13013

E. I. DU PONT DE NEMOURS & CO.

NIAGARA PLANT

GROUND WATER TREATMENT FACILITIES

ENGINEERING REPORT

Box #67

E. I. DU PONT DE NEMOURS & CO.

NIAGARA PLANT

GROUND WATER TREATMENT FACILITIES

ENGINEERING REPORT

I. Introduction

In late 1982 and early 1983, the U.S. Geological Survey, under the direction of the New York State Department of Environmental Conservation (DEC), installed and sampled five wells along the southern boundary of the Du Pont Niagara Plant. Samples of the ground water from these wells, which intercepted the water table at approximately the overburden/bedrock interface, were found to contain varying concentrations of contaminants - primarily volatile chlorinated hydrocarbons. This information prompted Du Pont to undertake an extensive geohydrologic investigation to determine the sources of these contaminants and develop a remediation program.

The plant has been in continuous operation since 1898 when the Niagara Electrochemical Company began the manufacture of sodium. Du Pont acquired the site in 1930 where, in addition to sodium, it developed new processes and products, both organic and inorganic. The site manufacturing peaked in both size and diversity in the 1950s, and since that time, many processes and products have been eliminated.

W E Newcomb
25 June 86

Table I presents a bar graph showing the primary products and their manufacturing period. Site history prior to Du Pont's acquisition is sketchy at best with no documented records available.

Woodward-Clyde Consultants (WCC) were retained as an independent technical advisor for the investigative studies and remediation plan. With the data obtained from the geohydrologic investigation, WCC developed a ground water model to estimate flow rates and contaminant loading in the overburden and bedrock zones. A computer simulation has been developed for this model to predict the flow rates through the pumping well collection system that will be installed to remove ground water from the overburden zone. In the bedrock zones west of Gill Creek, horizontal flow patterns are primarily toward an Olin production well. East of Gill Creek, the flow patterns are primarily toward the northeast. An agreement has been reached with the Olin Corporation to maintain pumping rates to their activated carbon treatment facilities necessary to achieve effective collection and removal of contaminants in bedrock ground water migrating from the Du Pont site.

Du Pont's Engineering Department has provided assistance in the selection, design and specification of a treatment facility to remediate overburden ground water. Steam

stripping has been chosen as the most cost-efficient technology that will provide satisfactory treatment. This Engineering Report characterizes the ground water and describes the steam stripping facility and its expected performance. Effluent from this facility will be discharged into the Niagara River via Gill Creek through existing Outfall 006 and will conform to the limits and regulatory requirements for an SPDES discharge. An application will be submitted for a modification to the plant SPDES permit for Outfall 006. Also, an air permit will be obtained for the stack vent provided for noncondensibles. Any contaminant residues resulting from treatment will be disposed of in an environmentally sound manner and in conformance with state and federal regulations.

II. Description of Industry

The facility described in this Engineering Report is designed specifically for the remediation of ground water contained within the overburden beneath the plant site. Existing plant processes will not discharge wastewater to the treatment facility. If future plant site construction requires treatment of displaced ground water, it will be processed through these facilities as long as the SPDES permit is not violated.

III. Treatment Objective

The treatment objective is to reduce the concentration of each volatile chlorinated hydrocarbon in the ground water pumped to the treatment facility to a level of 100 ug/l or less. This constitutes 98% removal for these volatile organics. In fact, the steam stripping facility described in this Engineering Report is expected to achieve substantially lower effluent concentrations and higher removal percentages than this. Based on an evaluation of New York State's BPJ methodologies, this facility would meet all indicated BAT target levels for volatile compounds.

IV. Existing Facilities

This Engineering report proposes the construction of a new facility to treat ground water from overburden. At this time, no ground water treatment facilities exist on site.

V. Ground Water Characteristics

A. Flow Rate

Ground water in the overburden will be removed by a pumping well system to be installed in both the east and west areas of the plant. The planned locations of these

wells is shown in Figure 1. Ground water modeling was used to determine the best routing for the wells. Ground water will be pumped to an equalization tank in the proposed water treatment facilities area also shown in Figure 1. The quantity of ground water expected from the pumping well system has been estimated from modeling results reported by WCC (Report for Hydraulic Comparison of Tile Drain Versus Pumping Well Remedial Alternatives Niagara Plant Site, dated 12/2/85). Based on WCC recommended flows, the treatment facilities have been sized for an average flow of 90 gpm and a maximum design capacity flow of 270 gpm. This capacity will handle the steady state pumping requirements as well as additional pumping requirements resulting from seasonal variations, high river elevation, spring snow melt, or a heavy precipitation event.

B. Composition

To provide a basis for estimating the characteristics of ground water pumped from the well system, the representative sample formulation developed by WCC was used (4/21/86 letter from M. N. Gallagher, WCC, to Richard Gentilucci, Du Pont). Table II shows this formulation as percent contributions from overburden wells to give a composite sample that would represent the average ground water quality.

Based on this formulation approach, composite concentrations of volatile indicator parameters, TOC, and total cyanide were calculated for the 11 sets of well samples taken and analyzed during the period June 1983 through March 1986. These sets of well sample analytical results previously had been sent to the DEC. Table III gives the calculated composite concentrations for each set of analyses. In calculating these weighted composite values, laboratory results reported to be non-detectable were assigned zeros and results reported as below method detection level were assigned values of 1/2 the detection level.

Table IV presents ground water characteristics that include the calculated average and maximum concentrations for the volatile indicator parameters. Also shown are estimated maximum concentrations for three East Plant Area organic compounds (1,4-dichlorobutane; 2-methyl furan, and tetrahydrothiophene) that were identified through a library search of mass spectra and are associated with the old adiponitrile process. The predicted maximum concentrations for the volatile indicator parameters are based on the mean plus two standard deviations to insure adequate design of the treatment facility. The maximum concentrations for TOC, total cyanide, and total recoverable phenols are based on the mean plus one

standard deviation. The maximum concentrations for the East Plant Area compounds are estimates based on limited sampling from wells which were found to contain these organics proportioned to the other wells using the weighing formulation. pH and temperature information were derived from field measurements at individual wells.

The total cyanide is predominantly tightly bound and apparently most of this is ferrocyanide. Speciation analyses done on the ground water showed that the free cyanide was less than detectable (<0.01 mg/l) and that only a small portion of the total cyanide is amenable to chlorination. The June 1985 ground water monitoring well samples were analyzed for free cyanide and cyanide amenable to chlorination as well as the usual indicator parameter of total cyanide. The results of these analyses are presented in Table V along with the weighted averages calculated using the estimates of percent contribution for the pumping well collection system. Of the weighted average of 8.6 mg/l total cyanide, less than 0.01 mg/l was determined to be free cyanide and only about 0.5 mg/l (6% of the total) was determined to be amenable to chlorination. Because Well 16A provides a very high proportion of the total cyanide to the weighted average (86% for the July 1985 sample), additional analyses have been run to determine the form of

cyanide from this well. Two samples indicated that essentially all the cyanide from this well is tied up as the ferrocyanide complex.

Based on these results, the total cyanide measured in the ground water is not free cyanide and is not dissociable. Therefore, this cyanide is not bioavailable and, consequently, not toxic. Also, the total cyanide could not be reduced by proven oxidation technologies such as alkaline chlorination or hydrogen peroxide treatment.

VI. Basis for Development of Treatment Facility Design Parameters

Steam stripping has been chosen from among the technologies evaluated as the most environmentally acceptable and cost-effective treatment method to reduce volatile organics in the ground water from the pumping well system. The attached flow diagram (Figure 2) shows the major components of the treatment system. Ground water pumped from the pumping wells is blended in the ground water equalization tank.

Ground water pumped from the equalization tank is adjusted to a pH in the range of 5 to 5.5 by the metering of sulfuric acid into a mixed tank with pH control. This adjustment will prevent hardness scale formation in the preheater and steam striper at elevated temperatures in the steam stripper. Then

the ground water is preheated and fed to the top of the stripper column. The liquid portion of the feed travels down the packed column where it is contacted countercurrently with live steam. When the feed reaches the bottom of the column, all specified organics are reduced to less than 50 ug/l concentration except for tetrahydrothiophene which is calculated to have a maximum concentration of 315 ug/l. The stripped ground water is readjusted to a pH of 6-8 if necessary by discharge through a mixed tank into which dilute sodium hydroxide can be metered on a pH controlled basis. The effluent from this tank is discharged through a monitoring station to Outfall 006. Online GC instrumentation will be used to monitor the concentration of 1,1,2,2-tetrachloroethane in the effluent since it is the most difficult indicator organic to strip. If the concentration of this constituent exceeds an acceptable level, the effluent can be recycled back to the equalization tank for reprocessing.

The stripped organics from the ground water feed along with a portion of the stripper steam leave the top of the column and are liquefied in a condenser. The liquid exiting the condenser will consist of two phases. The organic phase is decanted and sent to the concentrated organics storage tank while the aqueous phase from the decanter is combined with the ground water feed and recycled through the stripper. Any vapor from the condenser is vented to the storage tank. The equalization tank is also vented to this tank. The

storage tank, in turn, is vented to the atmosphere. The rate of accumulation of concentrated organic phase in this tank is expected to be about 3 gal/hr maximum and about 10 gal/day long-term average. The tank has been sized to hold a maximum 4,200 gal so that truck-load quantities can be removed periodically for off-site incineration. In addition to the stripped ground water discharge to Outfall 006, there is a maximum 30 gpm discharge to the outfall of noncontact cooling water used in the condenser.

The steam stripping process has been sized through computer simulation. The computer model used is available to Du Pont from Simulation Sciences, Inc., Fullerton, CA, through a royalty arrangement. SIMSCI computer simulations have been widely used by the chemical and petroleum industries in the design of distillation facilities. The size and operation of the steam stripper and the resulting quality of the stripped ground water are the strongest aspects of the simulation. The ability to steam strip each organic constituent modeled depends on its Henry's Law constant. For most of the organics, the Henry's Law constants were calculated from solubility data; however, such data for tetrahydrothiophene, 1,4-dichlorobutane, and 2-methylfuran were not found in the literature. Therefore, Henry's Law constants were measured directly for these three compounds. Attachment C describes this experimental determination. With all the required Henry's Law constants, the stripper column can be accurately designed.

The computer simulation involved a series of iterations to determine the number of theoretical stages required to reduce the least strippable of the specified indicator organics (1,1,2,2-tetrachloroethane) to less than 50 ug/l in the stripped ground water effluent. The loading was based on the calculated maximum concentration of each organic at the maximum flow rate. The optimum number of theoretical stages was determined to be 5. The height of each theoretical stage was determined from pilot plant work done at another Du Pont plant with a similar application of stripping volatile chlorinated hydrocarbons from ground water.

The overhead condenser behavior is less well-defined because as the vapor condenses some of the organics will reach their water solubility limit in the condensed stream and form a second liquid phase. Mutual solubility data for each organic-water pair as a function of temperature has been assembled for use in the model so that a rigorous vapor-liquid-liquid-equilibria (VLLE) correlation can be used in addition to the Henry's Law constants to allow prediction of the organic phase flow rates from the decanter at various overhead condensing temperatures.

Because there are VLLE uncertainties and also because various overhead condenser temperatures could be used, a pilot study was conducted to fine-tune the design of the steam

stripper overhead condensing facilities. The pilot study results supported our conclusions regarding the applicability of the steam stripper and enabled final equipment sizing.

VII. Design of Treatment System

The listing and basis for sizing of treatment system equipment is given in Attachment A. Information in this attachment may be modified somewhat for final design. The printout for the computer simulation of the steam stripping process is given in Attachment B. B-3 through B-7 presents the results of material and heat balances calculated by the computer program to establish the size of equipment. The detailed design of the treatment system facilities will be provided with the Plans and Specifications submittal to the DEC.

