ORIGINAL

ENVIRONMENTAL ASSESSMENT

for the proposed

INCREASE IN TOTAL DISSOLVED SOLIDS DISCHARGE

from the

THORN CREEK BASIN SANITARY DISTRICT

Prepared by:

James E. Huff, P.E.
Sean D. LaDieu, P.E.
November, 2000

TABLE OF CONTENTS

Page

1. INTRODUCTION 1-1

2. BACKGROUND INFORMATION 2-1
   - 2.1 Site Description 2-1
   - 2.2 Thorn Creek Description 2-3
   - 2.3 Description of Thorn Creek Basin Wastewater Treatment Plant 2-5
   - 2.4 Ground Water and Softening Activities 2-6
   - 2.5 Description of Rhodia 2-8
   - 2.6 Description of Proposed Silica Process 2-8
   - 2.7 Applicable Regulations 2-11
   - 2.8 Previously Obtained Adjusted Standard for Deer Creek and a Portion of Thorn Creek 2-13

3. THORN CREEK BASIN SANITARY DISTRICT EXISTING CONDITIONS 3-1
   - 3.1 Water Quality Database 3-1
   - 3.2 Influent and Effluent Quality 3-1
   - 3.3 Existing Rhodia Silica Plant Effluent Quality 3-7
   - 3.4 Effect of Elevated TDS and Sulfates on the Thorn Creek Basin WWTP 3-7
     - 3.4.1 Nitrification 3-7
     - 3.4.2 Anaerobic Digestion 3-9
     - 3.4.3 Biomass Solids Separation 3-13

4. THORN CREEK AND TRIBUTARY WATER QUALITY 4-1
   - 4.1 Introduction 4-1
   - 4.2 Thorn Creek Monitoring Database 4-1
   - 4.3 Tributary Monitoring Database 4-4
   - 4.4 Thorn Creek and Tributary Flow Rates 4-5
   - 4.5 Water Quality Data 4-9

5. TOXICITY OF TOTAL DISSOLVED SOLIDS AND SODIUM SULFATE 5-1
   - 5.1 Introduction 5-1
   - 5.2 Acute Toxicity of TDS 5-1
   - 5.3 Acute Toxicity of Sulfate 5-6
   - 5.4 Chronic Toxicity 5-11

6. BIOLOGICAL QUALITY OF THORN CREEK LITTLE CALUMET RIVER 6-1
   - 6.1 Introduction 6-1
   - 6.2 Sampling Locations 6-3

6.3 Previous Studies 6-5
6.4 Methodology 6-11
6.4.1 Macroinvertebrate Sampling 6-11
6.4.2 Fish Sampling 6-13
6.4.3 Water Samples 6-14
6.5 Benthic Macroinvertebrate Results 6-14
6.6 Fish Electroshocking Results 6-18
6.7 Water Quality Results 6-21
6.8 Biological Quality of Little Calumet River 6-22
6.9 Discussion 6-23

7. PROJECTED IMPACT ON THORN CREEK AND THE LITTLE CALUMET RIVER FROM PROPOSED EXPANSION 7-1
7.1 Introduction 7-1
7.2 Flow Curves for Stream Reaches 7-1
7.3 Projected TDS Levels 7-4
7.3.1 TDS Frequency Distribution 7-4
7.3.2 Daily Maximum TDS Levels 7-6
7.4 Projected Sulfate Levels 7-11
7.4.1 Annual Average Sulfate Levels 7-11
7.4.2 Daily Maximum Sulfate Levels 7-15
7.5 Crop Irrigation and Ground Water Impacts 7-17
7.6 Calumet-Sag Channel 7-17
7.7 Model Sensitivity 7-17
7.8 Summary 7-18

8. SUMMARY AND CONCLUSION 8-1

REFERENCES R-1

LIST OF TABLES

TABLE 2-1: THORN CREEK BASIN SANITARY DISTRICT, NPDES EFFLUENT LIMITS 2-1

TABLE 2-2: THORN CREEK RIVER MILES 2-5

TABLE 2-3: EXISTING AND PROJECTED LOADING FROM RHODIA SILICA PLANT 2-9

TABLE 2-4 ADJUSTED STANDARDS FOR THORN CREEK BASIN SANITARY DISTRICT 2-11

TABLE 3-1: MONTHLY AVERAGE EFFLUENT FLOW RATES, THORN CREEK BASIN SANITARY DISTRICT WWTP EFFLUENT 3-2

TABLE 3-2: INFLUENT AND EFFLUENT TDS LEVELS BEFORE THE SILICA PLANT IS ONLINE 3-3

TABLE 3-3: THORN CREEK BASIN SANITARY DISTRICT EFFLUENT TOTAL DISSOLVED SOLIDS AND SULFATES AFTER SILICA PLANT IS ONLINE 3-4

TABLE 3-4: RHODIA EFFLUENT DATA, TOTAL DISSOLVED SOLIDS AND SULFATE 3-8

TABLE 3-5: ANAEROBIC DIGESTER GAS ANALYSIS FOR HYDROGEN SULFIDE 3-11

TABLE 4-1: SUMMARY OF THORN CREEK AND TRIBUTARY GAGING STATIONS 4-3

TABLE 4-2: TRIBUTARY MONITORING LOCATIONS 4-4

TABLE 4-3: USGS GAGING STATIONS AVERAGE FLOW RATES, mgd 4-6

TABLE 4-4: SUMMARY OF FLOW DATA FOR THORN CREEK USGS STATIONS 4-5

TABLE 4-5: TDS AND SULFATE DATA- THORN CREEK AT JOE ORR RD 4-10

TABLE 4-6: INORGANICS AT USGS STATION 05536275 AT THORNTON AFTER RHODIA SILICA PLANT IS ONLINE 4-11

TABLE 5-1: ACUTE TOXICITY OF SODIUM SULFATE TO FISH 5-6

TABLE 5-2: ACUTE TOXICITY OF SULFATE TO FISH 5-7

TABLE 5-3: CHRONIC TOXICITY TESTS BASED ON PROJECTED MAXIMUM SULFATE LEVEL OF 1,350 mg/L 5-11

TABLE 6-1: SUMMARY OF USE SUPPORT ASSESSMENT CRITERIA FOR ILLINOIS STREAMS 6-3

TABLE 6-2: STREAM ECOLOGY 6-6

TABLE 6-3: HISTORICAL NUMBER OF BENTHIC ORGANISMS BY YEAR 6-8

TABLE 6-4: HISTORICAL NUMBER OF BENTHIC SPECIES BY YEAR 6-9

TABLE 6-5: HISTORICAL MBI VALUES BY YEAR 6-10

TABLE 6-6: BENTHIC MACROINVERTEBRATE SAMPLE COLLECTION 6-15

TABLE 6-7: FISH SURVEY RESULTS 6-20

TABLE 6-8: SUMMARY OF BENTHIC MACROINVERTEBRATES SAMPLE COLLECTION 6-24

TABLE 6-9: COMPARISON OF MBI SAMPLING RESULTS 6-26

TABLE 7-1: PROJECTED MAXIMUM THORN CREEK TDS LEVELS 7-10

TABLE 7-2: PROJECTED MAXIMUM THORN CREEK SULFATE LEVELS 7-15

TABLE 7-3: SUMMARY OF WATER QUALITY MODELING RESULTS PREDICTED PEAK CONCENTRATIONS, mg/L 7-19

TABLE 8-1: CURRENT REQUESTED WATER QUALITY STANDARDS 8-3

LIST OF FIGURES

FIGURE 2-1: SITE LOCATION MAP 2-2

FIGURE 2-2: THORN CREEK SYSTEM 2-4

FIGURE 2-3: FLOW DIAGRAM THORN CREEK BASIN SANITARY DISTRICT 2-7

FIGURE 2-4: BLOCK FLOW DIAGRAM SILICA PRODUCTION 2-10

FIGURE 4-1: MONITORING LOCATIONS 4-2

FIGURE 4-2: REACH #1—PER CENT TIME FLOW RATE IS NOT EXCEEDED 4-8

FIGURE 5-1: ACUTE TOXICITY CURVE FOR CHANNEL CATFISH ($TDS\text{-}SO_4^{=}$) 5-3

FIGURE 5-2: ACUTE TOXICITY CURVE FOR LARGEMOUTH BASS ($TDS\text{-}SO_4^{=}$) 5-4

FIGURE 5-3: ACUTE TOXICITY CURVE FOR BLUEGILL ($TDS\text{-}SO_4^{=}$) 5-5

FIGURE 5-4: ACUTE TOXICITY CURVE FOR CHANNEL CATFISH ($SO_4^{=}$) 5-8

FIGURE 5-5: ACUTE TOXICITY CURVE FOR LARGEMOUTH BASS ($SO_4^{=}$) 5-9

FIGURE 5-6: ACUTE TOXICITY CURVE FOR BLUEGILL ($SO_4^{=}$) 5-10

FIGURE 6-1: BIOLOGICAL STREAMS SAMPLING LOCATION MAP 6-4

FIGURE 7-1: PERCENT TIME FLOW RATES ARE BELOW 7-3

FIGURE 7-2: TDS FREQUENCY DISTRIBUTION - REACH #1 7-5

FIGURE 7-3: TDS FREQUENCY DISTRIBUTION - REACH #2 7-7

FIGURE 7-4: TDS FREQUENCY DISTRIBUTION - REACH #3 7-8

FIGURE 7-5: TDS FREQUENCY DISTRIBUTION - REACH #4 7-9

FIGURE 7-6: SULFATE FREQUENCY DISTRIBUTION - REACH #1 7-12

FIGURE 7-7: SULFATE FREQUENCY DISTRIBUTION - REACH #2 7-13

FIGURE 7-8: SULFATE FREQUENCY DISTRIBUTION - REACH #3 7-14

FIGURE 7-9: SULFATE FREQUENCY DISTRIBUTION - REACH #4 7-16

APPENDICES

A. Thorn Creek Basin Sanitary District and Silica Plant Data
B. Calculations and Mass Balances
C. Thorn Creek Data
D. Chronic Toxicity Bioassay
E. Benthic and Fish Data
F. Model Output

LIST OF ACRONYMS

7Q10	7-day, 10-year low flow
AS	Adjusted Standard
BSC	Biological Stream Characterization
CBOD	Carbonaceous Biological Oxygen Demand
CIWC	Consumers Illinois Water Company
District	Thorn Creek Basin Sanitary District
FeS	Iron Sulfide
F:M	Food-to-Microorganism
FRSS	Facility Related Stream Surveys
IBI	Index of Biotic Integrity
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
ISWS	Illinois State Water Survey
lbs/day	pounds per day
LC_{50}	Median Lethal Concentration
LOEC	Lowest Observed Effect Concentration
MBI	Macroinvertebrate Biotic Index
mgd	million gallons per day
mg/L	milligrams per liter
MIC	Microbiologically Influenced Corrosion
NaCl	Sodium Chloride
NOAEL	No Observed Acute Effect Level
NOEC	No Observed Effect Concentration
NPDES	National Pollution Discharge Elimination System
ppm(V)	parts per million by volume
SO_4	Sulfate
SRB	Sulfate Reducing Bacteria
TCBSD	Thorn Creek Basin Sanitary District
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
USGS	United States Geological Survey
WQ	Water Quality
WWTP	Wastewater Treatment Plant

1. INTRODUCTION

The Thorn Creek Basin Sanitary District (District) operates a municipal wastewater treatment plant (WWTP) in Chicago Heights, Illinois. The WWTP has a design average flow of 15.9 mgd and a design maximum flow of 40.25 mgd. The District serves Chicago Heights, Park Forest, Homewood, South Chicago Heights, Steger and Crete communities. The combined population served by the District is over 100,000 people. Effluent from the treatment plant is discharged into Thorn Creek, the largest subbasin of the Little Calumet River System (Dames & Moore, 1982).

The municipal service area contains numerous industrial users, including Rhodia, Inc. (Rhodia), formerly known as Rhône-Poulenc Basic Chemical Company, located in Chicago Heights, Illinois. Rhodia is a manufacturer of inorganic chemicals, primarily phosphate products, sodium bicarbonate and silica. The Rhodia silica plant currently discharges approximately 840,000 gallons per day (0.84 mgd) based on an average month to the District's sanitary sewer.[1]

The existing silica plant went on-line in October of 1995. Rhodia has proposed an expansion to the existing silica plant at its Chicago Heights plant as it is ideally located relative to both the raw materials necessary for the silica process and the receiving market. The silica manufacturing process generates sodium sulfate in an aqueous waste stream. Rhodia has approached the Thorn Creek Basin Sanitary District regarding the feasibility of the District accepting additional dissolved solids loading attributable to the additional sodium sulfate that would be generated.

This environmental assessment study was undertaken to determine the overall impact the additional dissolved solids will have on the receiving stream, Thorn Creek as well as the WWTP. Prior to addressing any potential environmental impact, background information is presented on the process, existing total dissolved solids (TDS) and sulfate loadings, and existing water quality. The incremental change in TDS and sulfate in the receiving stream due to the silica process are then modeled and the toxicity levels of both parameters are discussed, including biomonitoring results using water from Thorn Creek. This report will serve as a basis for defining the projected environmental impact should the proposed expansion proceed.

[1] This includes approximately 240,000 gallons per day from phosphate production and 600,000 gallons per day from silica production. Silica discharges range from 100,000 gallons per day to 1,000,000 gallons per day depending on silica on-stream time.

3. THORN CREEK BASIN SANITARY DISTRICT EXISTING CONDITONS

3.1 Water Quality Database

The Thorn Creek Basin WWTP monitors the influent and effluent quality as required by its NPDES permit. The parameters monitored are as follows:

Parameter	Influent	Effluent
Flow	X	X
pH		X
Suspended Solids	X	X
$CBOD_5$	X	X
Chlorine Residual		X
Fecal Coliform		X
Ammonia Nitrogen		X

These parameters are reported as monthly averages and daily maximums on the Discharge Monitoring Reports. In addition, the District has monitored total dissolved solids (TDS) on both the influent and effluent and sulfates on the effluent. The data generated on TDS and sulfates are presented in the Section 3.2.

3.2 Influent and Effluent Quality

The District monitors the plant effluent flow rates on a daily basis. Daily flow rates from April 21, 1996 to June 24, 1999 are provided in Appendix A. The monthly average flow data for the period of May 1996 to May 1999 are summarized in Table 3-1. During this period, 36 days were recorded with flow rates over 40.25 mgd. These excess flow days range from 40.33 mgd to 84.41 mgd.

