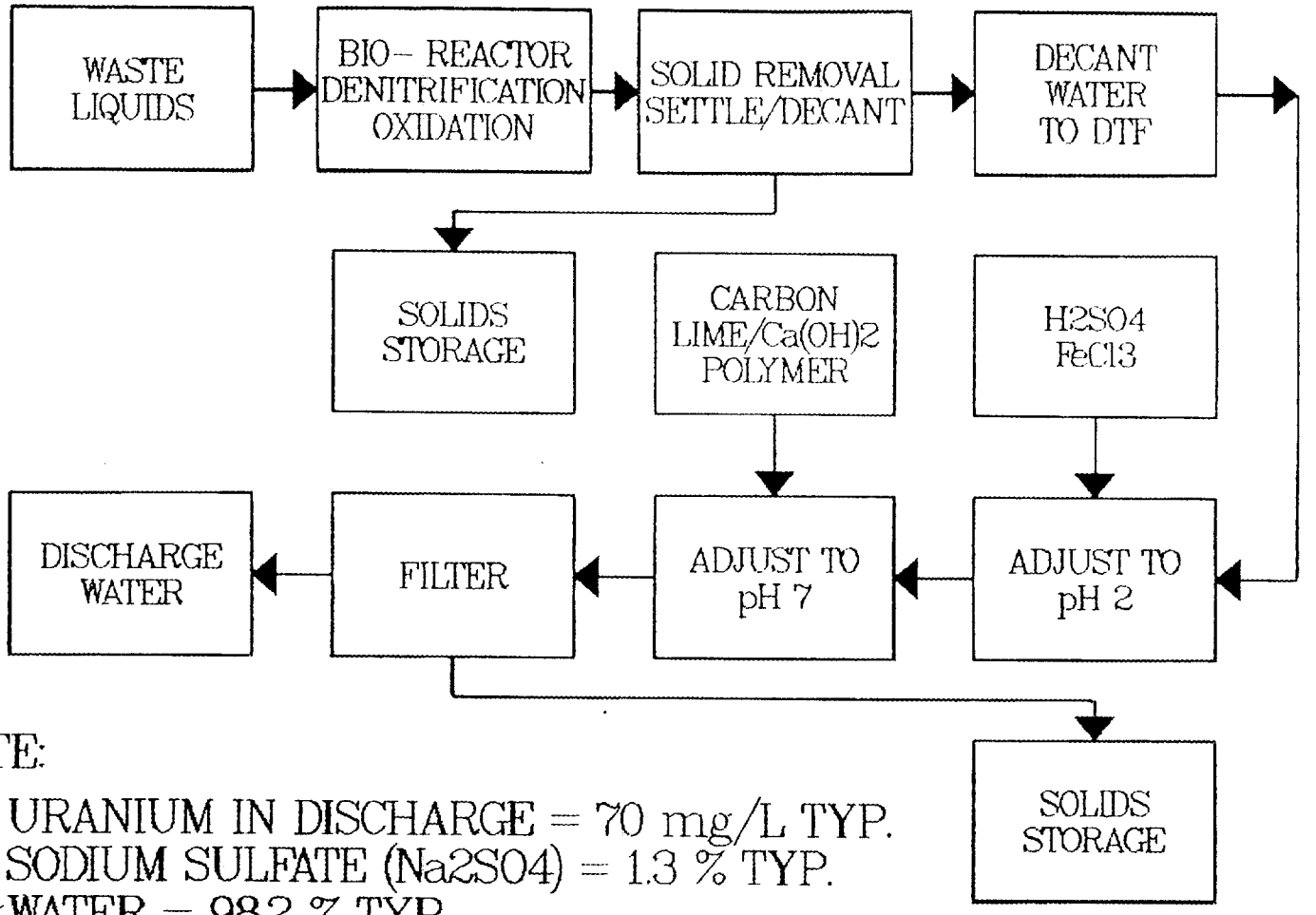
The nitrate wastes were processed through the fifth step in the bioreactors. The decant water contained an average 130 mg/L of uranium, 3650 mg/L of sulfate ions, and 15,200 mg/L of dissolved solids. The decanted water was then passed through a flocculation step.

The first process used at the CPCF II/S-3 LTF (Process No. 1) involved lowering the pH to 2 with sulfuric acid to convert carbonates to sulfates and raising it to 7 or 8 with lime and other flocculating agents (Fig. 1). The specific details are discussed later in this report. This process removed about 50% of the uranium. The biological test showed this effluent had a 3% NOEC (based on *Ceriodaphnia*).