VIII. Final Effluent Characteristics

Table VI summarizes expected treated effluent characteristics. The effluent concentrations for volatile indicator parameters and the three East Plant Area organic compounds were determined by computer simulation. These are predicted maximum effluent concentrations based on the use of the predicted maximum influent concentrations from Table IV in the computer modeling. Total recoverable phenols could not

be modeled because this parameter is not a specific compound. However, based on stripping efficiency for the compound phenol, the parameter total recoverable phenols is estimated to be only slightly reduced by steam stripping with about 190 ug/l, estimated to be a maximum value in the effluent. The effluent TOC is calculated by subtracting from the maximum TOC in Table V the organic carbon content of the volatile organics stripped from the ground water in accordance with the computer simulation results. Total cyanide in the effluent would be about 10 mg/l or less. The concentration of free cyanide in the effluent is expected to be below detectable limits (less than 0.01 mg/l). The total suspended solids concentration in the ground water pumped from the pumping well system is expected to be low (less than 50 mg/l) with the wells developed and operated appropriately. The steam stripping effluent pH would be adjusted to the 6-8 range and the stripper treatment process would raise the ground water temperature somewhat.

In comparison with the DEC target levels for the volatile compounds (Attachment D), effluent concentrations and percent reduction meet the "limitation" shown for BAT/BPJ for those compounds evaluated (benzene, chlorobenzene, methylene chloride, tetrachloroethylene, and trichloroethylene). Table VI shows that the percent reduction for all the volatile parameters evaluated is expected to meet or exceed 99%.

The only specified organics that apparently would be detectable at the ug/l level in the stripper effluent would be 1,1,2,2-tetrachloroethane and tetrahydrothiophene.

The discharge of treated ground water from the treatment facility to Outfall 006 into Gill Creek would have no effect on compliance with SPDES permit limitations. The estimated increase in plant COD discharge (conservatively calculated to be 2.5 times TOC) of 160 ppd and in TSS discharge of 50 ppd at steady state flows are small increases in present net discharge levels for these parameters and well within permit limitations as shown in Table VII. Both temperature and pH of the treated ground water would be within permit limitations for Outfall 006. Finally, the ground water would not contribute any significant amounts of oil and grease to the outfall.

Table VIII presents a comparison of the expected treated effluent maximum discharge characteristics with recent Outfall 006 average discharge data and the action levels for Outfall 006 given in the SPDES discharge permit. The WCC formulation approach was used to determine composite concentrations since metal concentrations would not be reduced through the treatment facility. The results indicate that the expected additional treated ground water discharge amounts into Outfall 006 would not affect conformance with the action levels except for total phenols. Lead discharges

in Outfall 006 already exceed the action level because of the lead concentration in the incoming water from the river. The net lead increase is only 0.288 ppd. Total recoverable phenol discharge to the river would still be less than 1 ppd from Outfall 006.

RFS:ams/3.45
6/24/86

TABLE 1

DU PONT NIAGARA FALLS

PRODUCTS

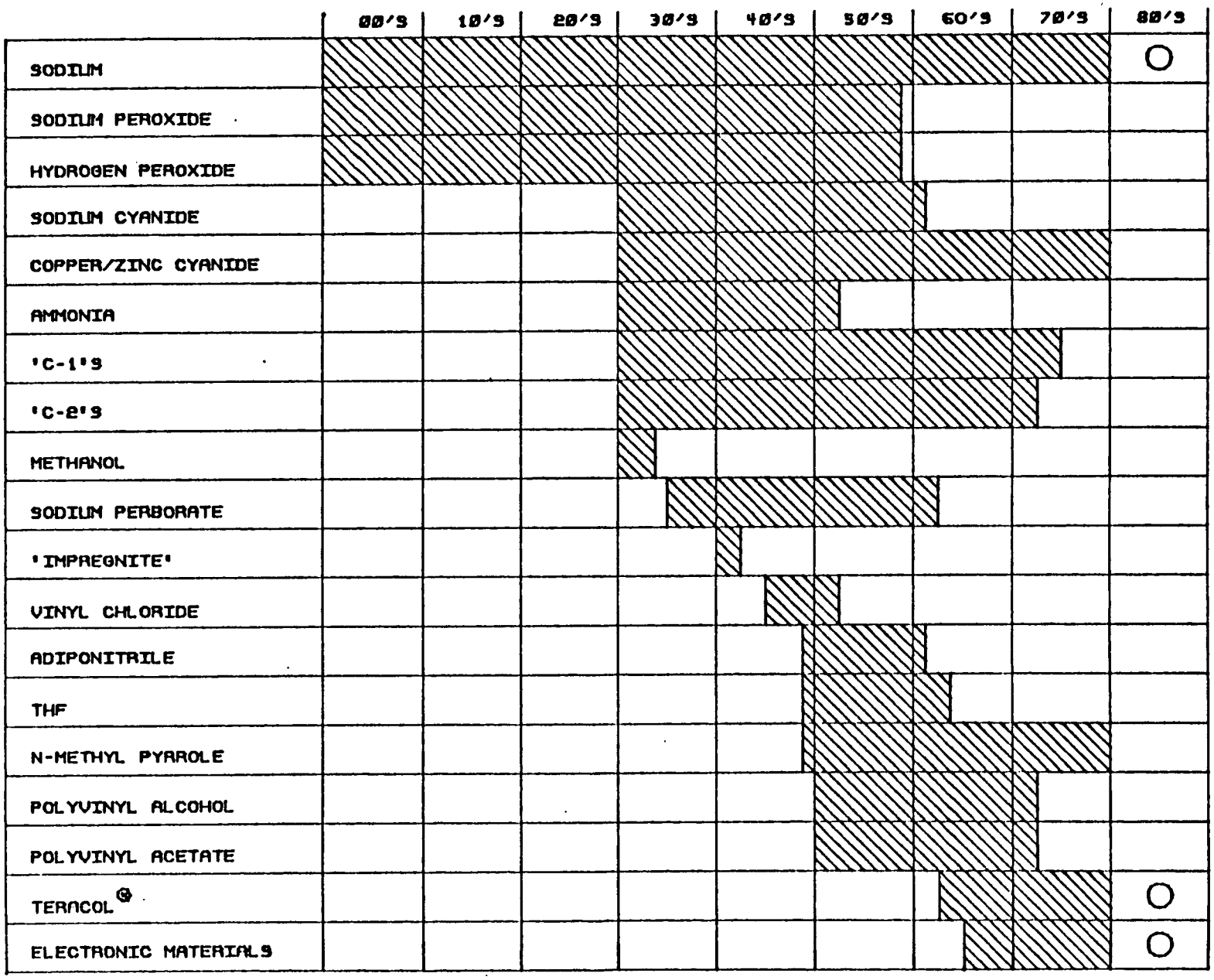


TABLE II

OVERBURDEN WELL CONTRIBUTIONS TO COMPOSITE SAMPLE FORMULATION

Well No.	Contributions (%)
1	4
2	8
3	7
4	2
8	5
9	7
10	15
11	6
12	4
13	12
14	4
15	7
16	4
18	7
21	8

RFS:ams/3.46
6/11/86

TABLE III
GROUND WATER INDICATOR PARAMETERS
CALCULATED COMPOSITE RESULTS (μg/l unless noted)

DATES WELLS SAMPLED	JUL 83	SEP 83	OCT 83	JUN-JUL 84	AUG-SEP 84	NOV-DEC 84	MAR 85	JUN 85	JUL 85	OCT 85	MAR 86
Vinyl Chloride	1,303	1,381	1,257	5,646	204	411	112	1,410	795	928	994
Meth. Chlor.	3,600	3,915	6,354	681	1,917	3,496	1,927	1,314	972	2,904	160
Trans-1,2-dichloroethylene	8,844	10,244	16,282	172	287	112	421	6,182	4,927	5,956	2,326
Chloroform	33,979	6,899	51,394	501	746	239	585	682	471	376	482
Trichloroethylene	14,335	12,755	26,519	2,580	7,354	2,045	4,259	5,868	4,294	5,553	5,453
Tetrachloroethylene	5,214	6,095	10,538	6,527	4,367	3,689	5,069	5,595	4,730	7,125	11,300
1,1,2,2-Tetrachloroethylene	3,985	1,856	2,232	5,230	304	1,253	983	894	948	777	1,177
Benzene	208	313	444	1,048	241	262	461	273	343	299	386
Chlorobenzene	2	10	333	24	93	12	17	1	1	6	5
Total Recoverable Phenols (mg/l)	0.16	0.03	0.16	0.20	0.25	0.16	0.21	0.13	0.11	0.15	0.12
Total Organic Carbon (mg/l)	82	80	51	40	170	15	32	78	87	101	48
Total Cyanide (mg/l)	4.5	2.3	5.4	8.9	11.8	6.9	8.8	8.6	7.2	8.1	8.4

TABLE IV

GROUND WATER CHARACTERIZATION

Parameter	Average (ug/l)	Predicted Maximum (ug/l)
Vinyl Chloride	1,300	4,300
Methylene Chloride	2,500	6,100
Trans-1,2-Dichloroethylene	5,100	15,400
Chloroform	8,800	43,000
Trichloroethylene	8,300	23,000
Tetrachloroethylene	6,400	11,300
1,1,2,2-Tetrachloroethane	1,800	4,800
Benzene	400	900
Chlorobenzene	50	240
1,4-Dichlorobutane	-	25,000
2-Methyl Furan	-	35,000
Tetrahydrothiophene	-	35,000
Total Recoverable Phenols	150	210
TOC (mg/l)	70	120
Total Cyanide (mg/l)	7	10
Total Suspended Solids (mg/l)	-	50
pH (Units) Range	6-9	
Temperature (°F) Winter	50	
Summer	70	

RFS:ams/3.48
6/25/86

TABLE V

DETAILED CN EVALUATIONS
JUNE 1985 GROUND WATER MONITORING

Well No.	Total CN (mg/l)	Free CN (mg/l)	CN Amenable to Chlorination (mg/l)	Contribution (%)
1A	0.036	<0.01*	<0.01	4
2A	2.0	<0.01	1.0	8
3A	0.21	<0.01	0.043	7
4A	0.36	<0.01	0.024	2
8A	16.0	<0.01	0.4	5
9A	4.9	<0.01	2.9	7
10A	<0.01	-**	-**	15
11A	0.035	<0.02	<0.01	6
12A	<0.01	-	-	4
13A	0.035	<0.01	0.035	12
14A	0.021	<0.01	<0.01	4
15A	0.33	<0.01	0.059	7
16A	178.0	0.10	3.8	4
18A	0.12	<0.01	0.081	7
21A	1.4	<0.01	0.058	8
Weighted Avg***	8.6	0.0091 (<0.01)	0.48 (0.5)	100

* Half of the "less than" results (ie 0.005 mg/l) were used to calculate weighted average

** The same value as for total cyanide (ie 0.005 mg/l) was used to calculate weighted average when no value was reported by laboratory

*** The weighted average was determined based on the % contribution expected for each monitoring well

RFS:ams/3.48
6/19/86

TABLE VI

EXPECTED EFFLUENT QUALITY AND TREATMENT REDUCTION

Parameter	Expected Maximum Eff. Conc. (ug/l)	Expected Treatment Reduction (%)
Vinyl Chloride	<1	>99
Methylene Chloride	<1	>99
Trans-1,2-Dichloroethylene	<1	>99
Chloroform	<1	>99
Trichloroethylene	<1	>99
Tetrachloroethylene	<1	>99
1,1,2,2-Tetrachloroethane	50	99
Benzene	<1	>99
Chlorobenzene	<1	>99
1,4-Dichlorobutane	<1	>99
2-Methyl Furan	<1	>99
Tetrahydrothiophene	315	>99
Total Recoverable Phenols	190	10
TOC (mg/l)	60	50
Total Cyanide (mg/l)	10	-
Free Cyanide (mg/l)	<0.01	-
TSS (mg/l)	50	-
pH (Units) Range	6-8	-
Temperature (°F) Winter	65	-
Summer	85	-