TABLE 3-1

MONTHLY AVERAGE EFFLUENT FLOW RATES
THORN CREEK BASIN SANITARY DISTRICT WWTP EFFLUENT

Month	Avg. Flow, mgd
May- 1996	28.16
June	19.96
July	18.91
August	12.11
September	11.84
October	12.36
November	13.65
December	17.10
January- 1997	17.01
February	27.11
March	19.22
April	14.75
May	15.73
June	16.29
July	12.16
August	14.71
September	10.87
October	11.11
November	11.39
December	14.12

Month	Avg. Flow, mgd
January- 1998	21.09
February	21.70
March	31.70
April	22.20
May	19.22
June	15.01
July	14.07
August	15.57
September	11.89
October	11.33
November	11.71
December	12.04
January –1999	20.71
February	15.64
March	17.91
April	26.81
May	16.42
June 1-24	17.68
Overall Average	**16.75**

Influent and effluent TDS data generated prior to the silica plant going online are tabulated in Table 3-2. The average TDS influent concentration is 778 mg/L for the months of November 1992 through April 1993, with a range of 599 mg/L to 1,104 mg/L. The average effluent TDS concentration for the same time period is 765 mg/L with a range of 574 mg/L to 1,031 mg/L. As would be expected, there is little change in TDS in comparison of the influent and effluent concentrations.

TABLE 3-2
INFLUENT AND EFFLUENT TDS LEVELS
BEFORE THE SILICA PLANT IS ONLINE

Date	Influent, mg/L	Effluent, mg/L
Nov. 3, 1992	599	574
Nov. 10, 1993	616	647
Nov. 17, 1992	759	750
Nov. 24, 1992	637	622
Dec. 1, 1992	845	786
Dec. 8, 1992	775	767
Dec. 15, 1992	772	769
Dec. 22, 1992	714	752
Dec. 29, 1992	683	721
Jan. 13 1993	953	904
Feb. 3, 1993	800	763
Mar. 2, 1993	1,104	1,031
Apr. 7, 1993	852	862
Average	**778**	**765**

Since the existing Rhodia silica plant went online in October 1995, the District has collected TDS and sulfate data from its effluent. These data are tabulated in Table 3-3 and include data from January 8, 1997 through July 22, 1999. During this period, the average TDS effluent has been 1,210 mg/L, with a minimum and maximum of 152 mg/L and 1,921 mg/L, respectively.

The average effluent sulfate level for the same period has been 496 mg/L with a range of 45 to 1,168 mg/L. The minimum values reflect periods when the silica production was shut down and high flow periods.

Historically, TDS levels have decreased with the increased number of communities using Lake Michigan for the water supply. TDS data from October 1980 to June 1983 obtained from the District's records indicate an average TDS concentration of 1,559 mg/L occurred in the effluent during this period and are summarized in Appendix A. This was during a period when 100 percent of the communities utilized well water. Sixty percent of the communities are currently using Lake Michigan for their water supply. The significance of this is that historical levels of TDS in the

TABLE 3-3

THORN CREEK BASIN SANITARY DISTRICT EFFLUENT
TOTAL DISSOLVED SOLIDS AND SULFATES
AFTER SILICA PLANT IS ONLINE

Date	TDS	Sulfate
01/08/1997	845	174
01/15/1997	1223	535
01/15/1997		573
01/22/1997	824	124
01/22/1997		223 c
01/29/1997	1411	543
01/29/1997		500
01/30/1997	1342 c	
02/05/1997	803	66
02/05/1997		279 c
02/06/1997		66
02/12/1997	1451	499 c
02/12/1997		674
02/20/1997	953	148
02/26/1997	1212	324 c
02/26/1997	986 c	404
03/06/1997	1193	404
03/12/1997	1361	570
03/12/1997		565 c
03/19/1997	720	205
03/19/1997		233 c
03/26/1997	1294	522
03/26/1997		298 c
03/27/1997	944 c	
04/02/1997	803	211
04/02/1997		206 c
04/10/1997	824	286
04/16/1997	633	222
04/23/1997	1218	255
04/23/1997		537 c
05/01/1997	1116	394
05/07/1997	1463	721
05/14/1997		223 c
05/15/1997	743	242
05/21/1997	1187	540
05/21/1997		521 c
05/26/1997	770 c	
05/28/1997	690	173
05/28/1997		212 c
06/04/1997	1451	770
06/13/1997	759	251
06/18/1997	1151	514
06/23/1997	700	172
06/23/1997	773 c	
07/03/1997	772	205
07/09/1997	556	138
07/16/1997	1534	676
07/22/1997	602	136
07/30/1997	1379	629
07/30/1997	1339 c	
08/08/1997	1371	644
08/13/1997	1019	434
08/20/1997	1153	480
08/27/1997	1315	580
08/27/1997	1303 c	
09/03/1997	1169	435
09/10/1997	1630	703
09/19/1997		395
09/23/1997	1461	461
10/09/1997	804	223
10/16/1997	1501	634
10/22/1997	1614	709
10/29/1997	1331	644
11/05/1997	1131	516
11/12/1997	1682	689
11/19/1997	960	363
11/23/1997	1425 c	
11/25/1997	1229	588
12/03/1997	1228	582
12/10/1997	1315	490
12/17/1997	1507	456
12/23/1997	1092	436
12/30/1997	1163	445
01/06/1998	799	234
01/14/1998	1184	458
01/21/1998	1265	559
01/28/1998	1537	586
01/28/1998	1512 c	
02/04/1998	1131	442
02/10/1998	1484 c	613 c
02/11/1998	964	358
02/17/1998	735 c	198 c
02/18/1998	727	255
02/24/1998	1173 c	477 c

TABLE 3-3

THORN CREEK BASIN SANITARY DISTRICT EFFLUENT
TOTAL DISSOLVED SOLIDS AND SULFATES
AFTER SILICA PLANT IS ONLINE

Date	TDS	Sulfate
02/25/1998	1075	553
03/04/1998	1479	631
03/05/1998	1358 c	552 c
03/11/1998	860 c	137 c
03/12/1998	860	230
03/18/1998	432 c	156 c
03/19/1998	713	282
03/24/1998	1322 c	502 c
03/25/1998	1256	489
03/31/1998	1325	540
03/31/1998	882 c	491 c
04/01/1998	878	369
04/07/1998	1090 c	
04/08/1998	907	355
04/14/1998	848 c	234 c
04/15/1998	1104	424
04/21/1998		341 c
04/22/1998	897	354
04/28/1998	1159 c	519 c
04/29/1998	705	330
05/05/1998	1421 c	
05/06/1998	1130	469
05/12/1998	1370	648
05/12/1998	1366 c	581 c
05/19/1998	1083 c	446 c
05/20/1998	1324	527
05/25/1998	1665 c	673 c
05/27/1998	1643	
06/04/1998	1448	778 c
06/04/1998	1473 c	751
06/09/1998	1365 c	609 c
06/10/1998	1313	649
06/16/1998	1397 c	646 c
06/16/1998		670
06/23/1998	1554 c	750 c
06/25/1998	1530	740
06/30/1998	1360 c	614 c
07/01/1998	1448	600
07/07/1998	934 c	
07/08/1998	937	340
07/14/1998	1402 c	427 c
07/15/1998	1705	760
07/20/1998	1029 c	375 c
07/21/1998	1348	591
07/28/1998	1357 c	
07/29/1998	1383	411
08/04/1998	427 c	228 c
08/05/1998	554	116
08/11/1998	1278 c	525 c
08/12/1998	1179	560
08/18/1998	1612 c	
08/19/1998	1332	473
08/25/1998	817 c	265 c
08/26/1998	1261	
09/01/1998	997 c	
09/02/1998	1281	
09/08/1998	1315 c	504 c
09/09/1998	1371	651
09/15/1998	1529 c	758 c
09/16/1998		787
09/22/1998	837 c	206 c
09/23/1998	728	192
09/29/1998	963 c	288 c
09/30/1998	1292	448
10/06/1998	1546 c	782 c
10/07/1998	1535	576
10/13/1998	1609 c	706 c
10/14/1998	1714	
10/20/1998	1793 c	791 c
10/21/1998	152	681
10/27/1998	1256 c	563 c
10/28/1998	816	394
11/03/1998	1625 c	603 c
11/04/1998	1345	699
11/09/1998	1691 c	799 c
11/10/1998	1086	751
11/16/1998	1639 c	640 c
11/17/1998	1347	650
11/24/1998	1921	958
11/24/1998	1872 c	820 c
12/01/1998	1759 c	589 c
12/02/1998	1750	744
12/08/1998	820 c	217 c
12/09/1998	855	210

TABLE 3-3

THORN CREEK BASIN SANITARY DISTRICT EFFLUENT
TOTAL DISSOLVED SOLIDS AND SULFATES
AFTER SILICA PLANT IS ONLINE

Date	TDS	Sulfate
12/15/1998		464 c
12/16/1998	1479	399
12/21/1998	1577 c	784 c
12/22/1998	1448	684
12/29/1998	1539 c	819 c
12/30/1998	1834	702
01/05/1999	1169 c	847 c
01/06/1999	1011	631
01/12/1999	1217 c	785 c
01/13/1999	1380	
01/19/1999	1559 c	528 c
01/20/1999	1634	661
01/26/1999	1231 c	453 c
01/27/1999	1366	533
02/02/1999	1254 c	498 c
02/03/1999	1168	589
02/09/1999	1426 c	639 c
02/10/1999	1517	708
02/16/1999	1244 c	530 c
02/17/1999	1327	680
02/23/1999	1673 c	858 c
02/24/1999	1682	818
03/02/1999	1092 c	
03/03/1999	1086	735
03/03/1999		780 c
03/09/1999	1318 c	590 c
03/10/1999	1580	691
03/17/1999	1166 c	223 c
03/18/1999	958	341
03/24/1999	1387 c	
03/25/1999	1424	
03/30/1999	1200 c	279 c
03/31/1999	1292	369
04/06/1999	1569 c	333 c
04/07/1999	1484	421
04/13/1999	1220 c	576 c
04/14/1999	1293	718
04/20/1999	1285 c	1002 c
04/21/1999	1249	1168
04/27/1999	917 c	961 c
04/28/1999	622	228
05/04/1999	1318 c	951 c
05/05/1999	1475	466
05/12/1999	755 c	83 c
05/12/1999	721	45
05/18/1999	1108 c	
05/19/1999	1231	434
05/25/1999	700 c	236 c
05/26/1999	1350	688
06/02/1999	756 c	256 c
06/03/1999	1014	417
06/08/1999	1030 c	480 c
06/09/1999	859	269
06/15/1999	1296 c	625 c
06/16/1999	1411	730
06/21/1999	1722 c	844 c
06/22/1999	1529	748
06/22/1999		
06/28/1999	1488 c	802 c
06/29/1999	1445	604
07/07/1999	842 c	255 c
07/08/1999	1310	
07/08/1999		
07/13/1999	1025 c	517 c
07/14/1999	823	289
07/21/1999	1574 c	
07/22/1999	1014	
Average	1210	496
Minimum	152	45
Maximum	1921	1168

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[TCB-FinalEffluent.xls]TDS

NOTE: "c" indicates a 24-hour composite sample

Thorn Creek exceed the current TDS effluent levels with the existing silica plant online.

3.3 Existing Rhodia Silica Plant Effluent Quality

Rhodia has collected TDS and sulfate samples from the silica plant sewer to the District, which is tabulated for the period of January 1997 to May 1999 in Table 3-4. Based on the data from January 1998 to May 1999, a period when the silica plant was operating at near capacity, the average TDS loading to the plant has been 65,800 lbs/day. This compares to the projected average TDS loading from the environmental assessment conducted in connection with the adjusted standard sought in AS94-7 of 83,100 lbs/day. The average sulfate loading to the District for the same period was 45,300 lbs/day. This compares to the projected loadings of 56,100 lbs/day in the earlier assessment.

3.4 Effect of Elevated TDS and Sulfates on the Thorn Creek Basin WWTP

3.4.1 Nitrification

The Thorn Creek Basin WWTP utilizes two stages of activated sludge to biologically treat the wastewater. The first stage of biological treatment occurs in the activated sludge process following the primary settling tanks. After the wastewater passes through the aeration tanks and secondary clarifiers, ammonia removal occurs in the second stage activated sludge process.

Bishop and Kinner (1981) reported that with an acclimation period, organic removals through biological treatment processes were the same with salinities up to 35,000 mg/L as with fresh water. However, shock loads of 12,000 mg/L TDS impaired the removal efficiency and biological growth. Nitrifying organisms tend to be more sensitive to changes in water chemistry. Hill and Gelman (1977) found that 16,500 mg/L TDS (as NaCl) inhibited nitrification in activated sludge systems. Ammonia removal rates at 16,500 mg/L TDS were only 25 percent of the rate on fresh water.

The projected TDS increase at the District's WWTP is significantly lower than the levels reported in the literature that were found to reduce biological treatment. Since the existing silica plant has gone online, the WWTP has operated with average effluent levels of 1,210 mg/L and levels as high as 1,921 mg/L, as indicated in Section 3.2 with no observable effect.

TABLE 3-4

RHODIA EFFLUENT DATA

TOTAL DISSOLVED SOLIDS and SULFATE

January 1997 to May 1999

Month	Flow, mgd	TDS, lbs/day		Sulfate, lbs/day	
		Monthly Avg.	Daily Max.	Monthly Avg.	Daily Max.
1997					
January	555589	28370	98954	34863	65729
February	591310	47658	99378	37469	65750
March	429734	40390	87857	29392	65106
April	419576	31808	88702	21647	65325
May	423213	44564	94391	30117	75815
June	411823	47659	107972	32971	71019
July	317994	31281	95345	25467	75680
August	415896	55760	79872	38574	58329
September	475801	40340	94426	26920	62564
October	515872	64200	97532	43628	61720
November	536760	57880	114334	36448	58721
December	486345	52044	90512	33628	61252
1998					
January	517786	49807	118893	34091	103640
February	543214	59287	96263	41002	70714
March	520481	60017	96879	40486	58779
April	551217	55699	96572	40975	65578
May	527735	66772	146853	43221	66670
June	625932	75701	96702	47154	69611
July	524860	58787	133208	37029	60216
August	498331	49354	78770	30058	51555
September	529624	56566	100601	40136	79328
October	660747	74338	99220	53456	75321
November	763847	79330	117963	59538	83485
December	709039	62602	114265	46091	73497
1999					
January	649012	69098	105168	54269	78375
February	658442	81001	122758	56929	79888
March	583437	64734	108831	48242	73778
April	644614	84951	112578	54375	65386
May	536855	70378	116516	43767	69747
Average 1997-1999	538796	57254	103838	40067	69399
Average 1998-1999	590893	65790	109532	45342	72092
Maximum 1997-1999	763847	84951	146853	59538	103640
Maximum 1998-1999	763847	84951	146853	59538	103640

a/ Speculative data as TDS was also 79328

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tab\[RhodEff.xls]Sheet1

3.4.2 Anaerobic Digestion

Toxicity of Sulfides to Anaerobic Sludges

Elevated sulfate concentrations have been identified as a cause of scaling in boilers and heat-exchangers, and can serve as a substrate for organisms implicated in bio-corrosion (Maree, et al., 1987).