A second process (Process No. 2) was then developed (Fig. 2). The second process removed >95% of the uranium and improved the biological test results. This process was used to treat the water after October 14, 1986. A permanent facility, the WETF, is scheduled to start operation in July 1987. The unit operations for the WETF (Fig. 3) start operation in July 1987. The unit operations for the WETF (Fig. 3) are the same as the CPCF II/S-3 LTF Process No. 1 (pH 2 to 7 process). Laboratory tests were made to determine the expected water quality to be produced by the WETF.

This report discusses laboratory and operational data obtained on the two CPCF II/S-3 LTF processes (Process No. 1 and No. 2) and laboratory data obtained on the WETF process.

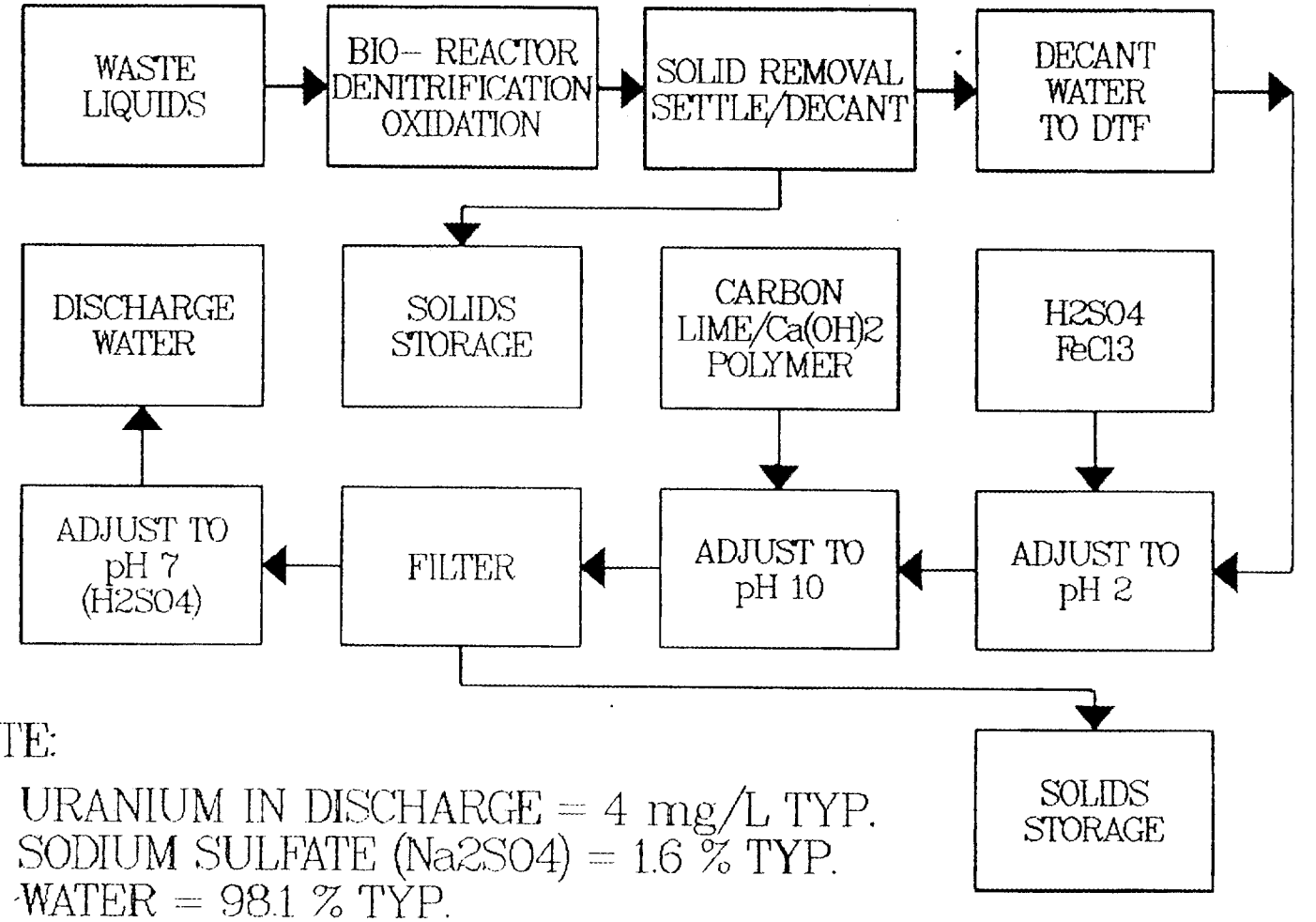
As stated before, the WETF process is essentially the same as Process No. 1. A major difference is that the WETF will use sodium hydroxide as the neutralizing agent, whereas the CPCF II/S-3 LTF uses calcium hydroxide. Based on laboratory results, the WETF process is expected to produce treated water containing an average uranium level of 11 mg/L, which is higher than CPCF II/S-3 LTF Process No. 2. A new WETF process being examined in laboratory tests should produce low uranium levels (<4 mg/L) and would also recycle some of the solids. This



NOTE:

URANIUM IN DISCHARGE = 70 mg/L TYP.
SODIUM SULFATE (Na_2SO_4) = 1.3 % TYP.
WATER = 98.2 % TYP.
TOTAL DISSOLVED SOLIDS = 1.8 % TYP.
BIO–TESTS = 1 % TYP.