RFS:ams/3.48
6/13/86

TABLE VII

EFFECT OF INCREASED COD & TSS FROM TREATMENT FACILITIES ON PLANT SPDES PERMIT LIMITS

	Maximum Increase* (ppd)	Average 1985 Plant Discharge (ppd)	SPDES Permit (Net Basis) Month Avg (ppd)	SPDES Permit (Net Basis) Day Max (ppd)
COD	160**	2,422	6,000	9,000
TSS	50	386	1,500	3,000

* At the maximum concentration and steady state flow of 90 gpm

** COD is conservatively calculated to be 2.5 x TOC

RFS:ams/3.50
6/19/86

TABLE VIII

COMPARISON OF EXPECTED TREATED GROUND WATER WITH OUTFALL 006 DISCHARGE AND ACTION LEVELS

Parameter	Expected Maximum Steam Stripper Discharge (mg/l)	Expected Maximum Steam Stripper Discharge (ppd**)	Outfall 006* Avg Discharge (Gross Basis) (ppd)	Action Level (Gross Basis) (ppd)
Copper	0.28	0.91	0.021	1.5
Arsenic	0.08	0.26	0.047	4.0
Lead	0.05	0.16	3.956***	0.50
Nickel	0.02	0.06	0	4.0
Phenols, Total	0.19	0.62	0.021	0.10
Selenium	<0.005	<0.016	0.048	4.0
Zinc	0.48	1.55	0.480****	20.0
Methylene Chloride	<0.001	<0.001	0.024	4.0
Trichloroethylene	<0.001	<0.001	0.072	4.0
Trans-1,2-Dichloroethylene	<0.001	<0.001	0.015	0.4
1,1,2,2-Tetrachloroethane	0.05	0.16	0.053	0.4
Tetrachloroethylene	<0.001	<0.001	0.028	4.0
Chloroform	<0.001	<0.001	0.082	4.0
Mercury, Total (mg/l)	0.002		0.001	0.001

* Volatile organics data from average of monthly 1985 samples and nonvolatile parameters from average of 1983-85 sample results.

** At maximum design flow of 270 gpm.

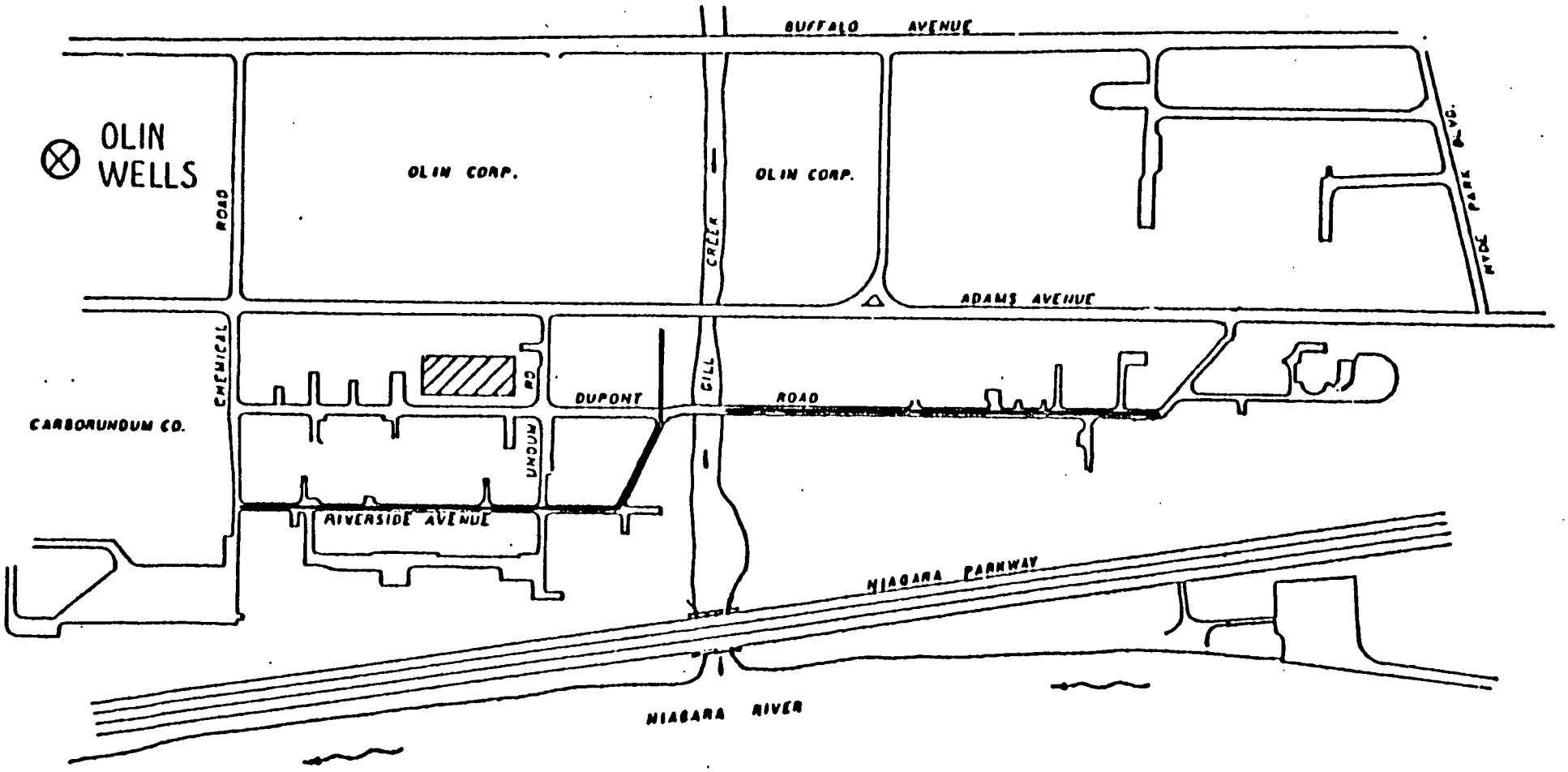
*** Net discharge averaged 0.288

**** Net discharge averaged 0.195

RFS:ams/3.57
6/19/86

FIGURE 1

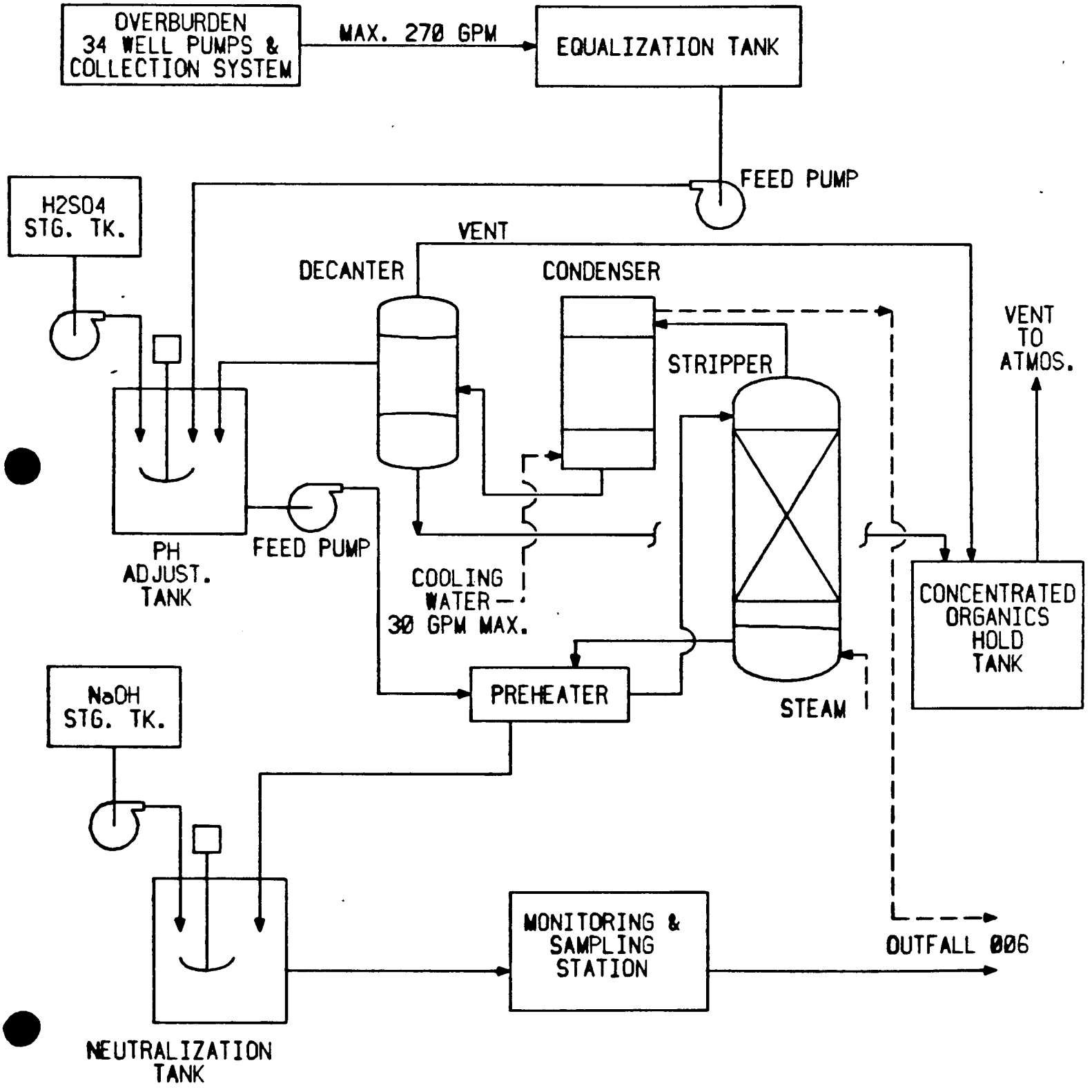
PUMPING WELL SYSTEM ROUTING & TREATMENT FACILITIES LOCATION



PUMPING WELL ROUTING

WATER TREATMENT FACILITIES

FIGURE 2
NIAGARA PLANT
GROUNDWATER TREATMENT
PROCESS SCHEMATIC



ATTACHMENT A-1

EQUIPMENT LIST AND SIZING

Equalization Tank

- Basis:
  - o Provide 24 hours of capacity at the average ground water flow rate of 90 gpm
  - o Carbon steel, closed top tank, vented to Concentrated Organics Storage Tank
- Calculation:
  - o Needed: 90 gpm for 24 hours duration → 129,600 gal
  - o Tank Sizing: 33' diameter and 22' height → 140,000 gal tank adequate

pH Adjustment Feed Pump

- Basis:
  - o Transfer the maximum flow rate from equalization tank to the pH adjustment tank
- Calculation:
  - o Requires 270 gpm pump

Storage Tank for Concentrated Organic Phase Condensate

- Basis:
  - o Provide storage for accumulating organic phase for off-site disposal in tank truck quantities (say 4,000 gal)
  - o Carbon steel with closed top and vent system
  - o Condensed organics accumulate at 10 gal/day average rate and 3 gal/hr maximum rate
- Calculation:
  - o Sizing: 9' diameter and 9' height tank → 4200 gal capacity
  - o Accumulation Time: 4200 gal → 420 days storage at average accumulation rate and 58 days storage at maximum rate