Dissimilatory anaerobic sulfate reduction is a process where Sulfate Reducing Bacteria (SRB) use sulfate as an electron acceptor in the oxidation of organic matter (Eis, et al, 1983). Sulfur is in the 6^+ oxidation state in sulfate compounds. The reduction of sulfate yields hydrogen sulfide (Hilton and Oleszkiewicz, 1987), where sulfur is in the 2^- oxidation state. The blackening of wastewater sludge is frequently due to the reaction of hydrogen sulfide and iron to produce a black iron sulfide (FeS) compound (WEF Manual of Practice 8, 1992).

In an anaerobic reactor, *desulfovibrio* and *desulfotomaculum* are the two major genera of sulfate reducing bacteria (Hilton and Oleszkiewicz, 1987). Acid forming *desulfovibrio* SRB incompletely oxidize C_3 compounds to acetate and hydrogen in the reduction of S^{+6} to S^{-2}. *Desulfotomaculum* completely oxidize acetate to CO_2 in the reduction of S^{+6} to S^{-2}. Methanogens compete with SRB for acetate and hydrogen produced by the acetoclastic bacteria to form methane.

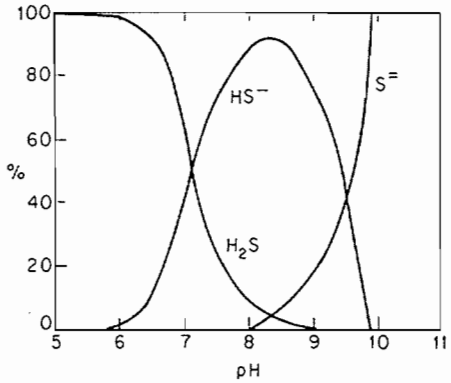
The H_2S evolved from biological activity ionizes in water and follows an equilibrium system:

$$H_2S \leftrightarrow H^+ + HS \leftrightarrow 2H^+ + S^{-2}$$

The equilibrium between H_2S and HS^- is pH dependent according to the following relationship:

$$H_2S = (1 + 1.02 * 10^{(pH - 7)})^{-1}$$

As depicted below, the percentage of un-ionized H_2S drops from 90 percent at pH 6.0 to 50 percent at pH 7.0 to 10 percent at pH 8.0. In anaerobic treatment, these variations are significant because the pH is maintained between 6.0 and 8.0. The optimal pH range for methanogens is between 6.8 and 7.5.



Effect of pH on hydrogen sulfide-sulfide equilibrium (10^{-3} molar solution, 32 mg H_2S/L)

Studies of sulfide toxicity to anaerobic cultures in treatment processes have shown complete inhibition of methanogenisis at concentrations of 200 mg/L un-ionized H_2S. A decrease in methane production can occur at a hydrogen sulfide concentration of 50 mg/L.

Using lactose as an electron donor, experiments were conducted on the effect of sulfide upon lactose utilization in the pH range of 6.0 to 8.0. Lactose was converted to acetic acid by acid forming bacteria. Results indicated that for sulfides at concentrations higher than 100 mg S^{-2}/L, lactose uptake was most rapid at pH 8.0 and lowest at pH 6.0 (Hilton and Oleszkiewicz, 1987). The induction period decreased with increased pH. At a sulfide concentration of 1,000 mg S^{-2}/L, lactose uptake was completed in ten hours at the pH of 8.0, and lactose uptake was not complete after 200 hours at pH 6.2. This experiment implies that sulfide toxicity can be reduced by increasing reactor pH (Hilton and Oleszkiewicz, 1987) or that un-ionized hydrogen sulfide is the toxic form.

Experiments also show that lactose utilization was inhibited specifically by H_2S concentration, and not total sulfide concentration (Hilton and Oleszkiewicz, 1987). For a total sulfide concentration of 500 mg/L, 100 percent lactose uptake was reported in eight hours. However, only 40 percent of lactose uptake was achieved for an H_2S concentration of 450 mg/L after ten hours. If glycolysis is inhibited, the complex carbohydrates fed to an anaerobic treatment reactor will not be broken down into a substrate that sulfate reducing bacteria and methanogens can derive energy from.

Microbiologically Influenced Corrosion (MIC)

Corrosion occurs in cooling systems when two dissimilar surfaces cause an electric potential. The oxidation of the metal is caused by the reduction of another compound. Dissolved solids and dissolved oxygen increase the electrical conductivity of the solution and accelerate corrosion. Almost all Microbiologically Influenced Corrosion (MIC) is due to the growth and metabolic activities of microbial communities on the surface of a metal or alloy (WEF Manual of Practice 8, 1992). Thus MIC may appear as localized crevices or pitting corrosion, and advanced MIC almost always looks like pitting corrosion. Studies have traditionally emphasized the role of SRB as the most important cause of MIC. More recent studies indicate that the extent of MIC cannot be entirely accounted for by the activities and levels of SRB. Instead, MIC seems to correlate with the presence of microbial communities composed of many different kinds of bacteria. Acid forming bacteria that convert organic materials into organic acids, such as acetic acid and lactic acid, were found to be of particular importance to the occurrence of MIC. Acids can cause active corrosion of many alloys, and also serve as nutrients for other SRB. MIC is caused by under-deposit acid attack and can occur internally or externally on metal alloys.

Thorn Creek Basin Sanitary District Experience

The District operates a two-stage anaerobic digester system. Limited H_2S monitoring in the gas generated has been conducted, and the results are presented in Table 3-5. Only 6.2 ppm(V) of H_2S was present before startup of the silica plant, while the levels have ranged from 3,900 to 10,000 ppm(V) since startup of the silica plant.

TABLE 3-5

ANAEROBIC DIGESTER GAS ANALYSIS FOR HYDROGEN SULFIDE

Date	Sample	H_2S, ppm (V)	Comments
August 1991	Primary	6.2	Before Rhodia's Silica Plant
August 1998	Primary	6,500	After Rhodia's Plant Goes Online
	Secondary	3,900	
November 1999	Primary	10,000	
	Secondary	5,000	
	Secondary	4,000	

At 30°C, the solubility of H_2S is approximately 3,000 mg/L (Merck Index, II Ed, 1989). The measured soluble sulfide (assumed to be the H_2S both un-ionized plus ionized H_2S) in the sludge is 13 mg/L. The total sulfides in the anaerobic sludge has been measured at 260 mg/L. The District has seen no deterioration in methane production since acceptance of the silica plant wastewater was initiated, nor would deterioration be expected at 13 mg/L H_2S. The measured H_2S in the offgas checks reasonably well with the measured liquid soluble sulfides, based on the Henry's law constant for H_2S (See Appendix B).

While inhibition has not been experienced in the District's digester, an increase in cleaning of the gas handling system due to fouling has been experienced. White deposits have been experienced in both the gas compressors and heaters where the digester gas in burned. Cleaning of the equipment has increased from quarterly to monthly since Rhodia's silica operation came on-line. This level of cleaning can be expected to increase proportionally with the increase in sulfates from Rhodia.

Currently the majority of the sulfides in the digester are in a precipitated form. However, with the expansion it is reasonable to assume no further cations are available to react with the soluble sulfides, and therefore all of the additional sulfur will form H_2S. The soluble sulfides will approach 100 mg/L in the digester, and the H_2S concentration in the off gas will reach 1.5 to 1.6 percent, approximately 50 percent higher than the present levels. The calculations on the sulfur balance are presented in Appendix B.

Based on the literature, soluble sulfide levels of 100 mg/L will not be inhibitory. The H_2S in the offgas of 15,000 ppm is a concern and sulfur removal will be necessary before burning the methane gas. This will also reduce the fouling experienced in the gas compressors and heaters. As the WWTP uses the digestor gas for mixing, consideration should be given to putting the H_2S removal system on this internal mixing stream. Such an approach would drastically lower the H_2S in the liquid phase, which would provide assurance that gas production will not be impacted and will reduce fouling throughout the digester system.

3.4.3 Biomass Solids Separation

Elevated sodium levels have been reported to result in the development of poorer settling solids in activated sludge processes (Higgins, J.M. and J.T. Novak, 1997). One theory is that the monovalent ions (e.g. sodium) displace the divalent ions (e.g. calcium and magnesium) within the biomass floc. Flocculation is know to improve with the valency of the cations, often referred to as the Schultze-Hardy Rule. This theory states that divalent ions are 30 to 60 times more effective than monovalent ions, and trivalent ions are 700 to 1,000 times more effective than monovalent ions (AWWA, 1971).

Recent research has found that at sodium to divalent cation ratios above 2:1, a deterioration in settling and dewatering characteristics can occur (Higgins, M.J. and J.T. Novack, 1997). This research indicated that deteriorations in settling can occur after approximately ten days of elevated sodium levels, with a similar lag when the sodium-to-divalent ratio was lowered.

Higgins et al., (1999) evaluated the effect of the monovalent-to-divalent ratio on the Sludge Volume Index (SVI) and effluent total suspended solids (TSS). At ratios up to 2.5:1 (monovalent-to-divalent), no impact was discerned. The next ratio studied was 6:1, and TSS and SVIs increased. Data between these two ratios (2.5:1 and 6:1) were not generated.

Deterioration in effluent TSS can be counteracted by maintaining a low food-to-microorganism (F:M) ratio, (or by carrying a higher biomass population in the activated sludge system). Thorn Creek already operates with low F:M ratios to maintain nitrification. Therefore increases in the sodium concentration would not be expected to occur until higher monovalent-to-divalent ratios exist. Based on the existing loadings from Rhodia, and limited calcium, magnesium, and potassium effluent data, the current average monovalent-to-divalent ratio is 1.3:1, below any level where poor settling would be anticipated. Assuming with the proposed expansion the average sodium increases by the same ratio as the projected peak production by Rhodia, the monovalent-to-divalent ratio will increase to 2.6:1. At this level, little or no deterioration in performance would be expected. However, if peak production occurs for a sustained period of time (e.g. greater than ten days), poorer settling solids could develop, with ratios of the monovalent-to-divalent cations up to 3.5:1.

Thorn Creek currently has an excellent settling biomass, with typical effluent suspended solids (before filtration) of less than two to four mg/L. Since 1998, there have been 13 periods of effluent sulfate levels between 700 and 960 mg/L for periods ranging from 4 to 21 days. A regression analysis of the effluent TSS versus sulfate revealed a poor correlation (R^2=0.12) between these two variables. Assuming a linear relationship, for every 140 mg/L increase in sulfates, the effluent TSS can be expected to increase one mg/L. Appendix B contains this analysis.

Thorn Creek has tertiary filters, so any increase in TSS will be significantly offset by the filtration. However, more frequent backwashing will be necessary. During periods of higher effluent suspended solids when the filter is down or during higher flows, a flocculant (e.g. a trivalent cation such as alum or ferric chloride) may be necessary, if the settleability deteriorates more than the linear regression predicts.

In summary, some deterioration in solids settling and effluent suspended solids may result from the proposed Rhodia expansion, especially during periods of peak production. This deterioration is not expected to be sufficient to create compliance issues with suspended solids, especially with the tertiary filters. If the deterioration becomes higher than predictable, long sludge ages or a coagulant added between the aeration tank and secondary clarifier would have to be implemented.

4. THORN CREEK AND TRIBUTARY WATER QUALITY

4.1 Introduction

Thorn Creek is classified a general use water under Title 35 of the State of Illinois rules and regulations as described in Section 2.7 of this report. The existing adjusted standard limits range from 2,100 mg/L to 1,700 mg/L for TDS and 1,000 mg/L to 750 mg/L for sulfate for the four reaches identified along Thorn Creek and the Little Calumet River. Before discussing the impact of Rhodia's proposed silica plant expansion on Thorn Creek, the existing water quality of Thorn Creek and its tributaries is described herein.

4.2 Thorn Creek Monitoring Database

Flow and chemical monitoring on Thorn Creek was routinely conducted by the United States Geological Survey (USGS) at two stations on Thorn Creek, one at Glenwood (Station 05536215) and one at Thornton (Station 05536275). Recent monitoring at these stations by the USGS is limited to flow. The IEPA has continued to collect water quality data at the Thornton Station and these data have been obtained for the period of 1990 to 1998. Both the Glenwood station and the Thornton station are located downstream of the Thorn Creek Basin WWTP outfall as depicted in Figure 4-1 at river miles 9.2 and 4.2, respectively.

The Glenwood station is located prior to (upstream of) the Deer Creek merger and is sensitive to water quality fluctuations from the District's WWTP discharge. The Thornton Station is located downstream of the three tributary mergers with Thorn Creek, and is therefore affected by all three creeks. Flow data recorded since 1977 have been obtained from the USGS. TDS and sulfates have also been analyzed and obtained from the station at Thornton by the USGS, but not at the Glenwood Station.