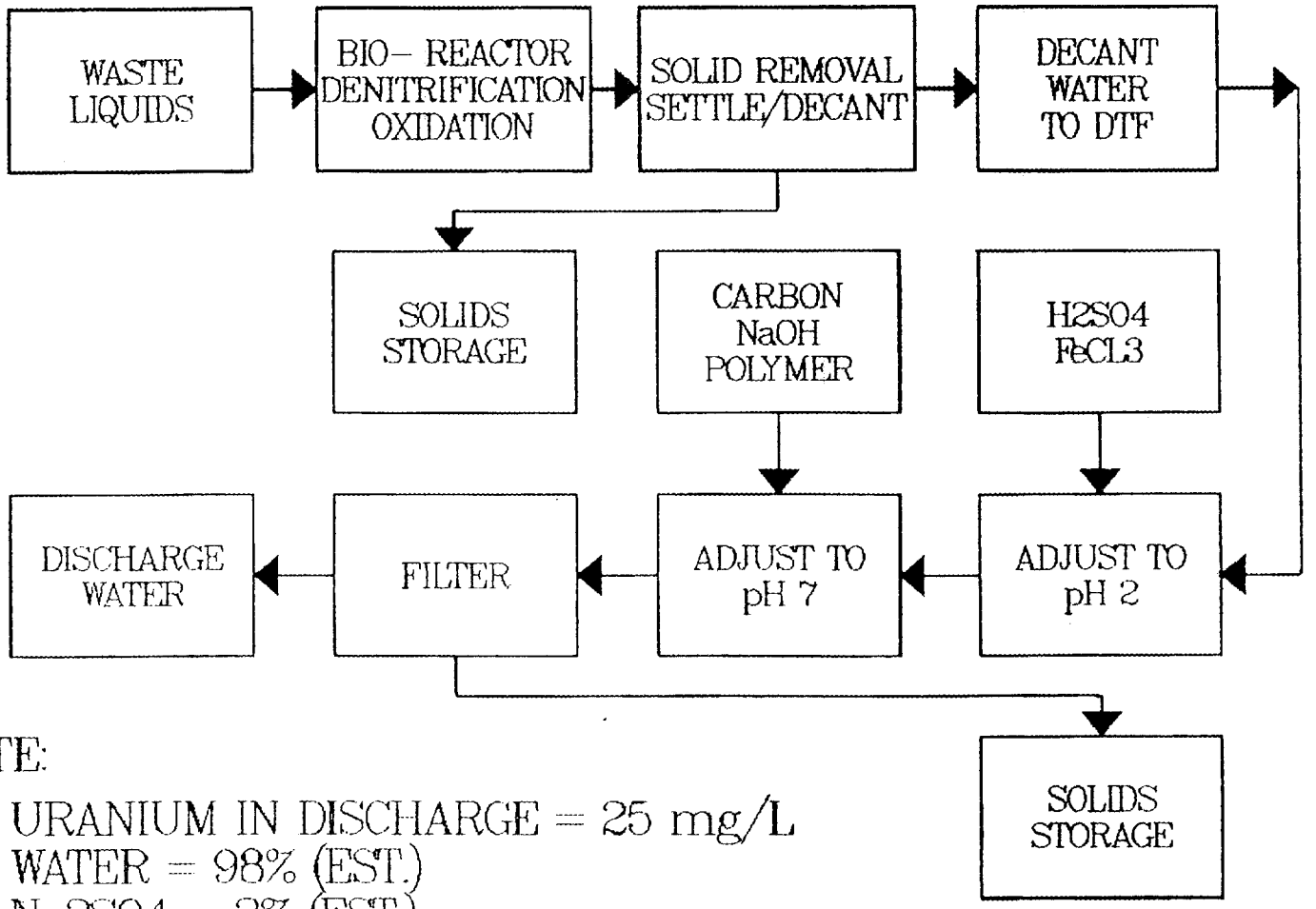
Fig. 1. CPCF II/S-3 LTF modified Process No. 1.



NOTE:

URANIUM IN DISCHARGE = 4 mg/L TYP.
SODIUM SULFATE (Na_2SO_4) = 1.6 % TYP.
WATER = 98.1 % TYP.
TOTAL DISSOLVED SOLIDS = 1.8 % TYP.
BIO–TESTS = 10 % TYP.