ATTACHMENT A-2

pH Adjustment Tank

- Basis:
  - o Provide 5 minutes hydraulic retention time at maximum flow rate to reduce pH to 5-5.5 range
  - o FRP, closed top tank
  - o 1 hp/1,000 gal agitation
- Calculation:
  - o Needed: 270 gpm for 5 minutes → 1350 gal
  - o Tank Sizing: 6' diameter and 9' height → 1900 gal adequate
  - o Agitation 1.9 hp

Preheater Feed Pump

- Basis:
  - o Transfer the maximum flow rate from pH adjustment tank to the preheater
- Calculation:
  - o Requires 270 gpm pump

Sulfuric Acid Metering Pump

- Basis:
  - o Supply sulfuric acid for pH 5 adjustment at maximum flow
  - o Approximately 300 mg/l alkalinity as $CaCO_3$ at pH 5 adjustment
  - o 93% sulfuric acid
- Calculation:
  - o Acid dose: 300 mg/l $CaCO_3$ alkalinity at 270 gpm with 93% H_2SO_4 → 68.1 gpd acid
  - o 68.1 gpd acid = 2.8 gph (say 3 gph acid metering pump)

Acid Supply Tank

- Basis:
  - o Store about one week's supply of 93% sulfuric acid at maximum flow rate

- o FRP tank

- Calculation:

  - o Needed: 68.1 gpd acid for 7 days → 480 gal
  - o Tank Sizing: 4.5' diameter and 6' height → 715 gal adequate

Neutralization Tank

- Basis:

  - o Provide 5 minutes hydraulic retention time at maximum flow rate to increase pH to 6-8 range
  - o FRP, closed top tank
  - o 1 hp/1,000 gal agitation

- Calculation:

  - o Needed: 270 gpm for 5 minutes → 1350 gal
  - o Tank Sizing: 6' diameter and 9' height → 1900 gal adequate

Caustic Metering Pump

- Basis:

  - o Supply NaOH for neutralization of pH 5 stripped ground water to pH 6-8 range
  - o Estimated 150 mg/l acidity as $CaCO_3$ to be neutralized
  - o 20% caustic solution available

- Calculation:

  - o Caustic Dose: 150 mg/l $CaCO_3$ acidity at 270 gpm with 20% NaOH → 190 gpd 20% caustic
  - o 190 gpd caustic = 7.95 gph (say 10 gph caustic metering pump)

Caustic Supply Tank

- Basis:

  - o Store about one week's supply of 20% caustic at maximum flow rate

- o FRP tank

- Calculation:

  - o Needed: 190 gpd caustic for 7 days → 1330 gal

  - o Tank Sizing: 6' diameter and 7' height → 1480 gal adequate

Feed Preheater

- Basis:

  - o To heat ground water from 10°C to near cooling water temperature

  - o Adequate capacity for maximum flow of 270 gpm

  - o 316 stainless steel construction

- Calculation:

  - o Duty is 11.53MM pcu/hr (1 pcu = 1.8 Btu)

  - o Area is 10,200 ft^2 @ U = 150 pcu/hr-ft^2-°C

  - o Operating Temperature: Hot side: 102.4 → 18.2°C
    Cold side: 10.0 → 95.4°C

  - o Operating Pressure: 16 psia

Steam Stripper Column

- Basis:

  - o To reduce the concentration of each indicator volatile organic to 50 ug/l or less at maximum flow rate of 270 gpm and maximum volatile organic concentrations

  - o Carbon steel or 304 stainless steel construction

- Calculation: (Based on SIMSCI Modeling)

  - o 42" diameter by 30' straight side column dimensions

  - o Packing:

    - One 16 ft deep bed of 1" slotted rings (Pall type)

    - Material 304 stainless steel

  - o Operating Temperature: 102.4°C

  - o Operating Pressure: 16 psia

ATTACHMENT A-5

Primary Condenser

- Basis:
  - o Condense stripped organics
  - o Titanium tubes and carbon steel shell
- Calculation: (Based on SIMSCI Modeling and Pilot Study)
  - o Duty is 69,480 pcu/hr
  - o Area is 85 ft^2 (3X computer sizing) @ U = 100 pcu/hr-ft^2-°C
  - o Operating Temperature: Hot Side: 99.1 → 30°C
    Cold Side: 25 → 35°C
  - o Cooling Water Required: 30 gpm maximum
  - o Operating Pressure: 15 psia

Decanter

- Basis:
  - o To provide adequate depth and cross-sectional area for separation into aqueous and organic phases and subsequent withdrawal of each phase from decanter
  - o Titanium construction
- Calculation: (Based on SIMSCI Modeling and Pilot Study)
  - o 10" diameter and 2'6" straight side (dimensions may be modified somewhat during final sizing)
  - o Operating Temperature: 25°C
  - o Operating Pressure: 15 psia

RFS:ams/3.55
6/24/86

FEED STREAMS : 6A 1

PRODUCT STREAMS : 12 13 15

OVERALL PLANT MOLAR BALANCE

	COMPONENT	FEED + LB MOLS/HR	REACTION LB MOLS/HR	PRODUCT = LB MOLS/HR	DEVIATION LB MOLS/HR	DEVIATION PERCENT
1	1122CLET	0.004	0.000	0.004	0.000	0.00
2	CHLOROFM	0.049	0.000	0.049	0.000	0.00
3	DCLMETHN	0.010	0.000	0.010	0.000	0.00
4	TCLETHLN	0.024	0.000	0.024	0.000	0.00
5	TECLETHE	0.009	0.000	0.009	0.000	0.00
6	12DCLETT	0.021	0.000	0.021	0.000	0.00
7	VINYLCL	0.009	0.000	0.009	0.000	0.00
8	BENZENE	0.002	0.000	0.002	0.000	0.00
9	THTHIOPH	0.054	0.000	0.054	0.000	0.00
*10	12DCLBN	0.027	0.000	0.027	0.000	0.00
**11	THF	0.066	0.000	0.066	0.000	0.00
12	CLBENZEN	0.000	0.000	0.000	0.000	0.00
13	WATER	7595.096	0.000	7595.097	0.000	0.00
	TOTAL	7595.370	0.000	7595.370	0.000	0.00

OVERALL PLANT MASS BALANCE

	COMPONENT	FEED + LBS/HR	REACTION LBS/HR	PRODUCT = LBS/HR	DEVIATION LBS/HR	DEVIATION PERCENT
1	1122CLET	0.65	0.00	0.65	0.00	0.00
2	CHLOROFM	5.81	0.00	5.81	0.00	0.00
3	DCLMETHN	0.82	0.00	0.82	0.00	0.00
4	TCLETHLN	3.11	0.00	3.11	0.00	0.00
5	TECLETHE	1.53	0.00	1.53	0.00	0.00
6	12DCLETT	2.08	0.00	2.08	0.00	0.00
7	VINYLCL	0.58	0.00	0.58	0.00	0.00
8	BENZENE	0.12	0.00	0.12	0.00	0.00
9	THTHIOPH	4.73	0.00	4.73	0.00	0.00
10	12DCLBN	3.38	0.00	3.38	0.00	0.00
11	THF	4.73	0.00	4.73	0.00	0.00
12	CLBENZEN	0.03	0.00	0.03	0.00	0.00
13	WATER	136825.66	0.00	136825.66	0.00	0.00
	TOTAL	136853.20	0.00	136853.20	0.00	0.00

Attachment B-1

* 1,2-Dichlorobutane was substituted for 1,4-Dichlorobutane because 1,2-DCB has very similar physical-chemical properties and these data were available in SIMSCI

** Tetrahydrofuran (THF) was substituted for 2-Methyl furan because THF has very similar physical-chemical properties and these data were available in SIMSCI

SUMMARY OF FLASH DRUMS,MIXER/SPLITTERS AND VALVES

UNIT ID	MIX1	DEWP	CHIL	MIX2
SEQ NO	1	3	7	8
NAME	RECYCLE MIX	FIX DEW PT	OVHD CHILLER	ORG PROD MIX
TYPE	MIXER	FLASH	FLASH	MIXER
FEEDS	1 10	6A	7	8 14
PRODUCTS	2 (L)	6 (V)	13 (V) 14 (L)	15 (L)
TEMP, DEG C	10.0087	102.3896	5.0000	25.0000
PRESSURE, PSIA	16.0000	16.0000	15.0000	15.0000
FRACTION LIQUID	1.00000	0.00000	0.00000	1.00000
DUTY, MM PCU*/HR	0.00000	-0.00221	0.00000	0.00000

* 1 pcu = 1.8 BTu

Attachment B-2

SUMMARY OF HEAT EXCHANGE UNITS

2 UNIT PHTR, FEED PREHTR , IS A HEAT EXCHANGER

*** OPERATING CONDITIONS

DUTY, MM PCU /HR	11.52812
LMTD, DEG C	7.561
F FACTOR (FT)	1.00000
MTD, DEG C	7.561
U*A, PCU /HR DEG C	1524646.125
U, PCU /HR DEG C SQ FT	150.000
A, SQ FT	10164.308

*** HOT SIDE CONDITIONS	INLET	OUTLET
FEED(S)	11	
LIQUID PRODUCT		12
VAPOR, LB MOLS/HR	0.0000	0.0000
M LBS/HR	0.0000	0.0000
CP, PCU /LB - DEG C	0.0000	0.0000
LIQUID, LB MOLS/HR	7595.0938	7595.0938
M LBS/HR	136.8256	136.8256
CP, PCU /LB - DEG C	1.0080	0.9990
TOTAL, LB MOLS/HR	7595.0938	7595.0938
CONDENS(VAPORIZ)ATION, LB MOLS/HR		0.0000
TEMPERATURE, DEG C	102.389	18.160
PRESSURE, PSIA	16.000	15.000

*** COLD SIDE CONDITIONS	INLET	OUTLET
FEED(S)	2	
VAPOR PRODUCT		4
LIQUID PRODUCT		3
VAPOR, LB MOLS/HR	0.0000	0.0000
M LBS/HR	0.0000	0.0000
CP, PCU /LB - DEG C	0.0000	0.0000
LIQUID, LB MOLS/HR	7496.8643	7496.8643
M LBS/HR	135.0790	135.0790
CP, PCU /LB - DEG C	0.9999	1.0056
TOTAL, LB MOLS/HR	7496.8643	7496.8643
CONDENS(VAPORIZ)ATION, LB MOLS/HR		0.0000
TEMPERATURE, DEG C	10.009	95.389
PRESSURE, PSIA	16.000	15.000

Attachment B-3

SUMMARY OF COMPRESSOR/EXPANDER/PUMP/TURBINE UNITS

6 UNIT PMP1, H2O LAYR PMP, IS A PUMP

FEED STREAMS ARE 9
LIQUID PRODUCT IS STREAM 10

OPERATING CONDITIONS

WORK, HP		0.00
EFFICIENCY, PERCENT		100.00
	INLET	OUTLET
MOLE FRACTION LIQUID	1.0000	1.0000
TEMPERATURE, DEG C	25.000	25.000
PRESSURE, PSIA	15.0000	16.0000
HEAD, FT		2.3153
HOT VOLUME, FT3/HR	1.270	1.270