The USGS also has three monitoring stations located upstream of the Thorn Creek Basin WWTP; one near Chicago Heights (Station 05536210), one at Chicago Heights (Station 05536204) and one at Park Forest (Station 05536201). Flow data from 1974 to 1978 are available for the station near Chicago Heights, but the USGS since then has stopped reporting flow data. No TDS or sulfate data

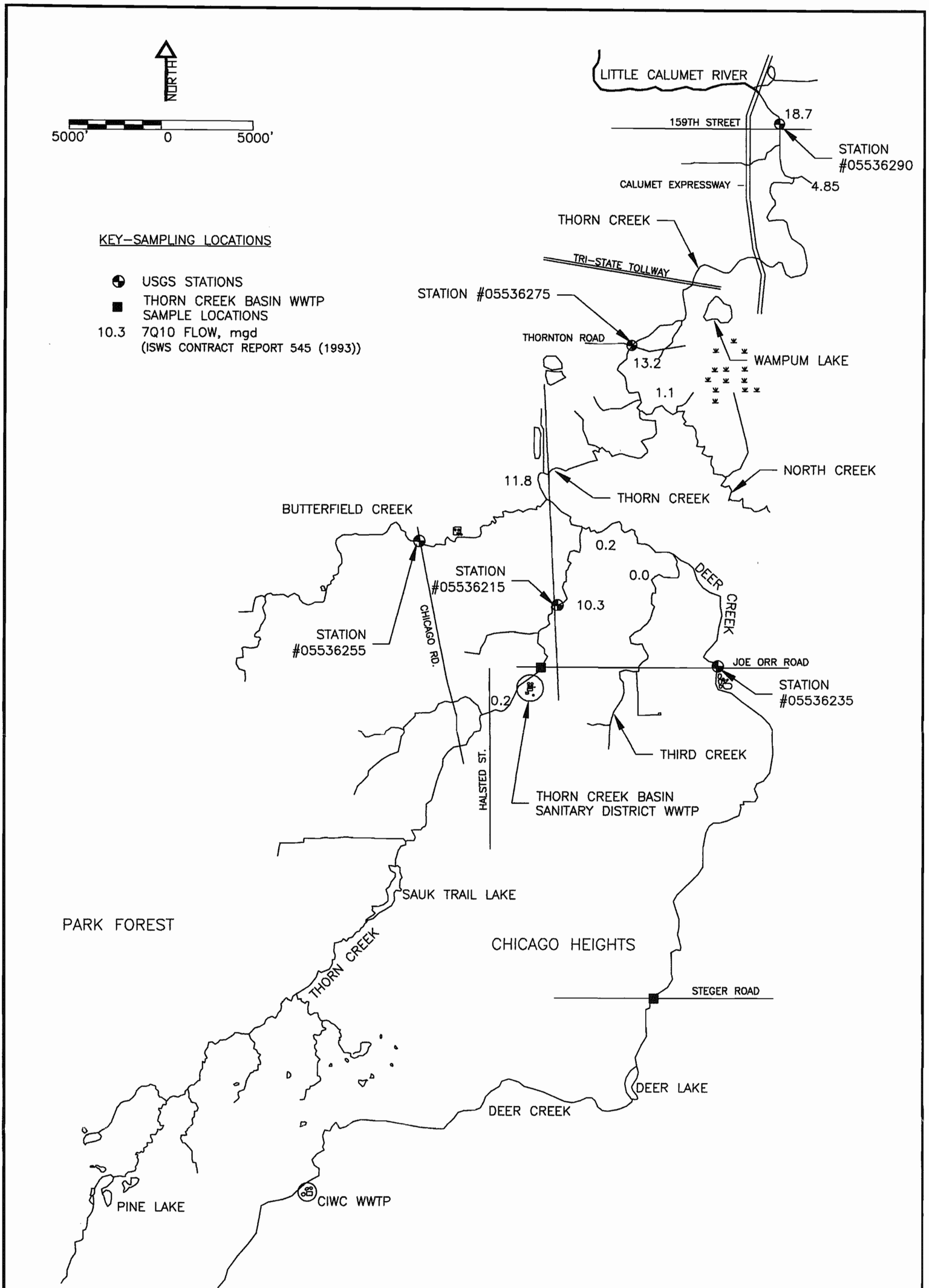


FIGURE 4–1
MONITORING LOCATIONS
THORN CREEK BASIN SANITARY DISTRICT
CHICAGO HEIGHTS, ILLINOIS

CADFILE:THORN–8

are available from the USGS at this station. USGS water resources reports do not contain any data for the remaining two stations. Table 4-1 summarizes the river mile locations for key points along Thorn Creek. The District has sampled Thorn Creek at Joe Orr Road for purposes of monitoring the TDS and sulfate levels since the Silica plant has gone online.

TABLE 4-1
SUMMARY OF THORN CREEK AND TRIBUTARY GAGING STATIONS

Description	River Mile	Distance from WWTP Outfall, miles
Confluence with Little Calumet River	0.0	10.1
USGS 05536275 at Thornton	4.2	5.9
Confluence with North Creek	4.5	5.6
B&O RR (formerly C&EI RR)	6.3	3.8
Confluence with Butterfield Creek	7.5	2.6
B&O RR (formerly C&EI RR) [b/]	7.6	2.5
Confluence with Deer Creek	8.1	2.0
USGS 05536215 at Glenwood [b/]	9.2	0.9
Joe Orr Road [b/]	9.9	0.2
WWTP Outfall [a/]	10.1	0.0
Halsted Street [a/ b/]	10.7	-0.6
USGS 05536210 nr. Chicago Heights	10.8	-0.7
Chicago Road	11.4	-1.3
Headwaters	19.5	-9.4
Source: Healy, 1979		

[a/] Estimated from topographic map

[b/] Thorn Creek WWTP sampling locations

4.3 Tributary Monitoring Database

Thorn Creek is influenced by three main tributaries; Deer Creek, Butterfield Creek and North Creek. The USGS has five monitoring stations on Deer Creek, but since 1974 the USGS only maintains flow data at the station near Chicago Heights (Station 05536235). There are four USGS stations on Butterfield Creek, but since 1974, the USGS only maintains flow data at the station at Flossmoor (Station 05536255). There is one USGS station on North Creek near Lansing (Station 0553670) that the USGS maintained up to 1978. TDS and sulfate are not monitored at any of these stations. The locations of these stations are summarized in Table 4-2.

TABLE 4-2
TRIBUTARY MONITORING LOCATIONS

Description	Waterway	Dist. above Thorn Creek Merger [a/]
USGS 05536235 near Chicago Heights	Deer Creek	2.8
USGS 05536255 at Flossmor	Butterfield Creek	1.2
USGS 05536270 near Lansing	North Creek	5.1
USGS Station 05536195 at Munster, IN	Little Calumet River	4.6 [b/]
USGS 05536290 at South Holland	Little Calumet River	0.4 [c/]

[a/] USGS River Miles
[b/] Distance upstream of Little Calumet River and Thorn Creek merger
[c/] Distance downstream of Little Calumet River and Thorn Creek merger

The USGS has maintained a gaging station (Station 05536195) on the Little Calumet River at Munster, Indiana since 1978. This gaging station is located 4.6 miles upstream of the Thorn Creek merger and 0.4 miles upstream of the Illinois and Indiana state line. Data have been collected for flow and chemical analysis. There are no major waterways that merge with Little Calumet River between the Munster gaging station and the Thorn Creek confluence. The water quality data obtained from this station would, therefore, be indicative of upstream water quality. The USGS also maintains a monitoring station on the Little Calumet River at South Holland (Station 05536290), 0.4 miles downstream of the Thorn Creek confluence. The USGS has only collected flow data at this station. No TDS or sulfate data have been collected.

4.4 Thorn Creek and Tributary Flow Rates

Annual average flow rates of the various waterways for the years 1977 to 1996 are summarized in Table 4-3. The average flow rate at the Thornton USGS gaging station (river mile 4.2) is 74 mgd for this time period. The average flow rate at the USGS Glenwood station (river mile 9.2) located upstream of the Deer Creek merger was 29 mgd for the same time period. Based upon the available flow data on the other tributaries, the following average contributions to the flow at Thornton were calculated:

	Percent of Flow at Thornton Station
Thorn Creek up to Deer Creek Merger	39
Deer Creek	19
Butterfield Creek	18
North Creek	11
Thorn Creek between Deer Creek and Thornton	13
TOTAL	100

Table 4-4 summarizes the flow data for the two Thorn Creek gaging stations, for the period of 1949 to 1997 for the Glenwood station and 1948 to 1997 for the Thornton station, indicating the flow regime for the stream.

TABLE 4-4
SUMMARY OF FLOW DATA FOR THORN CREEK USGS STATIONS

Flow Characteristic	USGS 05536215 at Glenwood	USGS 05536275 atThornton
Period of Record (Water Years)	1949-1997	1948-1997
Annual Mean	26 mgd	68 mgd
Highest Annual Mean	44 mgd (1993)	129 mgd (1993)
Lowest Annual Mean	16 mgd (1954)	33 mgd (1963)
Highest Daily Mean	969 mgd (1968, 1996)	2,460 mgd (1990)
Lowest Daily Mean	4 mgd (1949)	3 mgd (1949)

The USGS, as part of the statistical analysis of Thorn Creek, has determined flow values for the 10th, 50th, and 90th percentiles, indicating the percent of time a flow rate will be exceeded in Thorn Creek. These values can be used for predicting the effect a change in the TDS concentration

TABLE 4-3

USGS GAGING STATION AVERAGE FLOWRATES, mgd

	Thorn Creek			Deer Creek	Butterfield Creek	North Creek
Year a/	05536210 nr Chicago Hts.	05536215 at Glenwood	05536275 at Thornton	05536235 nr Chicago Hts.	05536255 at Flossmoor	05536270 nr Lansing
1977	7	23	55	9	9	8
1978	9	25	59	12	11	9
1979		33	80	18	15	
1980		25	60	11	8	
1981		27	69	13	13	
1982		36	94	16	20	
1983		26	74	11	13	
1984		25	72	14	11	
1985		28	76	16	12	
1986		20	54	9	8	
1987		22	68	10	11	
1988		22	58	9	9	
1989		25	65	10	9	
1990		37	107	21	18	
1991		36	101	23	16	
1992		22	56	8	7	
1993		45	130	29	27	
1994		30	64	11	12	
1995		30	61	13	11	
1996		38	82	14	18	
Average	8	29	74	14	13	8
River Mile	10.8	9.2	4.2			
Miles from WWTP Outfall	-0.7	0.9	5.9	2.0 b/	2.6 b/	5.6 b/

a/ Average for calendar year (opposed to water year)

b/ Distance to confluence with Thorn Creek

SOURCE: USGS Water-Data Reports IL-79-2 through IL-97-2
\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[TCTB43.xls]A

of Thorn Creek Basin plant's discharge will have on the receiving water. The values have been reversed to represent the percent time a flow rate will be less than the value indicated, as depicted in Figure 4-2 for Reach #1. For example, 90 percent of the time, the Thorn Creek flow rate is below 76 mgd, while 50 percent of the time the flow is below 17 mgd. These are based on the 1996 calendar year USGS data for the station at Glenwood.

In considering the environmental impact of loadings on a waterway, the worst case conditions caused by a loading will occur at low flow periods. The ISWS analyzes low flow conditions in the waterways throughout Illinois. Figure 4-1 includes the 7-day, 10-year (7Q10) low flow values as determined by the ISWS (1993). The 7Q10 flow at the Thornton gaging station (start of Reach # 3) is reported as 13.2 mgd. The distribution of this flow from the various tributaries is as follows:

Stream Segment	**7Q10, mgd**
Thorn Creek up to Deer Creek	10.3
Deer Creek	0.2
Butterfield Creek	0.0
North Creek	1.1
Thorn Creek between Deer Creek and Thornton	1.6
FLOW AT THORNTON	13.2

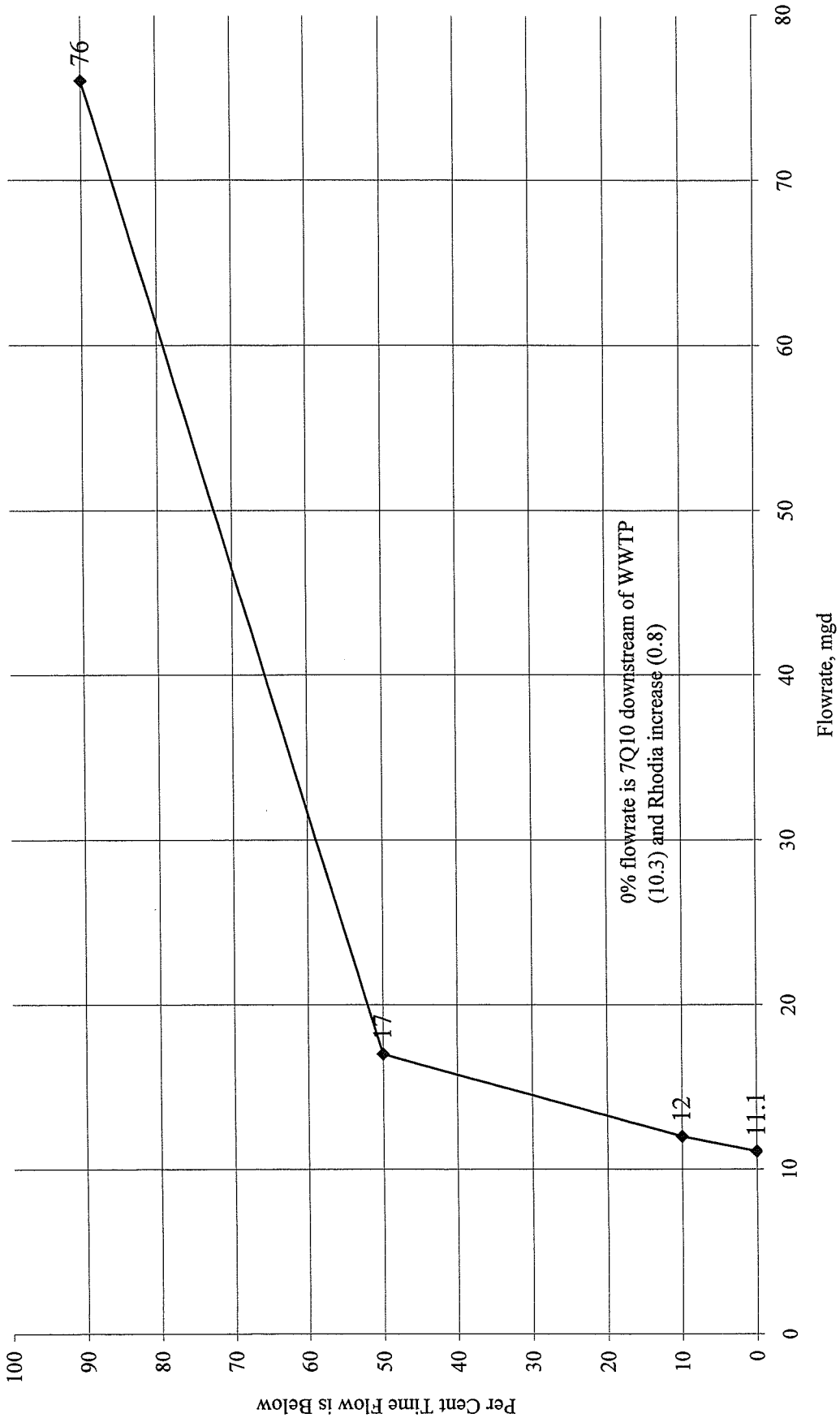
A 7Q10 of 11.1 mgd (10.3 + 0.8 mgd) can be assumed for the stretch of Thorn Creek between the Deer Creek merger and the Thornton Station, Reach #2, as Butterfield Creek has a zero 7Q10 and the North Creek merger is only 0.3 miles from the Thornton Station. Low flow values will be increased for the purposes of modeling Thorn Creek due to the average flow from Rhodia's silica plant of 0.8 mgd.[2]

The 7Q10 reported by the ISWS of Thorn Creek approximately 0.2 miles before the confluence with the Little Calumet River is 13.6 mgd, only 0.4 mgd greater than 7Q10 at the Thornton Station. The

[2] The average Silica plant flow rate is predicted to be 0.84 to 0.94 mgd. For modeling purposes, 0.84 mgd was used for conservative estimates of TDS and sulfate levels in Thorn Creek.