Fig. 2. CPCF II/S-3 LTF modified Process No. 2.



NOTE:

URANIUM IN DISCHARGE = 25 mg/L
WATER = 98% (EST.)
Na2SO4 = 2% (EST.)
TOTAL DISSOLVED SOLIDS = 2% (est.)
BIO–TESTS = 3%

Fig. 3. WETF process.

recycle process should lower the amounts of solids produced during treatment and would reduce the amounts of soluble salts in the treated water. Final results on this future WETF process are not yet available; a second report describing its development and results of testing will be published in May 1987.

CPCF II/S-3 LTF — PROCESS NO. 1

CHEMICAL DATA

The nitrate-contaminated liquid wastes from the Y-12 Plant are neutralized and biologically treated to remove nitrate ions. The denitrified wastes are then settled to separate the solids from the liquids. The decant liquid contains various impurities (Table 1). The data in Table 1 were obtained for four operating days (July 23-27, 1986). It should be noted that the 130-mg/L concentration of uranium in the decant feed and the concentration of a few other elements decreased slightly in August and September 1986 during the processing of decant from another tank.

The feed (Table 1) revealed the presence of high concentrations of 12 chemical elements or compounds. The major impurities are potassium, magnesium, sodium, uranium, fluoride, chemical oxygen demand (COD), suspended solids, dissolved solids, sulfates, total organic carbon (TOC), alkalinity (i.e., carbonates) and oil. As noted in Fig. 1, the water was initially treated using a process labeled Process No. 1. Very briefly, this process dropped the pH to 2 with sulfuric acid to convert the carbonates (alkalinity) to carbon dioxide. This step also formed sulfates in place of the carbonates. It was believed that the carbonates had to be removed in order to remove the uranium in subsequent steps, because uranium carbonate is soluble at moderate pH levels (pH 7). Ferric chloride 1.5 g/L) added at pH 2 later precipitated as a ferric hydroxide floc when the pH was raised to 7 with calcium hydroxide. Organic polymer was added (2.5 mg/L) to aid in the formation of the ferric hydroxide floc. Activated carbon (1 g/L of water) was added to remove organics from the water. The pH 7 water was decanted to remove most of the solids and was filtered to remove additional suspended solids.

Table 2 shows a typical chemical analysis of the flocculated water. This water meets all of the chemical parameters on the NPDES (National Pollutant Discharge Elimination System) permit. The permit does not specify a limit on uranium, but uranium and a number of other chemicals are routinely monitored for recording purposes. The NPDES permit also does not specify an exact biotest concentration. The biotests on Process No. 1 water of July 25 to 31, 1986, were <0.1% NOEC. As a result of these low values, development studies were started on August 8, 1986, to determine the cause of the low biotest results and to develop a new process to improve the results.

The data shown in Table 2 indicate that Process No. 1 reduced the uranium in the feed from 130 to 77 mg/L. The carbonate-biocarbonate alkalinity was destroyed, and the sulfates were increased from 3650 to 9135 mg/L. Except for these changes, the chemical analyses before and after treatment are about the same. The color of the water was changed from an opaque black to a very pale yellow during the treatment process. The black color is believed to result from trace quantities of metal sulfides, because the color was also eliminated by aeration accompanied by a small increase in the sulfate concentration.

Table 1. Typical data for CPCF II/S-3 LTF feed (four operating days; July 23-27, 1986)

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)
Al	1.6	1.4	2.1
B	4.4	4.4	4.5
Ca	42	23	96
Co	<0.02	<0.006	0.06
Cr	<0.10	0.02	<0.10
Cu	2.3	1.9	2.6
Fe	2.4	1.9	2.7
K	445	420	460
Li	3.4	3.3	3.4
Mg	112	110	120
Mo	2.9	2.8	2.9
Na	4775	4700	4800
Nb	0.05	0.02	0.12
Ni	0.80	0.73	0.82
P	14	13	15
Si	2.7	2.3	2.9
Sr	0.03	0.02	0.05
Ti	0.20	0.03	0.60
Zn	0.34	0.20	0.74
Zr	5.8	5.0	6.2
Hg	0.007	0.005	0.009
Phosphate	43	39	45
COD	725	602	970
Suspended[a] solids	150	107	202
Dissolved solids	15,208	14,524	15,738
U	130	120	140
F	78	5	100
S04[a]	3650	2900	4700
TOC	457	275	815
Alkalinity[a]	5507	4410	6100
Oil/grease	213	42	346

[a]One data point discarded due to a suspected inaccuracy.