Attachment B-4

SUMMARY OF THREE PHASE FLASH CALCULATION

UNIT NUMBER 5 UNIT I.D. COND UNIT NAME CONDNSR+DEC

NO. OF FEEDS;- 2 ; NO.OF PRODS:- 3 ; FLASH TYPE:- ISOTHERMAL

PRESSURE GIVEN , PSIA	15.00000
TEMPERATURE GIVEN , DEG. C	25.00000
HEAT DUTY FOR THIS UNIT, MM PCU /HR	-0.05087

STREAM IDS. -	FEEDS 4	FEEDS 5	VAPOR # 7	LIQUID L 8	LIQUID W 9
COMPONENT MOLE FRACTION : -					
1 1122CLET	0.000828	0.000000	0.013827	0.000005	
2 CHLOROFM	0.010687	0.000000	0.176023	0.000221	
3 DCLMETHN	0.002185	0.000000	0.035098	0.000102	
4 TCLETHLN	0.005106	0.000000	0.085545	0.000015	
5 TECLETHE	0.001983	0.000000	0.033299	0.000001	
6 12DCLETT	0.004708	0.000000	0.077629	0.000092	
7 VINYLCL	0.002080	0.000000	0.033622	0.000083	
8 BENZENE	0.000338	0.000000	0.005630	0.000003	
9 THTHIOPH	0.011814	0.000000	0.192216	0.000395	
10 12DCLBN	0.005742	0.000000	0.096186	0.000017	
11 THF	0.014297	0.000000	0.237197	0.000188	
12 CLBENZEN	0.000062	0.000000	0.001042	0.000000	
13 WATER	0.940170	0.000000	0.012687	0.998879	
PRODUCT/FEED RATIOS		0.000000	0.059531	0.940469	
TOTAL LB MOLS/HR	0.46408E+01	0.00000E+00	0.27627E+00	0.43645E+01	

NOTE: # - DOES NOT EXIST OR COMBINED WITH MIXED, IF ANY

	K - VALUES Y/XL	K - VALUES Y/XW	ACTIVITY COEFFICIENTS LIQUID L	ACTIVITY COEFFICIENTS LIQUID W
1 1122CLET	0.76404E-02	0.21106E+02	0.10017E+01	0.27672E+04
2 CHLOROFM	0.25617E+00	0.20370E+03	0.10094E+01	0.80268E+03
3 DCLMETHN	0.56409E+00	0.19395E+03	0.10058E+01	0.34583E+03
4 TCLETHLN	0.97682E-01	0.56839E+03	0.10119E+01	0.58881E+04
5 TECLETHE	0.25453E-01	0.10756E+04	0.10101E+01	0.42688E+05
6 12DCLETT	0.40782E+00	0.34503E+03	0.99283E+00	0.83996E+03
7 VINYLCL	0.38848E+01	0.15744E+04	0.10128E+01	0.41044E+03
8 BENZENE	0.12417E+00	0.26784E+03	0.10118E+01	0.21823E+04
9 THTHIOPH	0.23746E-01	0.11567E+02	0.99590E+00	0.48511E+03
10 12DCLBN	0.27116E-01	0.14917E+03	0.10066E+01	0.55373E+04
11 THF	0.22461E+00	0.28373E+03	0.99456E+00	0.12563E+04
12 CLBENZEN	0.14880E-01	0.14322E+03	0.10109E+01	0.97292E+04
13 WATER	0.24131E+01	0.30645E-01	0.78747E+02	0.10000E+01

Attachment B-5

SUMMARY OF THREE PHASE FLASH CALCULATION

(UNIT 5 - CONTINUED)

STREAM IDS. -	FEEDS 4 5	VAPOR# 7	LIQUID L 8	LIQUID W 9
COMPONENT WEIGHT FRACTION : -				
1 1122CLET	0.006052	0.000000	0.023266	0.000046
2 CHLOROFM	0.055568	0.000000	0.210642	0.001460
3 DCLMETHN	0.008084	0.000000	0.029882	0.000479
4 TCLETHLN	0.029223	0.000000	0.112669	0.000107
5 TECLETHE	0.014324	0.000000	0.055355	0.000007
6 12DCLETT	0.019878	0.000000	0.075439	0.000491
7 VINYLCL	0.005661	0.000000	0.021064	0.000286
8 BENZENE	0.001149	0.000000	0.004409	0.000011
9 THTHIOPH	0.045369	0.000000	0.169888	0.001922
10 12DCLBN	0.031769	0.000000	0.122466	0.000123
11 THF	0.044904	0.000000	0.171453	0.000748
12 CLBENZEN	0.000304	0.000000	0.001175	0.000001
13 WATER	0.737715	0.000000	0.002291	0.994318
PRODUCT/FEED RATIOS		0.000000	0.258665	0.741335
TOTAL LBS/HR	0.10655E+03	0.00000E+00	0.27560E+02	0.78988E+02

Attachment B-6

I SUMMARY FOR COLUMN UNIT 4 - COL , STM STRIPPR

1 TOTAL NUMBER OF ITERATIONS
FAST METHOD 0
SURE METHOD 32

2 COLUMN SUMMARY

TRAY	TEMP DEG C	PRESSURE PSIA	NET FLOW RATES, LB MOLS/HR LIQUID PHASE(L)	VAPOR PHASE(V)	FEED	PRODUCT	HEAT(COOL)ER DUTIES MM PCU /HR
1	98.8	15.00	7545.0		7496.9L	4.6V	
2	100.8	15.25	7573.3	52.8			
3	101.5	15.50	7581.9	81.1			
4	101.9	15.75	7588.7	89.7			
5	102.4	16.00		96.4	102.9V	7595.1L	

3 FEED AND PRODUCT STREAMS

		MASS RATES LB MOLS/HR	HEAT RATES MM PCU /HR
* FEED STREAMS:			
3	TO TRAY 1 IS LIQUID FROM UNIT 2, PHTR	0.74969E+04	0.12881E+02
6	TO TRAY 5 IS VAPOR FROM UNIT 3, DEWP	0.10287E+03	0.11857E+01
* PRODUCT STREAMS:			
11	IS LIQUID STREAM FROM TRAY 5	0.75951E+04	0.14014E+02
5	IS VAPOR STREAM FROM TRAY 1	0.46408E+01	0.53058E-01
OVERALL MASS BALANCE, (FEEDS - PRODS)		0.00000E+00	
OVERALL HEAT BALANCE, (HIN - HOUT)			0.21935E-04

Attachment B-7

IIA TRAY COMPOSITIONS

TRAY	1		2		3		4	
COMPONENT	X	Y	X	Y	X	Y	X	Y
1 1122CLET	2.0876E-06	8.2787E-04	7.2547E-07	2.9749E-04	1.6426E-07	6.7258E-05	3.2964E-08	1.3431E-05
2 CHLOROFM	3.4640E-06	1.0687E-02	1.5427E-07	4.9491E-04	4.4900E-09	1.4409E-05	1.1859E-10	3.7929E-07
3 DCLMETHN	8.3929E-07	2.1854E-03	4.4440E-08	1.1991E-04	1.5393E-09	4.1506E-06	4.8411E-11	1.3000E-07
4 TCLETHLN	7.4964E-07	5.1064E-03	1.5182E-08	1.0710E-04	2.0118E-10	1.4180E-06	2.4233E-12	1.7003E-08
5 TECLETHE	1.5177E-07	1.9831E-03	1.6043E-09	2.1684E-05	1.1101E-11	1.4984E-07	6.9882E-14	9.3834E-10
6 12DCLETT	1.4609E-06	4.7076E-03	6.3140E-08	2.0873E-04	1.7906E-09	5.8973E-06	4.6231E-11	1.5126E-07
7 VINYLCL	2.4747E-07	2.0795E-03	4.1417E-09	3.5356E-05	4.5620E-11	3.8684E-07	4.5873E-13	3.8558E-09
8 BENZENE	1.8111E-07	3.3763E-04	1.3597E-08	2.5876E-05	6.7073E-10	1.2698E-06	3.0125E-11	5.6593E-08
9 THTHIOPH	2.9497E-05	1.1814E-02	9.9140E-06	4.2050E-03	2.1562E-06	9.1996E-04	4.1402E-07	1.7681E-04
10 12DCLBN	2.2556E-06	5.7425E-03	1.2147E-07	3.2226E-04	4.2724E-09	1.1345E-05	1.3629E-10	3.6080E-07
11 THF	3.7940E-06	1.4297E-02	1.3843E-07	5.4207E-04	3.3014E-09	1.2930E-05	7.1478E-11	2.7894E-07
12 CLBENZEN	7.5901E-08	6.2109E-05	1.3075E-08	1.0842E-05	1.4823E-09	1.2200E-06	1.5231E-10	1.2415E-07
13 WATER	9.9996E-01	9.4017E-01	9.9999E-01	9.9360E-01	1.0000E+00	9.9896E-01	1.0000E+00	9.9981E-01
LB MOLS/HR	7.5450E+03	4.6408E+00	7.5733E+03	5.2809E+01	7.5819E+03	8.1083E+01	7.5887E+03	8.9697E+01

TRAY	5	
COMPONENT	X	Y
1 1122CLET	5.3593E-09	2.1718E-06
2 CHLOROFM	2.8586E-12	9.1069E-09
3 DCLMETHN	1.3844E-12	3.7004E-09
4 TCLETHLN	2.7008E-14	1.8856E-10
5 TECLETHE	4.0950E-16	5.4667E-12
6 12DCLETT	1.0931E-12	3.5518E-09
7 VINYLCL	4.2930E-15	3.5759E-11
8 BENZENE	1.2204E-12	2.2744E-09
9 THTHIOPH	6.4399E-08	2.7507E-05
10 12DCLBN	3.9485E-12	1.0414E-08
11 THF	1.4184E-12	5.5129E-09
12 CLBENZEN	1.3528E-11	1.0919E-08
13 WATER	1.0000E+00	9.9998E-01
LB MOLS/HR	7.5951E+03	9.6438E+01

Attachment B-8

IIB TRAY VAPOR RATES AND DENSITIES

TRAY	M	LBS/HR	MW	M STD FT3/HR	Z	M ACTUAL FT3/HR	ACTUAL LBS/M FT3
1		0.107	22.959	1.761	0.99059	2.202	48.384
2		0.978	18.513	20.041	0.99117	24.795	39.429
3		1.467	18.094	30.770	0.99114	37.517	39.106
4		1.617	18.030	34.039	0.99104	40.891	39.548
5		1.738	18.017	36.597	0.99093	43.326	40.105

IIC TRAY LIQUID RATES AND DENSITIES

TRAY	M	LBS/HR	MW	STD DRY LV FT3/HR	STD DRY LBS/FT3	ACTUAL GPM	ACTUAL LBS/FT3
1		135.950	18.018	2183.130	62.273	283.072	59.877
2		136.440	18.016	2191.027	62.272	284.499	59.791
3		136.590	18.015	2193.443	62.272	284.938	59.765
4		136.710	18.015	2195.377	62.272	285.287	59.745
5		136.826	18.015	2197.234	62.272	285.622	59.725

IIG TRAY TRANSPORT PROPERTIES

TRAY	THER. COND.,BTU/HR.FT.F LIQUID	VAPOR	VISCOSITY, CP LIQUID	VAPOR	S. TENSION DYNES/CM
1	0.3904E+00	0.1359E-01	0.2825E+00	0.1196E-01	0.5951E+02
2	0.3921E+00	0.1429E-01	0.2766E+00	0.1212E-01	0.5912E+02
3	0.3926E+00	0.1437E-01	0.2749E+00	0.1217E-01	0.5900E+02
4	0.3928E+00	0.1440E-01	0.2735E+00	0.1219E-01	0.5891E+02
5	0.3929E+00	0.1442E-01	0.2722E+00	0.1221E-01	0.5882E+02