FIGURE 4-2

REACH #1 - PER CENT TIME FLOWRATE IS NOT EXCEEDED



7Q10 of the Little Calumet River upstream of the Thorn Creek confluence is 4.85 mgd.. Downstream of the Thorn Creek and Little Calumet River confluence, the 7Q10 is 18.7 mgd.

4.5 Water Quality Data

There are limited data available on TDS and sulfates in the Thorn Creek Basin. Table 4-5 summarizes TDS data collected by the District after the silica plant went online from January 2, 1997 to June 9, 1999. Historic water quality data is used to develop the models for the water quality predictions and have been included in Appendix C.

The District data collected for Thorn Creek at Joe Orr Road represent water quality data collected after the Rhodia silica plant went online. Samples are collected weekly from this location. The average Thorn Creek TDS and sulfate concentrations during this period were 1,068 mg/L and 361 mg/L, respectively, and the maximum concentrations were 1,698 mg/L and 703 mg/L, respectively. These maximum levels are below the adjusted standards of 2,100 mg/L for TDS and 1,000 mg/L for sulfate.

Table 4-6 is a summary of the major cations and anions monitored at the USGS Station in Thornton from 1997 to 1998. This represents water quality at the Thornton station as monitored by the USGS after the silica plant went online. Comparison of historical data collected from the same USGS station before the silica plant went online indicates an increase in the average sulfate level from 149 mg/L to 419 mg/L, while the remaining ions remain relatively unchanged. The maximum sulfate level detected during this period is 742 mg/L, below the adjusted water quality standard of 850 mg/L. (The adjusted water quality standard changes from 1,000 mg/L to 850 mg/L at the Thornton station. Both standards have been consistently achieved.)

TABLE 4-5

TDS and SULFATE DATA
THORN CREEK AT JOE ORR ROAD

DATE	TDS, mg/L	SO4, mg/L	DATE	TDS, mg/L	SO4, mg/L
01/02/1997	845	199	11/12/1997	1606	672
01/08/1997	824	152	11/19/1997	1004	342
01/15/1997	1294	498	11/25/1997	1385	586
01/22/1997	808	117	12/03/1997	1259	539
01/29/1997	1365	421	12/10/1997	1409	493
02/05/1997	704	14	12/17/1997	1517	423
02/12/1997	1307	489	12/23/1997	977	341
02/20/1997	781	193	12/30/1997	1117	395
02/26/1997	1060	312	01/06/1998	526	144
03/06/1997	1019	352	01/14/1998	1085	391
03/12/1997	1175	477	01/21/1998	1244	505
03/19/1997	728	149	01/28/1998	1597	575
03/26/1997	1125	475	02/04/1998	939	338
04/02/1997	826	222	02/11/1998		218
04/10/1997	845	273	02/18/1998		158
04/16/1997	640	186	02/25/1998		518
04/23/1997	1183	214	03/04/1998		537
05/01/1997	986	317	03/12/1998		202
05/07/1997	1402	598	03/19/1998		165
05/15/1997	818	234	03/25/1998		363
05/21/1997	923	369	03/31/1998	1044	419
05/28/1997	630	161	04/01/1998	558	227
06/04/1997	1423	703	04/08/1998		270
06/13/1997	579	184	04/15/1998		355
06/18/1997	871	341	05/06/1998	674	251
06/23/1997	747	174	06/10/1998	1180	501
07/03/1997	856	224	07/08/1998	563	227
07/09/1997	522	127	08/19/1998	1297	441
07/16/1997	1588	658	09/09/1998	1111	478
07/22/1997	467	125	10/07/1998	1344	494
07/30/1997	1476	625	11/04/1998	1315	483
08/08/1997	1235	512	12/09/1998	696	200
08/13/1997	868	360	01/20/1999	1698	555
08/20/1997	1040	403	02/03/1999	806	487
08/27/1997	1274	545	03/10/1999	1565	455
09/03/1997	1238	423	04/14/1999	1416	619
09/10/1997	1650	668	05/12/1999	624	156
09/16/1997	806	193	06/09/1999	895	282
09/19/1997		325			
09/23/1997	1466	408	**OVERALL**		
09/24/1997	1202	508	**Average**	**1068**	**361**
10/09/1997	576	178	**Minimum**	**467**	**14**
10/16/1997	1441	177	**Maximum**	**1698**	**703**
10/22/1997	1621	673			
10/29/1997	1164	130	**WQ Standard**	**2100**	**1000**
11/05/1997	1164	463			

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[JoeOrrRd.xls]Sheet1

TABLE 4-6

INORGANICS at USGS Station 05536275 at Thornton
AFTER RHODIA SILICAL PLANT IS ONLINE

DATE	Calcium, diss. mg/L	Magnesium, diss. mg/L	Sodium, diss. mg/L	Potassium, diss. mg/L	Sulfate, total mg/L	Chloride, total mg/L	Sum of Ions, mg/L	% Sulfate
02/10/97	83	36	190	5	319	209	759	42
03/25/97	84	38	160	5.7	296	199	699	42
05/07/97	85	39	210	6.3	503	189	947	53
06/16/97	31	12	75	3.5	113	66	270	42
07/15/97	77	41	320	8.6	742	195	1307	57
09/23/97	78	36	390	9.7	622	161	1219	51
11/20/97	84	41	250	10	431	244	976	44
01/27/98	95	45	330	8.3	376	391	1150	33
03/02/98	95	42	180	6.1	327	198	753	43
04/13/98	87	38	130	5.1	160	123	456	35
05/27/98	97	56	270	8.6	561	204	1100	51
06/24/98	89	42	300	8.7	574	173	1098	52
08/07/98	41	17	35	4.9			57	0
09/15/98	87	41	300	8.3		150	499	0
10/30/98	63	30	130	7.9	243	92	503	48
12/03/98	82	40	330	10	592	156	1128	52
Average	79	37	225	7	419	183	807	40
Maximum	97	56	390	10	742	391	1307	57

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[DATA.xls]Sheet2

7. PROJECTED IMPACT ON THORN CREEK AND THE LITTLE CALUMET RIVER FROM PROPOSED EXPANSION

7.1 Introduction

As described in previous chapters, Thorn Creek and the Little Calumet River can be divided into four stream reaches for analysis purposes:

Reach #1	Thorn Creek Basin Sanitary District Outfall to Confluence with Deer Creek (2.0 miles)
Reach #2	Confluence with Deer Creek to Thornton USGS Gaging Station (3.9 miles)
Reach #3	USGS Gaging Station at Thornton to Confluence with the Little Calumet River (4.2 miles)
Reach #4	Thorn Creek Confluence with the Little Calumet River to the Little Calumet Confluence with the Calumet-Sag Channel (8.8 miles)

In this chapter, the projected TDS and sulfate water quality levels for each reach are presented. Both maximum and average levels are presented herein.

7.2 Flow Curves for Stream Reaches

In order to estimate water quality concentrations, flow curves on each stream were first developed. Figure 7-1 presents the projected flow curves for the four Thorn Creek/Little Calumet River reaches, each starting at the 7-day, 10-year low flow value (adjusted to include 0.84 mgd from Rhodia[4]). For modeling purposes, the 7Q10 value used for the Thorn Creek WWTP was taken as 10.3 mgd, the 7Q10 at the Glenwood gauging station, one mile downstream. This assumes that

[4] The average Silica plant flow rate is predicted to be 0.84 to 0.94 mgd. For modeling purposes, 0.84 mgd was used for conservative estimates of average TDS and sulfate levels in Thorn Creek.

all flow at this station during 7Q10 conditions is from the WWTP. The curves were developed from USGS flow data. The 7Q10 values were obtained from the ISWS Contract Report 545 (1993) for 7Q10 low flow values for northeastern Illinois. The 10 percent, 50 percent and 90 percent flow rate values were obtained from USGS data for calendar year 1996, the most recent calendar year available.

For Reach #2, the flow curve was derived based upon the drainage area for Thorn Creek to the Deer Creek confluence plus the drainage area in Deer Creek, as a fraction of the overall drainage basin at the USGS Station at Thornton. This approach results in a conservative flow value for much of the reach, as the flow contribution from Butterfield Creek and North Creek are excluded. Reach #3 was based on the current flow regime at the Thornton USGS Station. This station is at the beginning of this reach, therefore, the calculated concentrations are also conservative for this reach as the flow increases (TDS and sulfate concentration decreases) as the stream approaches the Little Calumet River.

The 7Q10 on the Little Calumet River, upstream of the Thorn Creek confluence, is 4.8 mgd. This, combined with 14 mgd of Reach #3 (which includes the 0.84 mgd from Rhodia), yields a 7Q10 of 18.8 mgd for Reach #4. Figure 2-1 in Chapter 2 depicted the different reaches. From Figure 7-1 and the above information, the following flow values were derived, rounded to the closest 1 mgd.

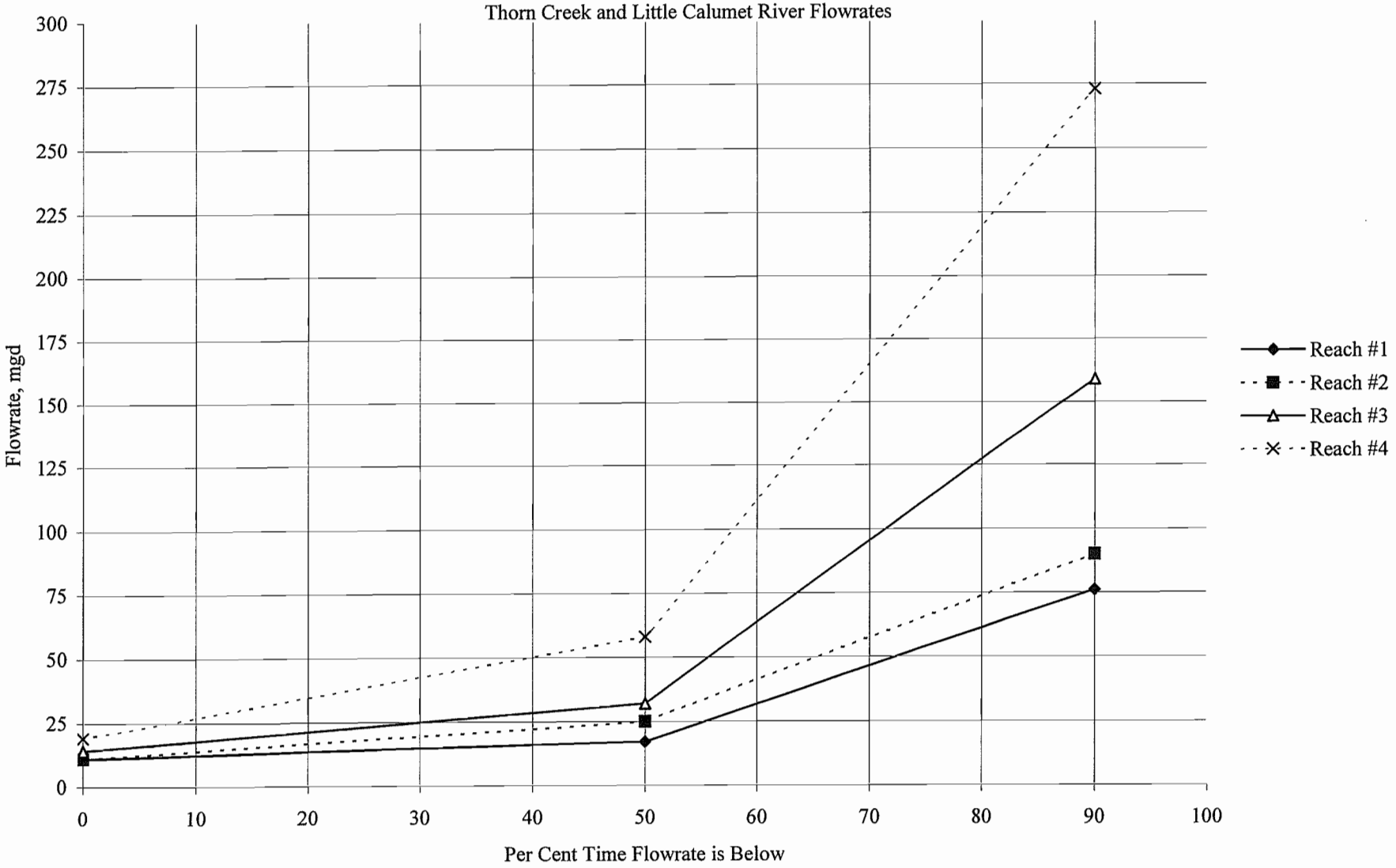
Reach Number	7Q10, mgd	Median Flow, mgd	90% Flow, mgd
1	11	17	76
2	11	25	90
3	14	32	159
4	19	58	273

Low flows in Reach #1 and #2 are similar, while the median flow in Reach #2 increases to 25 mgd from 17 mgd in Reach #1.

FIGURE 7-1

PER CENT TIME FLOWRATES ARE BELOW

Thorn Creek and Little Calumet River Flowrates



7.3 Projected TDS Levels

Using the water quality from Thorn Creek before the existing silica plant was online and the projected loadings from Rhodia, the resulting water quality in each reach can be determined. The water quality database for some of the reaches is limited since Rhodia started the silica operation, so the earlier water quality (data from the first environmental assessment, (Huff & Huff, 1993)) using the total Rhodia loading provided a more accurate estimate of the projected impact of the proposed expansion.

As presented in Chapter 2, average and maximum TDS levels discharged from Rhodia to the WWTP were projected based upon 365 days per year and used in the model as follows:

Total TDS Loading from Rhodia Silica Plant	
Annual Average	137,375 lbs/day
Daily Maximum	151,725 lbs/day

The annual average TDS discharge by Rhodia was utilized to prepare frequency distribution curves of the expected TDS levels. The maximum TDS discharge by Rhodia was used to predict the peak expected water quality TDS levels for each reach. The results of both of these projections are presented herein.