Table 2. CPCF II/S-3 LTF Process No. 1 treated water (July 23 27, 1986)

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)
Al	0.28	0.05	0.65
B	3.5	3.2	3.7
Ca	500	480	520
Co	0.02	0.01	0.02
Cr	0.02	<0.01	0.03
Cu	0.26	0.21	0.31
Fe	0.41	0.38	0.44
K	380	360	390
Li	2.9	2.6	3.1
Mg	105	99	110
Mo	1.4	1.1	1.6
Na	4100	3800	4200
Nb	0.016	<0.008	0.04
Ni	0.22	0.20	0.27
P	6.6	5.8	7.1
Si	2.5	2.4	2.7
Sr	0.26	0.23	0.29
Ti	0.009	0.006	0.01
Zn	0.10	0.07	0.15
Zr	0.07	0.06	0.08
Hg	<0.001	<0.001	0.001
Phosphate	19.5	17	21
COD	187	156	240
Suspended solids	65	13	83
Dissolved solids	18,009	17,220	18,778
U	77	73	80
F	29.5	25	32
S04	9135	7900	9940
TOC	57.5	30	120
Alkalinity	573	460	680
Oil/grease	36	6	96

BIOMONITORING DATA

The NPDES permit required that the treated water leaving the process would be biomonitored with fathead minnow larvae and *Ceriodaphnia dubia/affnis*. It was also agreed that water in East Fork Poplar Creek at the outfall of new Hope Pond would be biomonitored;

however, there was no evidence that the biotest results at this point were affected by the CPCF II/S-3 LTF discharge, and data from these tests are not discussed in this report. The uranium concentration in the creek did significantly increase as a result of the CPCF II/S-3 LTF discharge. A nominal uranium concentration of 0.030 mg/L is found in the creek without the CPCF II/S-3 LTF, whereas 0.300 mg/L was noted during discharge of the water.

The biotests were made on 24-h composite samples collected daily for seven days. On five of the seven days, complete chemical analyses of the water w@ere obtained. The average chemical data for most of the biotests are included as part of this report. The biotests reported mortality and weight gain for the fathead larvae. The biotests reported mortality and points were reported for the *Ceriodaphnia* tests. Because the fathead larvae were less sensitive than the *Ceriodaphnia*, only the *Ceriodaphnia* will be discussed in this report. Because of the dilutions used in the tests, mortality was not a serious problem with the *Ceriodaphnia* during the tests.

A set of samples was obtained for CPCF II/S-3 LTF Process No. 1 on July 25-31, 1986. The *Ceriodaphnia* showed a NOEC of <0.1% effluent in dilution water and the LOEC (lowest observed effect concentration) was 0.1%. A second set of samples was taken during September 24 to October 1, 1986. In this test, the NOEC was <0.5% and the LOEC was 0.5%. These values are slightly higher than the first test (0.1% NOEC) but are judged to be equivalent values. A third test was done during October 7-14, 1986. In this test, the water had a NOEC of 3% and a LOEC of >3%. The reason for the apparent reduction in toxicity in the biotests is not understood at this time. It should be noted that the chemical analysis did not show a significant change. The average concentration of uranium decreased slightly from 77 mg/L for the July 25-31 samples to 55 mg/L for the last set (October 7-14). Uranium added to water has been shown to affect the mortality and the reproduction rate of *Ceriodaphnia*.

CPCF II/S-3 LTF — PROCESS NO. 2

DEVELOPMENT OF PROCESS NO. 2

As previously noted, tests were made to develop a new modified process (Process No. 2). The development program tested various treatment processes and specific chemicals added to demineralized water. The tests using specific chemicals were designed to obtain information about the toxicity of common chemicals used in the treatment of wastewater. The first chemical tested was uranium as uranium nitrate. The biotests showed that reproduction of *Ceriodaphnia* was reduced at a uranium concentration of 0.1 to 0.5 mg/L. Mortality occurred at 7 mg/L, but the NOEC for survival of *Ceriodaphnia* is believed to be lower. About 3 to 4 mg/L may be a reasonable estimate for the mortality threshold with uranium.

Water was tested that had only been decanted and filtered (no aeration or flocculation). Reproduction was affected at 10% (but not at 1%) of full strength. Aeration of the decant water, followed by filtration, greatly increased the toxicity of the water (<0.1% NOEC).

Two primary treatment options were tested in the laboratory. The first process was similar to Process No. 1, except that the pH in the precipitation step was increased from 7 to 10. The second process eliminated the acidification step (i.e., pH 2) in order to reduce the amount of sulfates added to the treated water. These processes did not remove the uranium and produced water with a NOEC of <1%. Four tests were made using a modification to the first process (laboratory tests 9, 11, 12 and 13). Table 3 shows the chemical results of these tests. This modified process reduced the uranium concentration to an average of 4.5 mg/L, with two of the tests producing uranium levels of 0.38 and 0.48 mg/L. These low uranium levels were obtained using 1 mg/L of organic polymer (a flocculating agent) instead of the 5 mg/L used previously. Subsequent laboratory tests defining the best polymer level have confirmed that 0.1 to 1 mg/L of polymer produced the lowest uranium levels.