Attachment B-9

IIIA TRAY K VALUES

TRAY	--- 1 ---	--- 2 ---	--- 3 ---	--- 4 ---	--- 5 ---
COMPONENT					
1 1122CLET	3.9657E+02	4.1006E+02	4.0946E+02	4.0745E+02	4.0524E+02
2 CHLOROFM	3.0851E+03	3.2080E+03	3.2092E+03	3.1983E+03	3.1857E+03
3 DCLMETHN	2.6039E+03	2.6983E+03	2.6964E+03	2.6853E+03	2.6729E+03
4 TCLETHLN	6.8118E+03	7.0547E+03	7.0484E+03	7.0167E+03	6.9815E+03
5 TECLETHE	1.3066E+04	1.3516E+04	1.3498E+04	1.3427E+04	1.3350E+04
6 12DCLETT	3.2223E+03	3.3058E+03	3.2935E+03	3.2719E+03	3.2492E+03
7 VINYLCL	8.4034E+03	8.5366E+03	8.4798E+03	8.4054E+03	8.3297E+03
8 BENZENE	1.8642E+03	1.9031E+03	1.8932E+03	1.8786E+03	1.8636E+03
9 THTHIOPH	4.0051E+02	4.2415E+02	4.2665E+02	4.2706E+02	4.2713E+02
10 12DCLBN	2.5459E+03	2.6530E+03	2.6555E+03	2.6472E+03	2.6374E+03
11 THF	3.7683E+03	3.9158E+03	3.9164E+03	3.9025E+03	3.8866E+03
12 CLBENZEN	8.1829E+02	8.2922E+02	8.2302E+02	8.1516E+02	8.0720E+02
13 WATER	9.4021E-01	9.9362E-01	9.9896E-01	9.9981E-01	9.9998E-01
TEMP,DEG C	98.841	100.850	101.460	101.937	102.389
PRESS,PSIA	15.000	15.250	15.500	15.750	16.000

Attachment B-10

STREAM COMPONENT FLOW RATES - LB MOLS/HR

STREAM ID	1	2	3	5	6	8	9
NAME	COLD FEED	FEED+RECYCLE	COL FEED LIQ	STPR OVHD	LIVE STEAM	ORG PHASE	WATER PHASE
PHASE	LIQUID	LIQUID	LIQUID	VAPOR	VAPOR	LIQUID	LIQUID
1 1122CLET	0.0039	0.0039	0.0039	0.0038	0.0000	0.0038	0.0000
2 CHLOROFM	0.0486	0.0496	0.0496	0.0496	0.0000	0.0486	0.0010
3 DCLMETHN	0.0097	0.0101	0.0101	0.0101	0.0000	0.0097	0.0004
4 TCLETHLN	0.0236	0.0237	0.0237	0.0237	0.0000	0.0236	0.0001
5 TECLETHE	0.0092	0.0092	0.0092	0.0092	0.0000	0.0092	0.0000
6 12DCLETT	0.0214	0.0218	0.0218	0.0218	0.0000	0.0214	0.0004
7 VINYLCL	0.0093	0.0097	0.0097	0.0097	0.0000	0.0093	0.0004
8 BENZENE	0.0016	0.0016	0.0016	0.0016	0.0000	0.0016	0.0000
9 THTHIOPH	0.0536	0.0553	0.0553	0.0548	0.0000	0.0531	0.0017
10 12DCLBN	0.0266	0.0266	0.0266	0.0266	0.0000	0.0266	0.0001
11 THF	0.0655	0.0664	0.0664	0.0664	0.0000	0.0655	0.0008
12 CLBENZEN	0.0003	0.0003	0.0003	0.0003	0.0000	0.0003	0.0000
13 WATER	7492.2261	7496.5859	7496.5859	4.3632	102.8700	0.0035	4.3596
TOTALS, LB MOLS/HR	7492.4995	7496.8643	7496.8643	4.6408	102.8700	0.2763	4.3645
TEMPERATURE, DEG C	10.0000	10.0087	95.3890	98.8407	102.3896	25.0000	25.0000
PRESSURE, PSIA	16.0000	16.0000	15.0000	15.0000	16.0000	15.0000	15.0000
H, MM PCU /HR	1.3512	1.3531	12.8813	0.0531	1.1857	0.0002	0.0020
MOLECULAR WEIGHT	18.0180	18.0181	18.0181	22.9590	18.0150	99.7579	18.0976
MOLE FRACT LIQUID	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000
RECYCLE CONVERGENCE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STREAM ID	10	11	12	15	6A
NAME	WATER PHASE	COL BOTTOMS	STRPPD WATER	CONC ORGANIC	STEAM GUESS
PHASE	LIQUID	LIQUID	LIQUID	LIQUID	VAPOR
1 1122CLET	0.0000	0.0000	0.0000	0.0038	0.0000
2 CHLOROFM	0.0010	0.0000	0.0000	0.0486	0.0000
3 DCLMETHN	0.0004	0.0000	0.0000	0.0097	0.0000
4 TCLETHLN	0.0001	0.0000	0.0000	0.0236	0.0000
5 TECLETHE	0.0000	0.0000	0.0000	0.0092	0.0000
6 12DCLETT	0.0004	0.0000	0.0000	0.0214	0.0000
7 VINYLCL	0.0004	0.0000	0.0000	0.0093	0.0000
8 BENZENE	0.0000	0.0000	0.0000	0.0016	0.0000
9 THTHIOPH	0.0017	0.0005	0.0005	0.0531	0.0000
10 12DCLBN	0.0001	0.0000	0.0000	0.0266	0.0000
11 THF	0.0008	0.0000	0.0000	0.0655	0.0000
12 CLBENZEN	0.0000	0.0000	0.0000	0.0003	0.0000
13 WATER	4.3596	7595.0933	7595.0933	0.0035	102.8700
TOTALS, LB MOLS/HR	4.3645	7595.0938	7595.0938	0.2763	102.8700
TEMPERATURE, DEG C	25.0000	102.3890	18.1603	25.0000	105.0000
PRESSURE, PSIA	16.0000	16.0000	15.0000	15.0000	16.0000
H, MM PCU /HR	0.0020	14.0138	2.4857	0.0002	1.1879
MOLECULAR WEIGHT	18.0976	18.0150	18.0150	99.7579	18.0150
MOLE FRACT LIQUID	1.0000	1.0000	1.0000	1.0000	0.0000
RECYCLE CONVERGENCE	0.0000	0.0000	0.0000	0.0000	0.0000

Attachment B-11

STREAM COMPONENT FLOW RATES - LBS/HR

STREAM ID	1	2	3	5	6	8	9
NAME	COLD FEED	FEED+RECYCLE	COL FEED LIQ	STPR OVHD	LIVE STEAM	ORG PHASE	WATER PHASE
PHASE	LIQUID	LIQUID	LIQUID	VAPOR	VAPOR	LIQUID	LIQUID
1 1122CLET	0.6480	0.6517	0.6517	0.6449	0.0000	0.6412	0.0037
2 CHLOROFM	5.8054	5.9207	5.9207	5.9207	0.0000	5.8054	0.1153
3 DCLMETHN	0.8236	0.8614	0.8614	0.8614	0.0000	0.8236	0.0378
4 TCLETHLN	3.1052	3.1136	3.1136	3.1136	0.0000	3.1052	0.0084
5 TECLETHE	1.5256	1.5262	1.5262	1.5262	0.0000	1.5256	0.0006
6 12DCLETT	2.0791	2.1180	2.1180	2.1180	0.0000	2.0791	0.0388
7 VINYLCL	0.5805	0.6032	0.6032	0.6032	0.0000	0.5805	0.0226
8 BENZENE	0.1215	0.1224	0.1224	0.1224	0.0000	0.1215	0.0009
9 THTHIOPH	4.7253	4.8771	4.8771	4.8340	0.0000	4.6822	0.1518
10 12DCLBN	3.3752	3.3849	3.3849	3.3849	0.0000	3.3752	0.0097
11 THF	4.7253	4.7844	4.7844	4.7844	0.0000	4.7253	0.0591
12 CLBENZEN	0.0324	0.0325	0.0325	0.0324	0.0000	0.0324	0.0001
13 WATER	134972.4531	135050.9844	135050.9844	78.6022	1853.2030	0.0631	78.5391
TOTALS, LBS/HR	135000.0000	135078.9844	135078.9844	106.5482	1853.2030	27.5603	78.9879
TEMPERATURE, DEG C	10.0000	10.0087	95.3890	98.8407	102.3896	25.0000	25.0000
PRESSURE, PSIA	16.0000	16.0000	15.0000	15.0000	16.0000	15.0000	15.0000
H, MM PCU /HR	1.3512	1.3531	12.8813	0.0531	1.1857	0.0002	0.0020
MOLECULAR WEIGHT	18.0180	18.0181	18.0181	22.9590	18.0150	99.7579	18.0976
MOLE FRACT LIQUID	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000
RECYCLE CONVERGENCE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STREAM ID	10	11	12	15	6A
NAME	WATER PHASE	COL BOTTOMS	STRPPD WATER	CONC ORGANIC	STEAM GUESS
PHASE	LIQUID	LIQUID	LIQUID	LIQUID	VAPOR
1 1122CLET	0.0037	0.0068	0.0068	0.6412	0.0000
2 CHLOROFM	0.1153	0.0000	0.0000	5.8054	0.0000
3 DCLMETHN	0.0378	0.0000	0.0000	0.8236	0.0000
4 TCLETHLN	0.0084	0.0000	0.0000	3.1052	0.0000
5 TECLETHE	0.0006	0.0000	0.0000	1.5256	0.0000
6 12DCLETT	0.0388	0.0000	0.0000	2.0791	0.0000
7 VINYLCL	0.0226	0.0000	0.0000	0.5805	0.0000
8 BENZENE	0.0009	0.0000	0.0000	0.1215	0.0000
9 THTHIOPH	0.1518	0.0431	0.0431	4.6822	0.0000
10 12DCLBN	0.0097	0.0000	0.0000	3.3752	0.0000
11 THF	0.0591	0.0000	0.0000	4.7253	0.0000
12 CLBENZEN	0.0001	0.0000	0.0000	0.0324	0.0000
13 WATER	78.5391	136825.5938	136825.5938	0.0631	1853.2030
TOTALS, LBS/HR	78.9879	136825.6406	136825.6406	27.5603	1853.2030
TEMPERATURE, DEG C	25.0000	102.3890	18.1603	25.0000	105.0000
PRESSURE, PSIA	16.0000	16.0000	15.0000	15.0000	16.0000
H, MM PCU /HR	0.0020	14.0138	2.4857	0.0002	1.1879
MOLECULAR WEIGHT	18.0976	18.0150	18.0150	99.7579	18.0150
MOLE FRACT LIQUID	1.0000	1.0000	1.0000	1.0000	0.0000
RECYCLE CONVERGENCE	0.0000	0.0000	0.0000	0.0000	0.0000