7.3.1 TDS Frequency Distributions

Figure 7-2 presents the frequency distribution of TDS levels projected for Reach #1 with the Rhodia expansion. The average TDS level of 689 mg/L based on data collected before the Rhodia silica plant went online was utilized as the Thorn Creek upstream base level. The treatment plant effluent TDS is similarly based upon the average TDS effluent level of 765 mg/L before the existing silica plant was online. Based upon Rhodia's projected average TDS loading, ten percent of the time the TDS will be above 2,100 mg/L, the existing adjusted water quality standard.

FIGURE 7-2

TDS Frequency Distribution, Reach #1

Average Rhodia Discharge

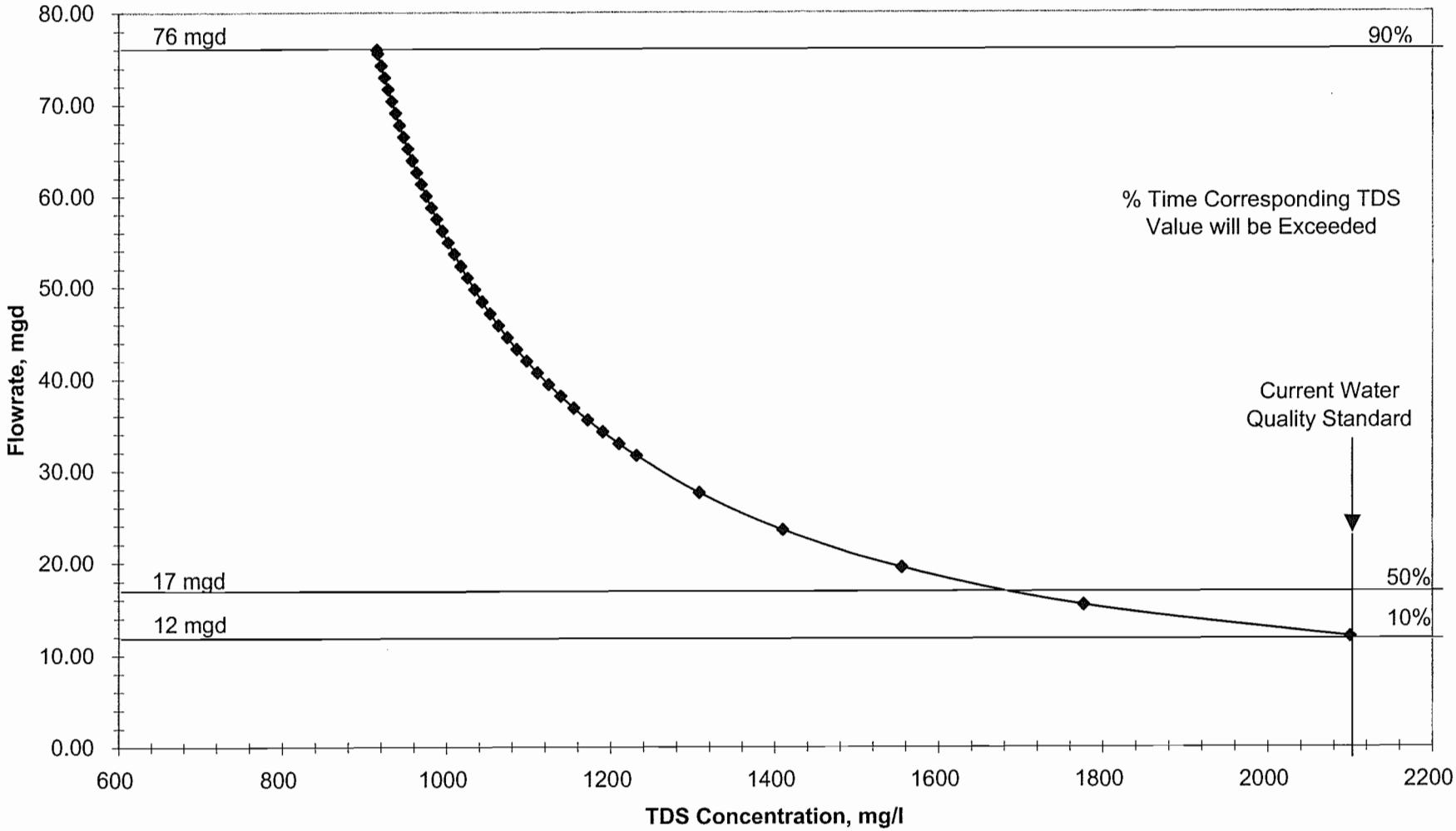


Figure 7-3 presents the TDS frequency distribution projected for Reach #2 at average loadings. A background TDS level of 689 mg/L was used as Deer Creek's background TDS level, the TDS level obtained from Thorn Creek upstream of the WWTP. Using Rhodia's projected average discharge of 137,375 pounds per day, ten percent of the time, the TDS will be above 2,100 mg/L, which is also the adjusted water quality standard for this reach.

Using current TDS concentrations and flow data from the USGS Station at Thornton (presented in Chapter 4), Rhodia's projected average incremental loading of 137,375 pounds per day was modeled for Reach #3 and is presented in Figure 7-4. The TDS level in Reach #3 will exceed 1,480 mg/L ten percent of the time. This TDS level is below the current adjusted water quality standard of 1,900 mg/L which will not be exceeded in this reach under average conditions.

The projected average TDS loading expected from Thorn Creek was also utilized to model Reach #4, the portion of the Little Calumet River between Thorn Creek and the Calumet-Sag Channel. Figure 7-5 depicts the TDS frequency distribution in Reach #4. A TDS level of 1,080 mg/L is expected to be exceeded ten percent of the time. This is below the existing adjusted water quality standard of 1,700 mg/L, which will not be exceeded in this reach under average conditions.

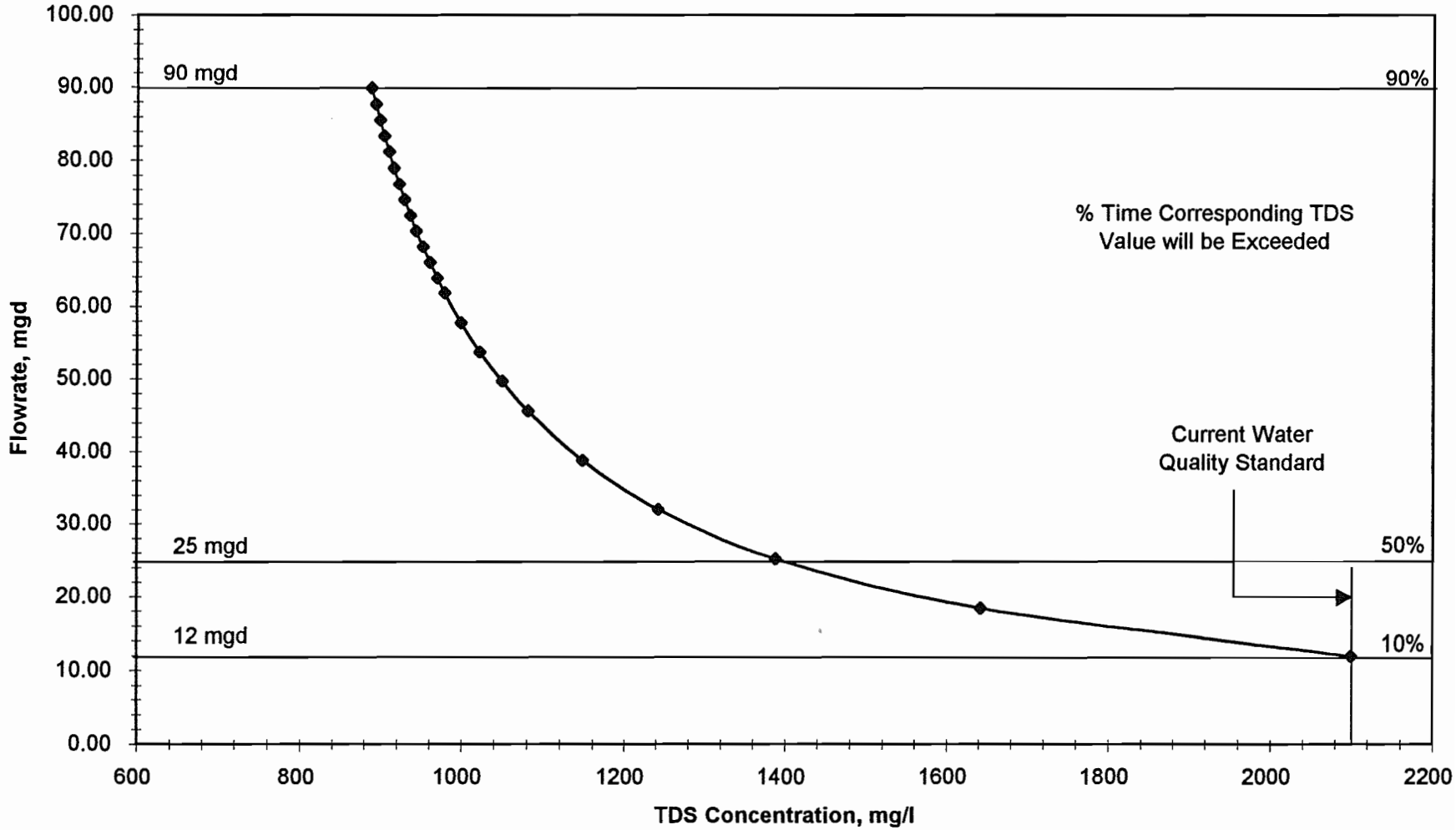
7.3.2 Daily Maximum TDS Levels

The peak projected TDS levels were calculated to establish a basis for setting water quality standards for the impacted reaches, as water quality standards are typically based upon a not to be exceeded basis. The peak TDS levels will occur during periods of low flow and maximum Rhodia loading. The daily maximum TDS loading from Rhodia is 151,725 pounds per day at a flow rate of 1.1 mgd (in Chapter 2). The maximum projected TDS levels in the impacted reaches would occur when the treatment plant and upstream TDS levels are also at a maximum.

FIGURE 7-3

TDS Frequency Distribution, Reach #2

Average Rhodia Discharge



1doc/ThornCrk/Rhodia99Tabl/TCR2AT2.xls

FIGURE 7-4

TDS Frequency Distribution, Reach #3

Average Rhodia Discharge

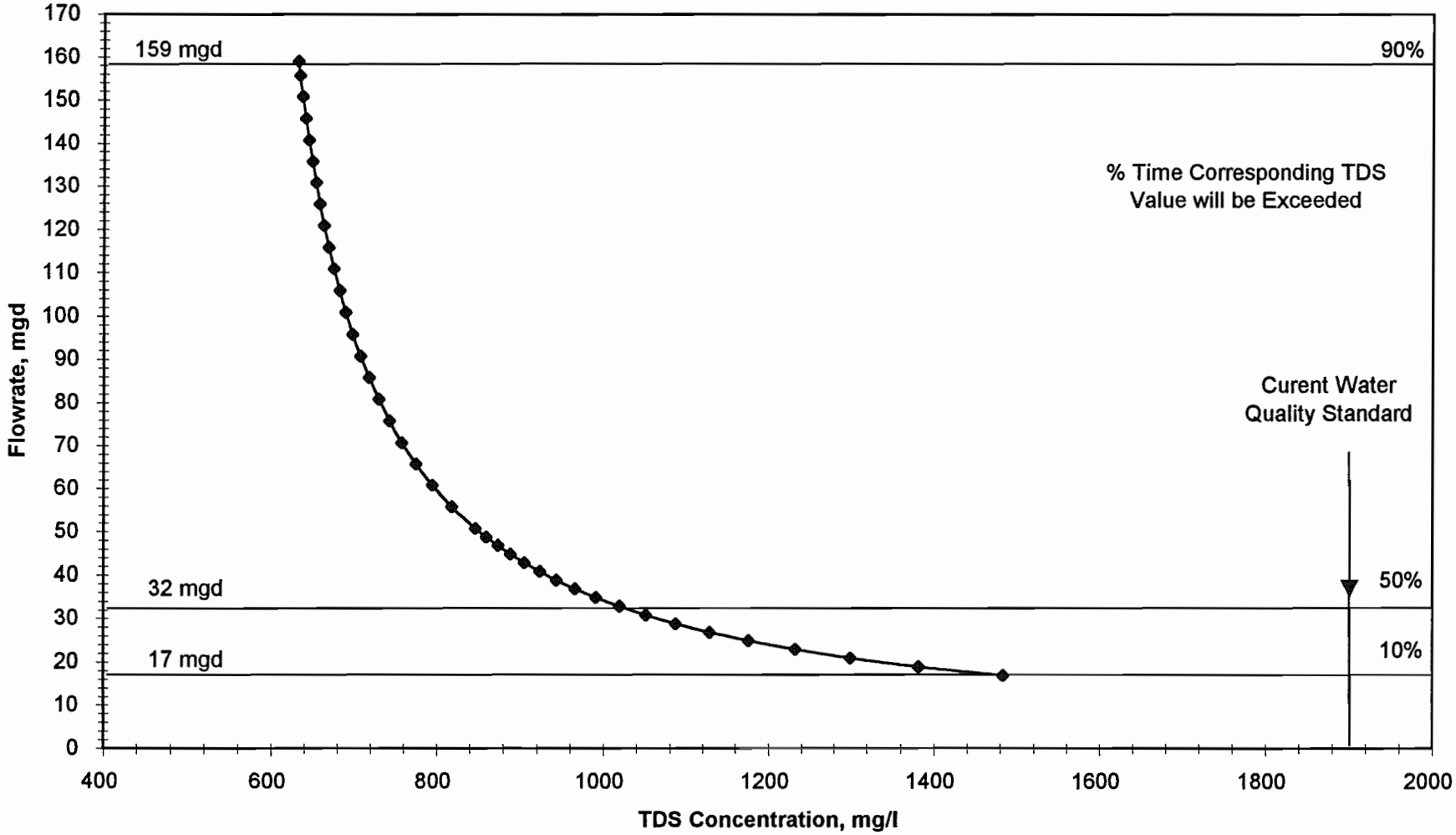
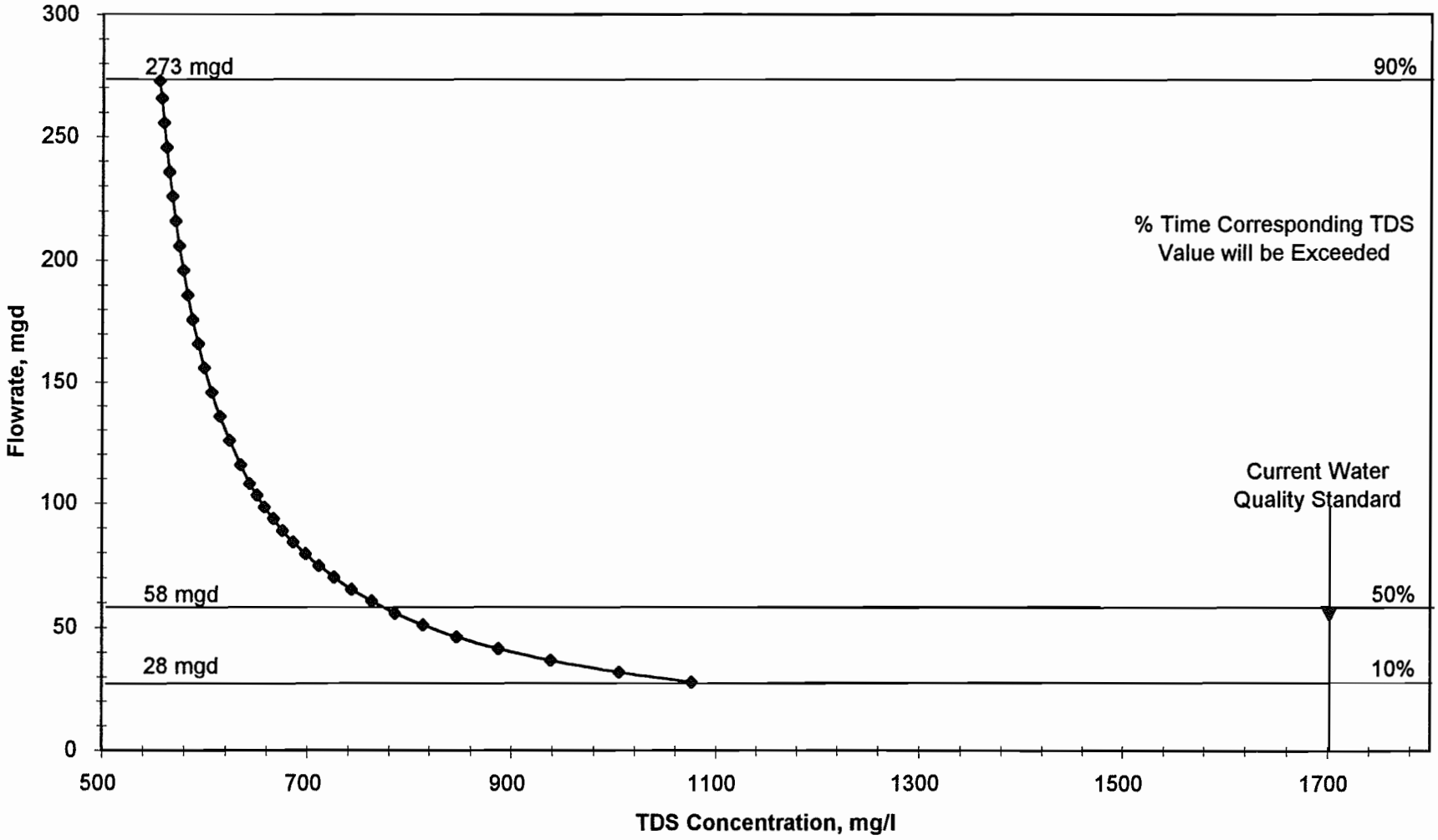