The analyses reported in Table 3 show the concentrations of the other chemicals at about the same levels as obtained in Process No. 1 (Table 2 vs Table 3). The biomonitoring results were significantly better than previous process tests (NOEC of 10% vs 1%); the uranium concentration was very low (4.5 vs 77 mg/L), which could have improved the biotest results. Because of these favorable test results, this process was recommended.

EXPERIENCE WITH PROCESS NO. 2

The CPCF II/S-3 LTF equipment was modified to use the newly developed process (Fig. 2). Very briefly, the only difference between Process No. 1 and Process No. 2 was the higher pH (10 vs 7) used to remove the uranium. As soon as the process equipment was modified, the treatment process was restarted. The first biotests were made from November 4 to 11, 1986. The water was tested at a maximum dilution of

Table 3. CPCF II/S-3 LTF Process No. 2 treated water (Laboratory experiments 9, 11, 12, and 13)

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)
Al	0.56	<0.2	0.81
B	3.9	3.7	4.1
Ca	543	430	640
Co	0.05	<0.05	<0.05
Cr	<0.11	<0.05	0.13
Cu	<0.05	<0.4	0.06
Fe	0.51	0.11	0.81
K	368	350	380
Li	2.8	2.4	3.1
Mg	48	7.2	91
Mo	1.7	1.4	2.2
Na	5650	4900	6500
Nb	0.17	<0.07	0.28
Ni	0.58	0.45	0.74
P	<2	<2	<2
Si	1.6	0.47	3.1
Sr	0.47	0.44	0.52
Ti	<0.03	<0.03	<0.03
Zn	0.02	<0.01	0.04
Zr	0.06	<0.05	0.08
Hg	<0.002	0.001	0.007
Phosphate	<6	<6	<6
COD	875	220	1570
Suspended solids[a]	259	46	808
Dissolved solids	19,475	17,460	22,070
U	4.5	0.38	9
F	24	17	33
	10,625	10,000	11,300
S04[a]	690	170	1555
TOC			
Alkalinity[a]	628	170	1120
Oil	3	3	4
NOEC	10%[a]		
LOEC	10%[a]		

[a]Two tests were biomonitored at the 10% level without affecting reproduction rates. Two tests were biomonitored at only the 1% level; the 10% level was not tested

3% because this is higher than the expected in-stream waste concentration from the facility to East Fork Poplar Creek. The water passed the biotest with a NOEC of 3%. The uranium concentration in the treated water during these dates was 1.57 mg/L, which was essentially the same as obtained in the laboratory tests.

All of the chemical data (Table 4) during these dates were essentially the same as the laboratory tests (Table 3 vs Table 4).

A second biotest was made on Process No. 2 during November 18 through 25, 1986. This treated water had a NOEC of 1%. The uranium concentration was 3.3 mg/L (Table 5), with the other chemicals at about the same concentration obtained in the laboratory tests and the previous tests (Table 5 vs Tables 3 and 4).

Table 4. Plant experience with CPCF II/S-3 LTF Process No. 2 during November 4-11, 1986

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)
Al	0.44	<0.32	0.51
B	3.6	3.1	4.0
Ca	247	188	304
Co	0.003	0.003	<0.004
Cr	0.007	0.006	0.012
Cu	0.048	0.037	0.076
Fe	0.39	0.26	0.48
K	198	173	218
Li	1.39	1.20	1.66
Mg	6.18	2.6	10.1
Mo	1.53	1.34	1.71
Na	4091	3430	4370
Nb	0.01	0.01	0.01
Ni	0.53	0.42	0.61
P	13	10.7	14.9
Si			
Sr	0.25	0.18	0.31
Ti	0.002	<0.002	0.003
Zn	0.116	<0.088	0.167
Zr	0.002	<0.002	0.002
Hg	<0.0002	0.0002	0.0003
Phosphate			
COD			
Suspended solids[a]	23.9	6	39
Dissolved solids			
U	1.57	0.18	3.78
F	7.6	4.0	9.5
SO4[a]	9400	7000	13,000
TOC	377	210	1200
Alkalinity[a]			
Oil	4	2	13
NOEC 3%[a]			
LOEC 3%[a]			

[a]The maximum tested dilution was 3%. The water passed this biotest.