Attachment B-12

STREAM MOLAL COMPOSITIONS - FRACTIONS

STREAM ID	1	2	3	5	6	8	9
NAME	COLD FEED	FEED+RECYCLE	COL FEED LIQ	STPR OVHD	LIVE STEAM	ORG PHASE	WATER PHASE
PHASE	LIQUID	LIQUID	LIQUID	VAPOR	VAPOR	LIQUID	LIQUID
1 1122CLET	5.1529E-07	5.1791E-07	5.1791E-07	8.2787E-04	0.0000E+00	1.3827E-02	5.0049E-06
2 CHLOROFM	6.4905E-06	6.6156E-06	6.6156E-06	1.0687E-02	0.0000E+00	1.7602E-01	2.2134E-04
3 DCLMETHN	1.2942E-06	1.3528E-06	1.3528E-06	2.1854E-03	0.0000E+00	3.5098E-02	1.0207E-04
4 TCLETHLN	3.1543E-06	3.1610E-06	3.1610E-06	5.1064E-03	0.0000E+00	8.5545E-02	1.4700E-05
5 TECLETHE	1.2278E-06	1.2276E-06	1.2276E-06	1.9831E-03	0.0000E+00	3.3299E-02	7.8786E-07
6 12DCLETT	2.8624E-06	2.9142E-06	2.9142E-06	4.7076E-03	0.0000E+00	7.7629E-02	9.1746E-05
7 VINYLCL	1.2397E-06	1.2873E-06	1.2873E-06	2.0795E-03	0.0000E+00	3.3622E-02	8.2953E-05
8 BENZENE	2.0761E-07	2.0901E-07	2.0901E-07	3.3763E-04	0.0000E+00	5.6303E-03	2.6100E-06
9 THTHIOPH	7.1529E-06	7.3784E-06	7.3784E-06	1.1814E-02	0.0000E+00	1.9222E-01	3.9456E-04
10 12DCLBN	3.5467E-06	3.5548E-06	3.5548E-06	5.7425E-03	0.0000E+00	9.6186E-02	1.7483E-05
11 THF	8.7462E-06	8.8504E-06	8.8504E-06	1.4297E-02	0.0000E+00	2.3720E-01	1.8775E-04
12 CLBENZEN	3.8421E-08	3.8461E-08	3.8461E-08	6.2109E-05	0.0000E+00	1.0416E-03	1.0821E-07
13 WATER	9.9996E-01	9.9996E-01	9.9996E-01	9.4017E-01	1.0000E+00	1.2687E-02	9.9888E-01
TOTALS, LB MOLS/HR	7492.4995	7496.8643	7496.8643	4.6408	102.8700	0.2763	4.3645
TEMPERATURE, DEG C	10.0000	10.0087	95.3890	98.8407	102.3896	25.0000	25.0000
PRESSURE, PSIA	16.0000	16.0000	15.0000	15.0000	16.0000	15.0000	15.0000
H, MM PCU /HR	1.3512	1.3531	12.8813	0.0531	1.1857	0.0002	0.0020
MOLECULAR WEIGHT	18.0180	18.0181	18.0181	22.9590	18.0150	99.7579	18.0976
MOLE FRACT LIQUID	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000
RECYCLE CONVERGENCE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STREAM ID	10	11	12	15	6A
NAME	WATER PHASE	COL BOTTOMS	STRPPD WATER	CONC ORGANIC	STEAM GUESS
PHASE	LIQUID	LIQUID	LIQUID	LIQUID	VAPOR
1 1122CLET	5.0049E-06	5.3593E-09	5.3593E-09	1.3827E-02	0.0000E+00
2 CHLOROFM	2.2134E-04	2.8586E-12	2.8586E-12	1.7602E-01	0.0000E+00
3 DCLMETHN	1.0207E-04	1.3844E-12	1.3844E-12	3.5098E-02	0.0000E+00
4 TCLETHLN	1.4700E-05	2.7008E-14	2.7008E-14	8.5545E-02	0.0000E+00
5 TECLETHE	7.8786E-07	4.0950E-16	4.0950E-16	3.3299E-02	0.0000E+00
6 12DCLETT	9.1746E-05	1.0931E-12	1.0931E-12	7.7629E-02	0.0000E+00
7 VINYLCL	8.2953E-05	4.2930E-15	4.2926E-15	3.3622E-02	0.0000E+00
8 BENZENE	2.6100E-06	1.2204E-12	1.2204E-12	5.6303E-03	0.0000E+00
9 THTHIOPH	3.9456E-04	6.4399E-08	6.4401E-08	1.9222E-01	0.0000E+00
10 12DCLBN	1.7483E-05	3.9485E-12	3.9485E-12	9.6186E-02	0.0000E+00
11 THF	1.8775E-04	1.4184E-12	1.4184E-12	2.3720E-01	0.0000E+00
12 CLBENZEN	1.0821E-07	1.3528E-11	1.3528E-11	1.0416E-03	0.0000E+00
13 WATER	9.9888E-01	1.0000E+00	1.0000E+00	1.2687E-02	1.0000E+00
TOTALS, LB MOLS/HR	4.3645	7595.0938	7595.0938	0.2763	102.8700
TEMPERATURE, DEG C	25.0000	102.3890	18.1603	25.0000	105.0000
PRESSURE, PSIA	16.0000	16.0000	15.0000	15.0000	16.0000
H, MM PCU /HR	0.0020	14.0138	2.4857	0.0002	1.1879
MOLECULAR WEIGHT	18.0976	18.0150	18.0150	99.7579	18.0150
MOLE FRACT LIQUID	1.0000	1.0000	1.0000	1.0000	0.0000
RECYCLE CONVERGENCE	0.0000	0.0000	0.0000	0.0000	0.0000

Attachment B-13

STREAM WEIGHT COMPOSITIONS - FRACTIONS

STREAM ID	1	2	3	5	6	8	9
NAME	COLD FEED	FEED+RECYCLE	COL FEED LIQ	STPR OVHD	LIVE STEAM	ORG PHASE	WATER PHASE
PHASE	LIQUID	LIQUID	LIQUID	VAPOR	VAPOR	LIQUID	LIQUID
1 1122CLET	4.8003E-06	4.8246E-06	4.8246E-06	6.0524E-03	0.0000E+00	2.3266E-02	4.6418E-05
2 CHLOROFM	4.3003E-05	4.3831E-05	4.3831E-05	5.5568E-02	0.0000E+00	2.1064E-01	1.4600E-03
3 DCLMETHN	6.1004E-06	6.3769E-06	6.3769E-06	8.0845E-03	0.0000E+00	2.9882E-02	4.7901E-04
4 TCLETHLN	2.3001E-05	2.3050E-05	2.3050E-05	2.9223E-02	0.0000E+00	1.1267E-01	1.0672E-04
5 TECLETHE	1.1301E-05	1.1298E-05	1.1298E-05	1.4324E-02	0.0000E+00	5.5355E-02	7.2194E-06
6 12DCLETT	1.5401E-05	1.5679E-05	1.5679E-05	1.9878E-02	0.0000E+00	7.5439E-02	4.9146E-04
7 VINYLCL	4.3003E-06	4.4653E-06	4.4653E-06	5.6610E-03	0.0000E+00	2.1064E-02	2.8647E-04
8 BENZENE	9.0006E-07	9.0612E-07	9.0612E-07	1.1487E-03	0.0000E+00	4.4088E-03	1.1265E-05
9 THTHIOPH	3.5002E-05	3.6106E-05	3.6106E-05	4.5369E-02	0.0000E+00	1.6989E-01	1.9222E-03
10 12DCLBN	2.5002E-05	2.5059E-05	2.5059E-05	3.1769E-02	0.0000E+00	1.2247E-01	1.2270E-04
11 THF	3.5002E-05	3.5419E-05	3.5419E-05	4.4904E-02	0.0000E+00	1.7145E-01	7.4808E-04
12 CLBENZEN	2.4002E-07	2.4027E-07	2.4027E-07	3.0450E-04	0.0000E+00	1.1753E-03	6.7301E-07
13 WATER	9.9980E-01	9.9979E-01	9.9979E-01	7.3771E-01	1.0000E+00	2.2910E-03	9.9432E-01
TOTALS, LBS/HR	135000.0000	135078.9844	135078.9844	106.5482	1853.2030	27.5603	78.9879
TEMPERATURE, DEG C	10.0000	10.0087	95.3890	98.8407	102.3896	25.0000	25.0000
PRESSURE, PSIA	16.0000	16.0000	15.0000	15.0000	16.0000	15.0000	15.0000
H, MM PCU /HR	1.3512	1.3531	12.8813	0.0531	1.1857	0.0002	0.0020
MOLECULAR WEIGHT	18.0180	18.0181	18.0181	22.9590	18.0150	99.7579	18.0976
MOLE FRACT LIQUID	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000
RECYCLE CONVERGENCE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STREAM ID	10	11	12	15	6A
NAME	WATER PHASE	COL BOTTOMS	STRPPD WATER	CONC ORGANIC	STEAM GUESS
PHASE	LIQUID	LIQUID	LIQUID	LIQUID	VAPOR
1 1122CLET	4.6418E-05	4.9934E-08	4.9934E-08	2.3266E-02	0.0000E+00
2 CHLOROFM	1.4600E-03	1.8943E-11	1.8943E-11	2.1064E-01	0.0000E+00
3 DCLMETHN	4.7901E-04	6.5270E-12	6.5268E-12	2.9882E-02	0.0000E+00
4 TCLETHLN	1.0672E-04	1.9698E-13	1.9698E-13	1.1267E-01	0.0000E+00
5 TECLETHE	7.2194E-06	3.7695E-15	3.7696E-15	5.5355E-02	0.0000E+00
6 12DCLETT	4.9146E-04	5.8824E-12	5.8824E-12	7.5439E-02	0.0000E+00
7 VINYLCL	2.8647E-04	1.4894E-14	1.4892E-14	2.1064E-02	0.0000E+00
8 BENZENE	1.1265E-05	5.2919E-12	5.2919E-12	4.4088E-03	0.0000E+00
9 THTHIOPH	1.9222E-03	3.1519E-07	3.1520E-07	1.6989E-01	0.0000E+00
10 12DCLBN	1.2270E-04	2.7839E-11	2.7839E-11	1.2247E-01	0.0000E+00
11 THF	7.4808E-04	5.6776E-12	5.6776E-12	1.7145E-01	0.0000E+00
12 CLBENZEN	6.7301E-07	8.4521E-11	8.4521E-11	1.1753E-03	0.0000E+00
13 WATER	9.9432E-01	1.0000E+00	1.0000E+00	2.2910E-03	1.0000E+00
TOTALS, LBS/HR	78.9879	136825.6406	136825.6406	27.5603	1853.2030
TEMPERATURE, DEG C	25.0000	102.3890	18.1603	25.0000	105.0000
PRESSURE, PSIA	16.0000	16.0000	15.0000	15.0000	16.0000
H, MM PCU /HR	0.0020	14.0138	2.4857	0.0002	1.1879
MOLECULAR WEIGHT	18.0976	18.0150	18.0150	99.7579	18.0150
MOLE FRACT LIQUID	1.0000	1.0000	1.0000	1.0000	0.0000
RECYCLE CONVERGENCE	0.0000	0.0000	0.0000	0.0000	0.0000