FIGURE 7-5

TDS Frequency Distribution, Reach #4

Average Rhoida Discharge



1doc/Thorncrk/Rhodia99Tabl/TCR4AVT.xls

Guidance for predicting the WWTP effluent and upstream TDS maximum levels was obtained from EPA's Technical Support Document for Water Quality-based Toxics Control, (EPA, 1991). A statistical approach from this document was used due to the limited amount of TDS data available for the WWTP (13 TDS samples) and Thorn Creek upstream of the WWTP (nine TDS samples). The TDS data for the WWTP and upstream were presented in Table 3-2 and 4-5, respectively. Using the U.S. EPA statistical approach, a predicted peak TDS upstream of 2,093 mg/L and a peak background TDS from the WWTP discharge of 1,186 mg/L were computed. The calculations are included in the Appendix F.

Using the values determined above, and the maximum discharge from Rhodia of 151,725 pounds per day, the peak concentrations were determined based upon low flow conditions. Table 7-1 presents a summary of the projected peak TDS levels in the four reaches. The maximum values range from 2,650 mg/L in Reach #1 and declining to 2,020 mg/L in Reach #4. The spreadsheets and supporting calculations used for determining the maximum TDS levels are presented in the Appendix F.

TABLE 7-1
PROJECTED MAXIMUM THORN CREEK TDS LEVELS
AT RHODIA PEAK LOADING

Reach Number	Maximum TDS, mg/L
1	2,650
2	2,620
3	2,360
4	2,020

The maximum TDS level in Reach #2 for Deer Creek was input as 2,100 mg/L, the adjusted water quality standard for Reach #2 already obtained by CIWC and Nutrasweet. Reach #3 was again based upon actual data obtained from the USGS station at Thornton. The maximum TDS determined for Reach #3 without any contribution from Rhodia was 1,180 mg/L. No factor was used to increase this maximum as there were sufficient data to determine the maximum level. The maximum TDS level for Reach #4 at low flow was input as the current water quality standard for Little Calumet River of 1,000 mg/L.

7.4 Projected Sulfate Levels

The same procedure was followed for the projected sulfate water quality levels, as was used for the TDS projected levels. Existing water quality levels were utilized with Rhodia's sulfate contribution at average and maximum loadings. The sulfate levels used in the model are as follows:

Total Sulfate Loading From Rhodia Silica Plant	
Annual Average	92,750 lbs/day
Daily Maximum	102,640 lbs/day

7.4.1 Annual Average Sulfate Levels

The sulfate loading from Rhodia of 92,750 pounds per day was modeled to depict the sulfate frequency distribution for Thorn Creek. Figure 7-6 depicts the projected sulfate levels for Reach #1 based upon Rhodia's average loading. The existing average sulfate levels of 186 mg/L and 207 mg/L are 27 percent of the measured existing upstream Thorn Creek TDS and WWTP TDS levels, respectively. (The 27 percent sulfate is based on USGS Thornton station water quality data for 1991.) Based upon these modeled TDS loadings, ten percent of the time, the sulfate level will be above 1,130 mg/L, and 28 percent of the time will exceed the existing adjusted sulfate water quality standard of 1,000 mg/L.

Figure 7-7 depicts the Rhodia sulfate frequency distribution for Reach #2. A sulfate level of 1,130 mg/L will be exceeded ten percent of the time. The adjusted sulfate water quality standard in Reach #2 of 1,000 mg/L will be exceeded 17 percent of the time. Projected sulfate loadings in Reach #3 were modeled using existing sulfate concentrations and flow data obtained from the USGS station at Thornton. Rhodia's maximum incremental average loading was input into the model and the results are depicted in Figure 7-8. Based upon the model, a sulfate level of 800 mg/L will be exceeded ten percent of the time. The adjusted water quality standard of 850 mg/L will be exceeded six percent of the time.

FIGURE 7-6

Sulfate Frequency Distribution, Reach #1

Average Rhodia Discharge

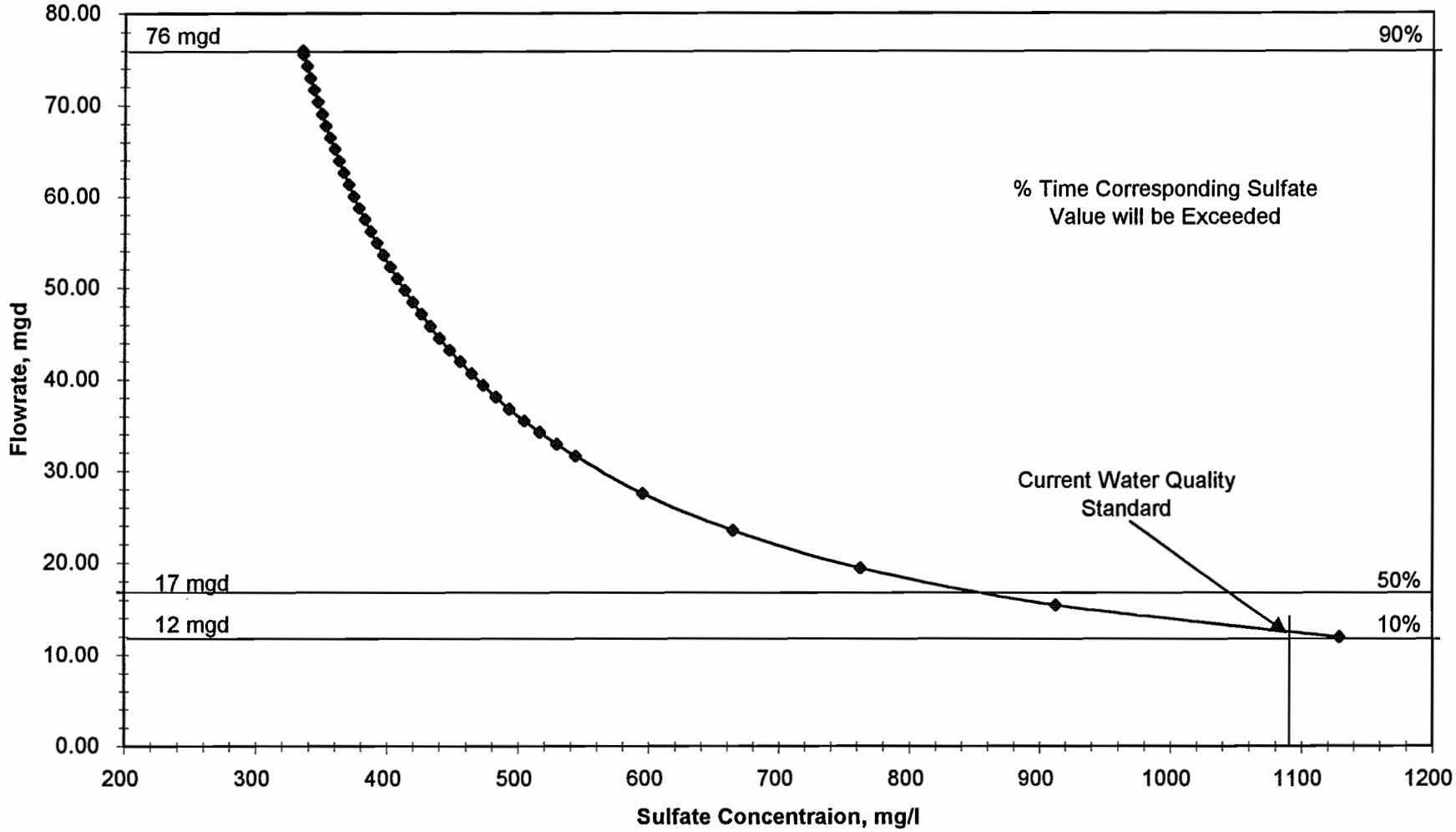
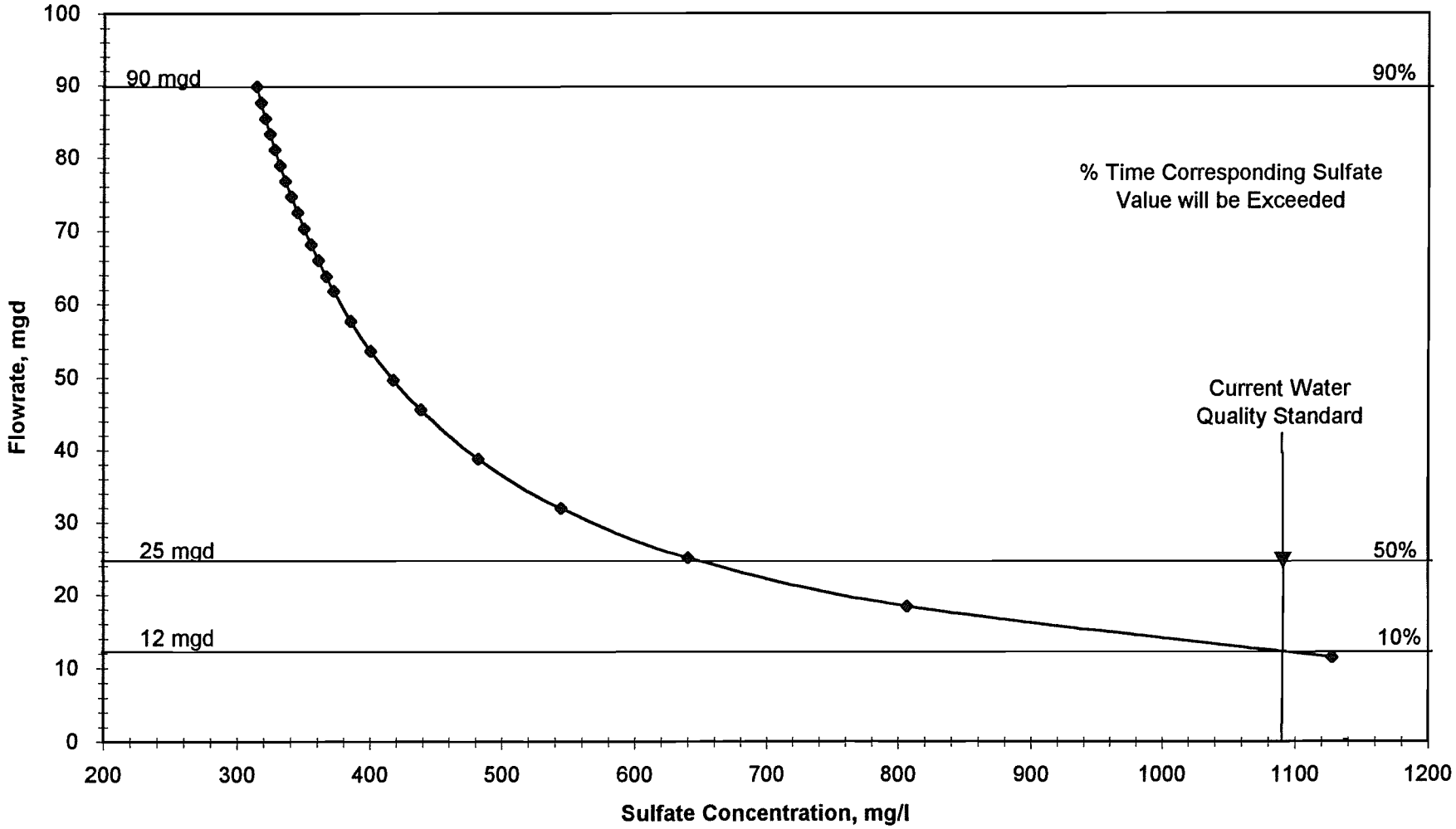