Table 5. Plant experience with CPCF II/S-3 LTF Process No. 2 during November 18-25, 1986

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)
Al	0.30	<0.25	0.34
B	4.24	3.84	4.73
Ca	297	194	412
Co	0.003	0.002	<0.002
Cr	0.006	0.006	0.006
Cu	0.051	0.037	0.062
Fe	0.47	0.36	0.64
K	186	164	210
Li	1.49	1.36	1.63
Mg	5.5	1.7	12.4
Mo	1.65	1.49	1.83
Na	4329	3370	4970
Nb	0.01	0.01	0.01
Ni	0.56	0.54	0.59
P	14.6	13.0	17.7
Si			
Sr	0.30	0.25	0.42
Ti	0.002	<0.002	0.003
Zn	0.26	<0.07	0.048
Zr	0.002	<0.002	0.002
Hg	<0.0003	0.0002	0.0010
Phosphate			
COD			
Suspended solids	15	5	37
Dissolved solids			
U	3.34	1.11	8.52
F	13.7	11	17
S04	11,857	10,000	14,000
TOC	263	240	280
Alkalinity			
Oil	14	8	20
NOEC	5%		
LOEC	10%		

WETF PROCESS

The WETF process was originally designed in 1984. Construction began in 1985, and operation of the facility is expected in July 1987. The NPDES water discharge limits for the WETF had not been established in 1984, so unit operations were selected based on estimated NPDES permit limits to be negotiated at a later date. The unit operations chosen for the WETF were basically the same as those used for the CPCF II/S-3 LTF Process No. 1 (Figs. 1 and 3), except that sodium hydroxide was selected instead of calcium hydroxide as the neutralization agent for the WETF. During operation of the CPCF II/S-3 LTF, a significant amount of new information was generated from biotests using *Ceriodaphnia*. Some of this information has been discussed in this report. One of the facts established by the tests was the adverse effects of uranium on the reproduction rate of *Ceriodaphnia*. A second fact was that the original process used at the CPCF II/S-3 LTF produced water that met the chemical limits defined by the NPDES permit but did not pass the biotest at high concentrations (3% NOEC). The NPDES permit does not specify a limit for uranium and does not specify a biotest limit. It was assumed that the process would@ be closely monitored and that limits for these parameters would be established later.

The WETF process involved lowering the pH to 2 with sulfuric acid and raising it to 7 with sodium hydroxide. In general, neutralization with sodium hydroxide removes less uranium than with calcium hydroxide. Also, precipitation at a pH of 7 is usually less effective for uranium than at a pH of 10. Several laboratory tests were made to determine the water quality from the future WETF.

CHEMICAL DATA

The greatest concern about the WETF process is its ability to remove uranium to below 5 mg/L. Denitrified water from the West Tank Farm was tested using the WETF process, and uranium removal was measured. Uranium levels of 25 mg/L were obtained in one of the WETF tests; however, the uranium levels in tests averaged 11.5 mg/L using feed water that contained an average uranium concentration of 93.2 mg/L.

In these tests, the WETF water was also neutralized with calcium hydroxide at a pH of 7 (the same as in the WETF, except that calcium hydroxide was used in place of sodium hydroxide). A uranium concentration of 16 mg/L was obtained in one test. This concentration was higher than in CPCF II/S-3 LTF Process No. 2 (i.e., <5 mg/L).

Denitrified/bio-oxidized water treated by the WETF process (sodium hydroxide at a pH of 7) was also tested for toxicity to Ceriodaphnia. Chemical analysis of the biotest water is not complete at this time but is believed to be similar to the data reported for Process No. 1 (uranium level of 25 mg/L). The seven-day biotests with Ceriodaphnia showed that the treated water had a 3% NOEC.

EQUIPMENT MODIFICATION TO WETF

The equipment presently in the WETF cannot be used to implement the modified process (Fig. 2). The equipment changes, construction time, and costs required to convert the WETF process to Process No. 2 are now being examined. A delay in startup of the WETF would certainly occur if the WETF were modified to process wastes using Process No. 2. The water quality expected from the modified WETF should be equal to the quality obtained in Process No. 2 (i.e., <5 mg/L of uranium and an NOEC of 5 to 10%.

Recent statements from the technical staff of the Health, Safety, Environment, and Accountability Division within the Y-12 Plant indicate that the biotest quality of water emitted by the WETF will eventually need to be better than that emitted by Process No. 2. In other words, the biotest results should have a NOEC value greater than 3%. If modified with Process No. 2, the biotest quality will not be significantly improved beyond an NOEC of 3% because of the amounts of soluble ions in the incoming feed (e.g., sodium sulfate).

FUTURE PROCESS FOR WETF

Process laboratory development studies are continuing to investigate unit operations in an endeavor to reduce WETF effluent toxicity to biotest animals. A report on the results of these studies will be available in May.

BIOTEST RESULTS ON SPECIFIC CHEMICALS

Laboratory tests are continuing to investigate the toxicity of specific chemicals added to demineralized water. As previously reported, uranium killed *Ceriodaphnia* at a concentration of 7 mg/L and reduced the reproduction rate at a concentration of 0.1 to 0.5 mg/L.