Attachment B-14

STREAM SUMMARY

STREAM ID	1	2	3	5	6	8	9
NAME	COLD FEED	FEED+RECYCLE	COL FEED LIQ	STPR OVHD	LIVE STEAM	ORG PHASE	WATER PHASE
PHASE	LIQUID	LIQUID	LIQUID	VAPOR	VAPOR	LIQUID	LIQUID
FROM UNIT/TRAY	0/ 0	1/ 0	2/ 0	4/ 1	3/ 0	5/ 0	5/ 0
TO UNIT/TRAY	1/ 0	2/ 0	4/ 1	5/ 0	4/ 5	8/ 0	6/ 0
FROM STREAM							
LB MOLS/HR	7492.500	7496.864	7496.864	4.641	102.870	0.276	4.365
TEMPERATURE, DEG C	10.000	10.009	95.389	98.841	102.390	25.000	25.000
PRESSURE, PSIA	16.000	16.000	15.000	15.000	16.000	15.000	15.000
H, MM PCU /HR	1.351	1.353	12.881	0.053	1.186	0.000	0.002
M PCU /LB MOLE	0.180	0.180	1.718	11.433	11.526	0.788	0.451
PCU /LB	10.009	10.017	95.361	497.972	639.786	7.895	24.902
MOLE FRACT LIQUID	1.00000	1.00000	1.00000	0.00000	0.00000	1.00000	1.00000
M LBS/HR	135.000	135.079	135.079	0.107	1.853	0.028	0.079
MOLECULAR WEIGHT	18.018	18.018	18.018	22.959	18.015	99.758	18.098
STD LIQ FT3/HR	2167.850	2169.117	2169.117	1.643	29.760	0.376	1.268
DEG API	10.059	10.059	10.059	4.443	10.063	-11.391	9.968
SP GR	0.9996	0.9996	0.9996	1.0409	0.9996	1.1781	1.0002
LBS/FT3	62.2737	62.2737	62.2737	64.8461	62.2718	73.3951	62.3136
UOP K	8.761	8.761	8.761	8.386	8.762	7.327	8.755
REDUCED TEMP	0.437	0.437	0.569	0.579	0.580	0.530	0.461
REDUCED PRESS	0.005	0.005	0.005	0.005	0.005	0.019	0.005
ACENTRIC FACTOR	0.348	0.348	0.348	0.342	0.348	0.243	0.348
VAPOR							
M LBS/HR	0.000	0.000	0.000	0.107	1.853	0.000	0.000
MOLECULAR WEIGHT	0.000	0.000	0.000	22.959	18.015	0.000	0.000
STD LIQ FT3/HR	0.000	0.000	0.000	1.643	29.760	0.000	0.000
STD M FT3/HR	0.000	0.000	0.000	1.761	39.038	0.000	0.000
ACTUAL M FT3/HR	0.000	0.000	0.000	2.202	46.215	0.000	0.000
LBS/M FT3	0.000	0.000	0.000	48.384	40.100	0.000	0.000
Z	0.00000	0.00000	0.00000	0.99059	0.99093	0.00000	0.00000
COND,BTU/HR.FT.F	0.0000E+00	0.0000E+00	0.0000E+00	1.3595E-02	1.4420E-02	0.0000E+00	0.0000E+00
VISC,CP	0.0000E+00	0.0000E+00	0.0000E+00	1.1959E-02	1.2211E-02	0.0000E+00	0.0000E+00
CP,PCU /LB MOL C	0.0000E+00	0.0000E+00	0.0000E+00	9.0808E+00	8.2055E+00	0.0000E+00	0.0000E+00
LIQUID							
M LBS/HR	135.000	135.079	135.079	0.000	0.000	0.028	0.079
MOLECULAR WEIGHT	18.018	18.018	18.018	0.000	0.000	99.758	18.098
STD LIQ FT3/HR	2167.850	2169.117	2169.117	0.000	0.000	0.376	1.268
ACTUAL GPM	269.5978	269.7560	280.5803	0.0000	0.0000	0.0473	0.1583
FT3/HR	2162.405	2163.674	2250.493	0.000	0.000	0.379	1.270
LBS/FT3	62.430	62.430	60.022	0.000	0.000	72.673	62.203
Z	0.00084	0.00084	0.00063	0.00000	0.00000	0.00358	0.00076
COND,BTU/HR.FT.F	3.3960E-01	3.3960E-01	3.8936E-01	0.0000E+00	0.0000E+00	7.2524E-02	3.3383E-01
VISC,CP	1.2988E+00	1.2985E+00	2.9319E-01	0.0000E+00	0.0000E+00	6.1365E-01	8.8974E-01
CP,PCU /LB MOL C	1.8019E+01	1.8019E+01	1.8115E+01	0.0000E+00	0.0000E+00	3.1961E+01	1.8000E+01
SURF,DYNES/CM	7.3579E+01	7.3578E+01	6.0171E+01	0.0000E+00	0.0000E+00	2.9169E+01	7.1650E+01

STD LIQUID CONDITIONS ARE 60.0 DEG F AND 14.696 PSIA
STD VAPOR VOLUME IS 379.490 FT3/LB MOLE

Attachment B-15

STREAM SUMMARY

STREAM ID	10	11	12	15	6A
NAME	WATER PHASE	COL BOTTOMS	STRPPD WATER	CONC ORGANIC	STEAM GUESS
PHASE	LIQUID	LIQUID	LIQUID	LIQUID	VAPOR
FROM UNIT/TRAY	6/ 0	4/ 5	2/ 0	8/ 0	0/ 0
TO UNIT/TRAY	1/ 0	2/ 0	0/ 0	0/ 0	3/ 0
FROM STREAM					
LB MOLS/HR	4.365	7595.094	7595.094	0.276	102.870
TEMPERATURE, DEG C	25.000	102.389	18.160	25.000	105.000
PRESSURE, PSIA	16.000	16.000	15.000	15.000	16.000
H, MM PCU /HR	0.002	14.014	2.486	0.000	1.188
M PCU /LB MOLE	0.451	1.845	0.327	0.788	11.547
PCU /LB	24.902	102.421	18.167	7.895	640.977
MOLE FRACT LIQUID	1.00000	1.00000	1.00000	1.00000	0.00000
M LBS/HR	0.079	136.826	136.826	0.028	1.853
MOLECULAR WEIGHT	18.098	18.015	18.015	99.758	18.015
STD LIQ FT3/HR	1.268	2197.234	2197.234	0.376	29.760
DEG API	9.968	10.063	10.063	-11.391	10.063
SP GR	1.0002	0.9996	0.9996	1.1781	0.9996
LBS/FT3	62.3136	62.2718	62.2718	73.3951	62.2718
UOP K	8.755	8.762	8.762	7.327	8.762
REDUCED TEMP	0.461	0.580	0.450	0.530	0.584
REDUCED PRESS	0.005	0.005	0.005	0.019	0.005
ACENTRIC FACTOR	0.348	0.348	0.348	0.243	0.348
VAPOR					
M LBS/HR	0.000	0.000	0.000	0.000	1.853
MOLECULAR WEIGHT	0.000	0.000	0.000	0.000	18.015
STD LIQ FT3/HR	0.000	0.000	0.000	0.000	29.760
STD M FT3/HR	0.000	0.000	0.000	0.000	39.038
ACTUAL M FT3/HR	0.000	0.000	0.000	0.000	46.544
LBS/M FT3	0.000	0.000	0.000	0.000	39.816
Z	0.00000	0.00000	0.00000	0.00000	0.99110
COND,BTU/HR.FT.F	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.4535E-02
VISC,CP	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2317E-02
CP,PCU /LB MOL C	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	8.2116E+00
LIQUID					
M LBS/HR	0.079	136.826	136.826	0.028	0.000
MOLECULAR WEIGHT	18.098	18.015	18.015	99.758	0.000
STD LIQ FT3/HR	1.268	2197.234	2197.234	0.376	0.000
ACTUAL GPM	0.1583	285.6217	273.8477	0.0473	0.0000
FT3/HR	1.270	2290.930	2196.492	0.379	0.000
LBS/FT3	62.203	59.725	62.293	72.673	0.000
Z	0.00081	0.00067	0.00077	0.00358	0.00000
COND,BTU/HR.FT.F	3.3383E-01	3.9288E-01	3.4727E-01	7.2524E-02	0.0000E+00
VISC,CP	8.8974E-01	2.7223E-01	1.0477E+00	6.1365E-01	0.0000E+00
CP,PCU /LB MOL C	1.8000E+01	1.8154E+01	1.7998E+01	3.1961E+01	0.0000E+00
SURF,DYNES/CM	7.1650E+01	5.8823E+01	7.2585E+01	2.9169E+01	0.0000E+00

STD LIQUID CONDITIONS ARE 60.0 DEG F AND 14.696 PSIA
STD VAPOR VOLUME IS 379.490 FT3/LB MOLE

Attachment B-16

ATTACHMENT C

EXPERIMENTAL HENRY'S LAW CONSTANT DETERMINATION

The groundwater at the Niagara Falls Plant contains twelve organic contaminants, all of limited solubility in water. Effective design of a stripping column to remove these organics requires knowledge of the binary vapor-liquid-equilibria (VLE) for each organic-water pair. A convenient form of the VLE is the Henry's Law Constant which can be calculated from solubility data.

For three of the twelve Niagara Falls groundwater contaminants (tetrahydrothiophene, 1,4-dichlorobutane, and 2-methylfuran), no solubility data were available. The Engineering Test Center (ETC) was commissioned to measure these solubilities and/or Henry's Law Constants. The ETC measured these Henry's Law Constants directly using a procedure similar to that described by Nicholson, et al.: "Henry's Law Constants for the Trihalomethane: Effects of Water Composition and Temperature", Environmental Science Technology, Vol. 18, No. 7, 1984, p.518.

To validate the ETC procedure, a control compound (chloroform) was run for which solubility in water and Henry's Law Constant values are known. Agreement to 10% of the known values was reached. The ETC results are as follows:

Compound	Temperature °C	Henry's Law Constant $m^3 \cdot atm \cdot gmol^{-1}$	Henry's Law Constant $atm \cdot mol\ frac^{-1}$
0.199 wt% chloroform	25.0	3.60×10^{-3}*	193.7
0.0195 wt% chloroform	25.5	3.57×10^{-3}	197.6
0.196 wt% tetrahydrothiophene	28.0	0.308×10^{-3}	17.03
0.196 wt% tetrahydrothiophene	45.0	0.741×10^{-3}	40.73
0.046 wt% 1,4-dichlorobutane	25.5	0.680×10^{-3}	37.6
0.046 wt% 1,4-dichlorobutane	45.0	1.84×10^{-3}	101.14
0.100 wt% 2-methylfuran	28.0	6.44×10^{-3}	356.17
0.100 wt% 2-methylfuran	45.1	13.0×10^{-3}	714.47

* A published literature value for chloroform at 25°C is 3.9×10^{-3} $m^3 \cdot atm \cdot gmol^{-1}$.

E. Volatile Compounds

Pollutants	BAT/BPJ 30-day Ave. (mg/l)	BAT/BPJ Daily Max. (mg/l)	BAT/BPJ % Reduction(2)	Technologies Used
1. 3V-Benzene	N/A	0.01 (0.034(1))	N/A	1,4 or 3,4
	N/A	0.25	N/A	1,5
	N/A	0.04 (0.05(1))	90	6
2. 6V-Carbon Tetrachloride	N/A	0.01	N/A	3,4
3. 7V-Chlorobenzene	N/A	0.01	N/A	1,4 or 1,3,4
	N/A	0.25	N/A	1,5
	N/A	0.04	95	6
4. 19V-Ethylbenzene	N/A	0.01	N/A	1,3,4
	N/A	0.65	N/A	1,5
	N/A	0.04	85	6
5. 21V-Methyl Chloride	4.5	7.2	N/A	1,5
	N/A	1.0	N/A	6
6. 22V-Methylene Chloride	12.5	25.0	N/A	5
	N/A	2.0	N/A	6
7. 24V-Tetrachloroethylene	N/A	0.01	N/A	1,4 or 1,3,4
	N/A	0.4	N/A	5
	N/A	1.8	85	6
8. 25V-Toluene	N/A	0.01	N/A	4 or 1,4 or 5,4
	N/A	0.5	N/A	5 or 1,5
	N/A	0.2	90	6
9. 27V-1,1,1-Trichloroethane	N/A	0.01	N/A	4 or 5,4
	N/A	0.5	90	5 or 1,5
	N/A	3.5	N/A	6
10. 29V-Trichloroethylene	N/A	0.01	N/A	4 or 1, 4 or 1,3,4 or 1,5,
	N/A	0.1	90	5 or 1,5
	N/A	0.35	85	6

(1) - Promulgated effluent guidelines for Iron & Steel Category, By-Product Coke Subcategory.

(2) - Where % reductions and Daily Max. limits are both given, the less stringent will apply.

ATTACHMENT D