The chemicals tested to date are common to treated waters and would be difficult to remove from the water. Biotest results shown in Tables 6 and 7 are discussed below.

- Sodium sulfate (Na_2SO_4). The major impurity in the treated water from the CPCF II/S-3 LTF and the WETF is sodium sulfate. The concentration in these waters is >16,000 mg/L. The high level of Na is a result of the high original concentration in the feed (8 plus the sulfate added in the treatment processes as sulfuric acid. As noted in Tables 6 and 7, 4400 mg/L killed the *Ceriodaphnia* in the seven-day test. A concentration of 2200 mg/L significantly reduced the reproduction rate. The lowest toxicity level for Na_2SO_4 has not yet been established. The test results completed at this time clearly indicate that the treated CPCF II/S-3 LTF or the WETF water will not pass a biotest of >10% NOEC because the treated water contains sodium sulfate concentrations of 16,000 mg/L. A 10% dilution of this water would leave a Na_2SO_4 concentration of 1600 mg/L, which, based on the tests with pure chemicals, is high enough to affect *Ceriodaphnia* reproduction.

- Potassium chloride (KCl). The CPCF II/S-3 LTF or the WETF feed is expected to contain 450 mg/L of potassium ions. If present as the chloride, the KCI concentration would be 850 mg/L. A sample containing 960 mg/L (500 mg/L as potassium) was toxic; the *Ceriodaphnia* died within the seven-day test period. The minimum toxicity level for potassium will be determined in future tests.

- Lithium nitrate ($LiNO_3$). A nominal 3.5 mg/L of lithium ions were found in the feed. If present as $LiNO_3$, the concentration of that compound would be 35 mg/L. Two tests with 200 and 100 mg/L of $LiNO_3$ (20 and 100 mg/L as Li) were made. Both concentrations killed the *Ceriodaphnia* within the seven-day test. The lowest toxic level for lithium will be determined in future tests.

- Sodium bicarbonate ($NaHCO_3$). Carbonate or bicarbonate ions will be present in denitrified water unless the solution is acidified. Carbon dioxide is produced as part of the denitrification process and bicarbonates or carbonates are formed. Five solutions were tested, and concentrations as low as 1095 mg/L were toxic. The lowest concentration of $NaHCO_3$ that is toxic to *Ceriodaphnia* will be determined in future tests.

Table 6. Specific chemical tests[a]

Compound	Concentration (mg/L)	Survivors	Reproduction (mean number of young per female)
Control water (two samples)		8 of 10	19.1 + 23.6
NaHC03	1095	7	8.4
	1825	0	0
	2738	0	0
	3650	0	0
	5475	0	0
Na2S04	4400	0	0
	2950	10	1.1
	2220	10	8.6
NaCl	3300	0	0
	1650	8	5
KCl	960	2	10
	190	8	18.6
	90	9	19.1
$LiNO_3$	1000	0	0
	200	0	0

Table 7. Toxicity of common chemicals (in mg/L)

Compound	Survival		Reproduction	
	NOEC	LOEC	NOEC	LOEC
NaHC03	<1095	<1825	<1095	1095
Na2S04	2970	4400	<2200	2200
NaCl	1650	3300	<1650	1650
KCI	190	960	190	960
LiN03	<200	200	<200	200

- **Sodium chloride (NaCl)**. This is a common chemical and could be present in any of the liquid wastes. A solution containing 3300 mg/L of NaCI was toxic; the *Ceriodaphnia* died within the seven-day tests. The lowest toxic level of NaCl will be determined in later tests.

CONCLUSIONS

Process development studies have shown that the reproduction rate of *Ceriodaphnia* is affected by uranium concentrations between 0.1 to 0.5 mg/L. Other common chemicals used in the removal of toxic metallic ions are toxic to this species. The lowest concentrations of the common chemicals (e.g., sodium sulfate) that affect *Ceriodaphnia* have not yet been established, but data to date show that all of the common chemicals were toxic at levels of <4400 mg/L. These are water-soluble chemicals, and the incoming water contained these chemicals in concentrations as high as 10,000 mg/L. When treated, the concentrations of some of the common chemicals were increased to >16,000 mg/L, which is significantly higher than their toxicity threshold to *Ceriodaphnia*.

The first treatment process used at the DTF produced water containing uranium at 77 mg/L and with a biotest NOEC of less than 3%. A second process was developed and used. The uranium concentration was significantly lower (<5 mg/L) and the biotest results were better (3% NOEC).

The new WETF is about to begin operation. The treated water quality of this facility is projected to be the same as CPCF II/S-3 LTF Process No. 1. The equipment costs and schedule required to modify the WETF are being estimated. Process development studies are to be continued in order to understand and improve the biological test results of the treated water.

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