FIGURE 7-7

Sulfate Frequency Distribution, Reach #2

Average Rhodia Discharge



1doc/ThonCrk/Rhodia99Tabl/TCR2AVS.xls

FIGURE 7-8

Sulfate Frequency Distribution, Reach #3

Average Rhodia Discharge

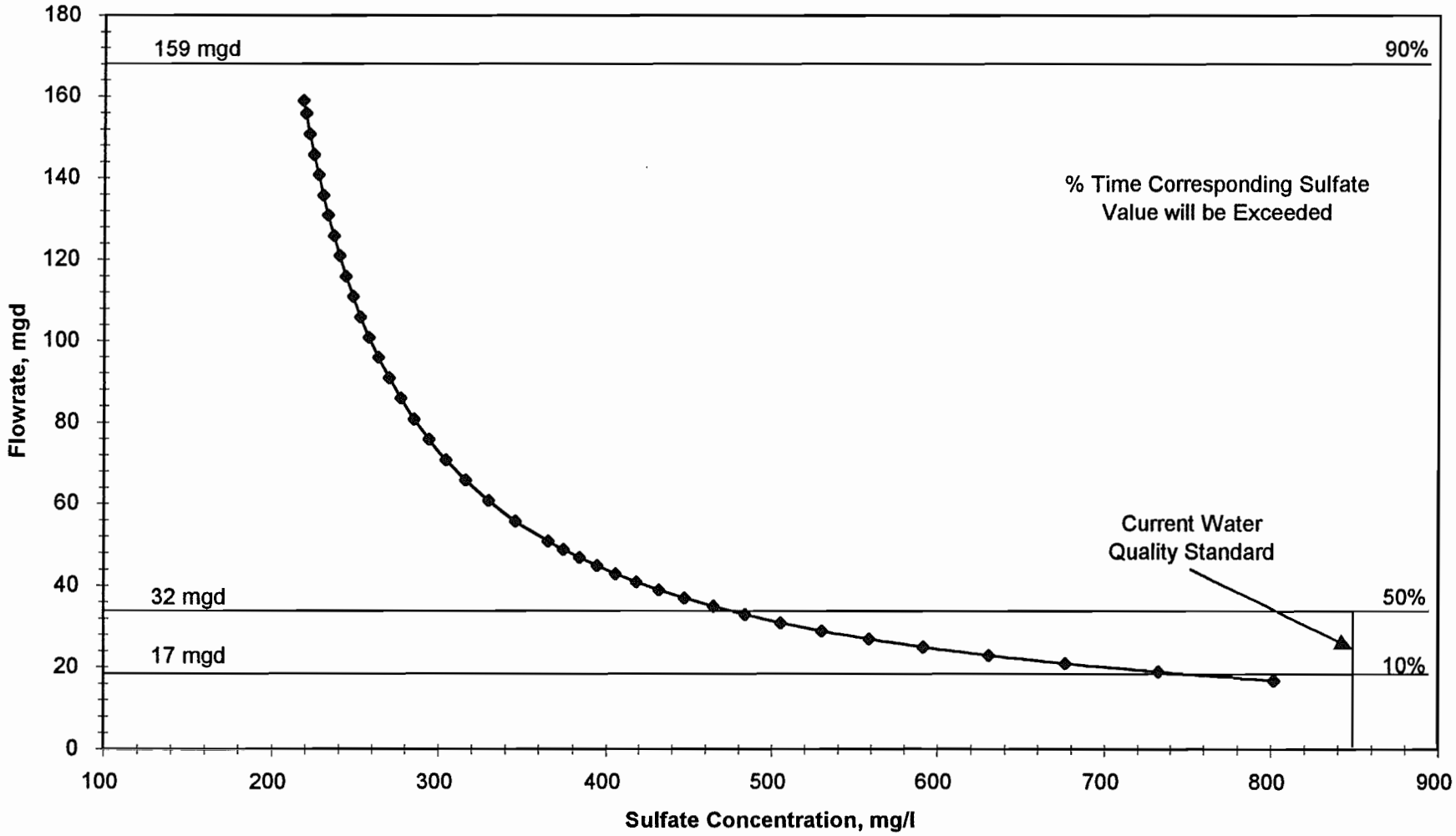


Figure 7-9 projects the sulfate loading on the Little Calumet River, designated as Reach #4. Sulfate levels start at the general use water quality standard of 500 mg/L at low flow, and then use the average sulfate concentrations based upon USGS station 05536195 sampling data. The model projects that a sulfate level of 220 mg/L will be exceeded 10 percent of the time while the adjusted water quality standard of 750 mg/L will be exceeded one percent of the time under average conditions.

7.4.2 Daily Maximum Sulfate Levels

The peak projected sulfate levels were determined for purposes of establishing a basis for setting water quality standards for the impacted reaches. Similar to the TDS levels, peak sulfate levels will occur during low flow conditions, maximum Rhodia loading, and maximum upstream and WWTP sulfate levels. The maximum daily sulfate loading from Rhodia is 102,640 pounds per day at a flow rate of 1.1 mgd (presented in Chapter 2).

Maximum sulfate levels existing for the treatment plant and upstream were determined again using the EPA Technical Support Document (EPA, 1991). Maximum sulfate levels for Reaches #2, #3, and #4 were prepared consistent with the maximum TDS levels for the respective reaches.

Table 7-2 presents the projected maximum sulfate levels. For Reach #1, the maximum projected sulfate level will be 1,350 mg/L, declining to 1,000 mg/L by Reach #4.

TABLE 7-2

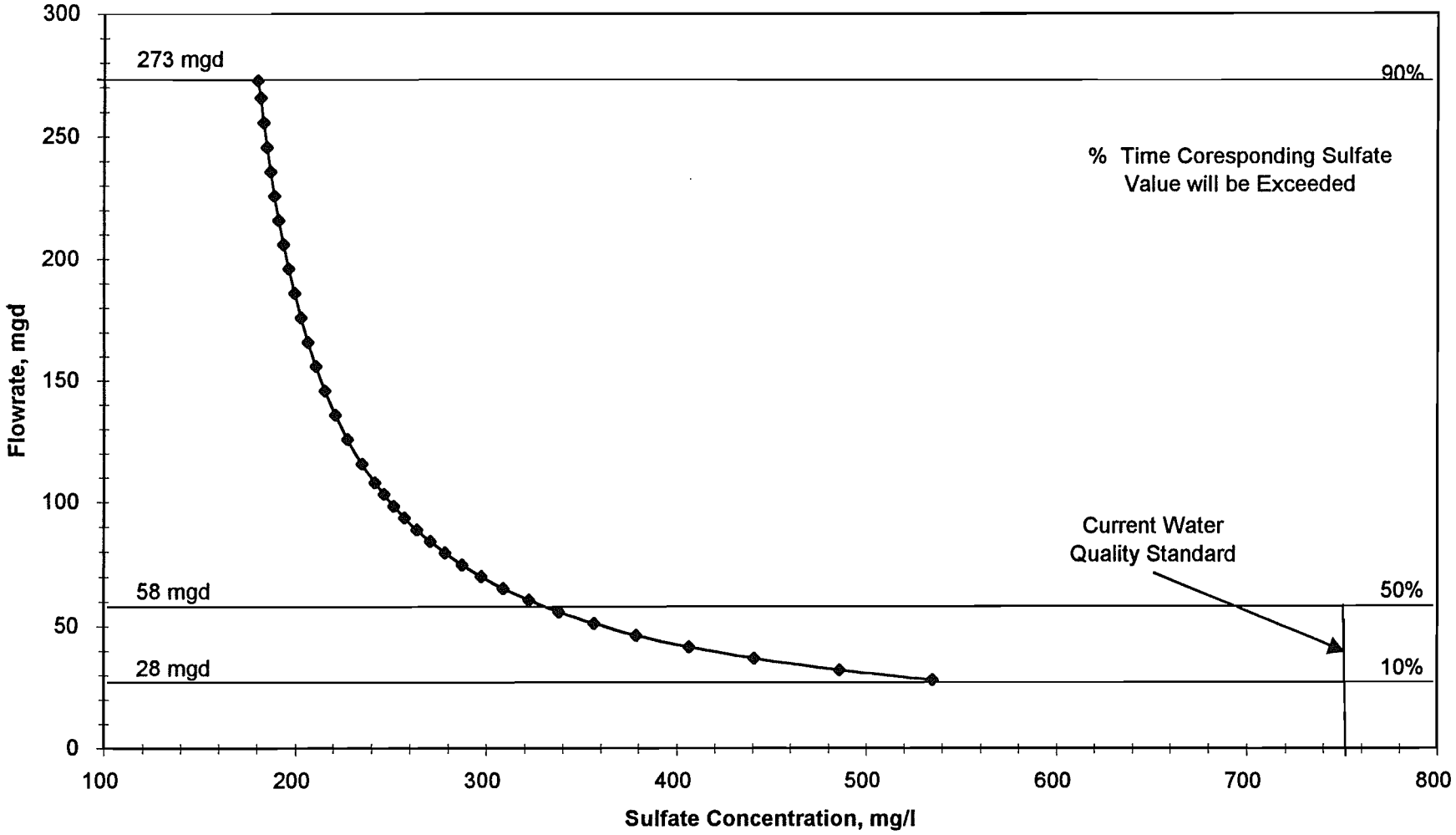
PROJECTED MAXIMUM THORN CREEK SULFATE LEVELS AT RHODIA PEAK LOADING

Reach Number	Maximum Sulfate, mg/L
1	1,350
2	1,340
3	1,160
4	1,000

FIGURE 7-9

Sulfate Frequency Distribution, Reach #4

Average Rhodia Discharge



1doc/Thorncrk/Rhodia99Tabl/TCR4AVS.xls

7.5 Crop Irrigation and Ground Water Impacts

The areas surrounding Thorn Creek from the District's outfall to the merger with the Little Calumet River are limited to forest preserves and developed areas. No commercial crops are grown, and no evidence of water withdrawal for irrigation of crops was observed during the stream study.

Communities along Thorn Creek downstream of the District's outfall, all derive their water supply from Lake Michigan. Communities including Chicago Heights, Flossmoor, Harvey, Glenwood, Homewood, South Holland, Thornton, Calumet City, Dolton, and Lansing were all contacted and confirmed that each municipal water supply system currently uses Lake Michigan water. Most water supply wells have been capped and taken out of service in these communities. Based upon this investigation, Rhodia's proposed project will not increase the TDS in any public water supply.

7.6 Calumet-Sag Channel

The Little Calumet River section designated as Reach #4 merges with the Calumet-Sag Channel as depicted in Figure 2-2. The Calumet-Sag Channel is a secondary contact waterway and receives effluent from the Calumet WWTP. The water quality standard for TDS on the Calumet-Sag Channel is 1,500 mg/L, and no standard exists for sulfate. Included in Appendix F for reference are the projected levels of TDS in Calumet-Sag Channel. Under maximum Rhodia loading, the projected maximum TDS and sulfate levels for the Calumet-Sag Channel is projected to be 1,370 mg/L, below the water quality standards.

7.7 Model Sensitivity

Thorn Creek upstream and treatment plant effluent TDS data used in the model were obtained from a limited database. The upstream TDS levels were measured nine times in the months of November and December while the TDS WWTP effluent levels were measured 13 times in the months of November to April. Due to the limited database, uncertainty of the model output is inherently present. The average effluent TDS concentration before the existing silica plant was online was 765

mg/L and the average upstream TDS concentration was 689 mg/L for the average conditions model.

The peak TDS effluent and upstream levels were 1,186 mg/L and 2,093 mg/L, respectively. These TDS levels were determined based upon the EPA method presented in the EPA Technical Support Document (EPA, 1991).

The upstream and treatment plant TDS levels were increased by one percent each and modeled for Reach #1 under average conditions to evaluate the sensitivity of the model to changes in the TDS levels. Reach #1 was used as this is the most impacted of the Thorn Creek reaches. A one percent increase in the upstream TDS level did not change the downstream TDS level, while a one percent increase in the treatment plant TDS increases the downstream TDS by seven mg/L. The model is therefore more sensitive to WWTP TDS levels.

A similar procedure was used for the sulfate levels on Reach #1. A one percent increase in upstream sulfate levels increases downstream sulfate levels one mg/L and a one percent increase in WWTP sulfate increases the downstream sulfate by two mg/L. Again, the model is more sensitive to WWTP levels.

7.8 Summary

Presented in Table 7-3 is a summary of the projected water quality if Rhodia is to proceed with the proposed silica plant expansion. From Table 7-3, it is apparent that the proposed process will increase the TDS and sulfate levels above the current water quality standards, at peak loadings and low flow conditions in the four stream reaches, totaling 19 river miles. This is the basis behind seeking an adjusted standard.

TABLE 7-3

SUMMARY OF WATER QUALITY MODELING RESULTS
PREDICTED PEAK CONCENTRATIONS, mg/L

Parameter	Reach #1	Reach #2	Reach #3	Reach #4
Average TDS	2,160	2,130	1,670	1,500
Peak TDS	2,650	2,620	2,360	2,020
Existing Adjusted TDS WQ Standard	2,100	2,100	1,900	1,700
Average Sulfate	1,170	1,150	930	820
Peak Sulfate	1,350	1,340	1,160	1,000
Existing Adjusted Sulfate WQ Standard	1,000	1,000	850	750

Under low flow conditions and the maximum Rhodia loading, the TDS water quality will be above the current adjusted standard in all four reaches, with a projected maximum level of 2,650 mg/L in Reach #1. Sulfate levels will be above the existing adjusted standard under low flow conditions in all four reaches, with the maximum value of 1,350 mg/L projected in Reach #1. Chronic toxicity tests conducted at and above these levels demonstrated the absence of any aquatic toxicity.

8. SUMMARY AND CONCLUSION

Rhodia has approached the District with a request to expand its existing silica manufacturing process at its Chicago Heights plant. The process, which produces silica (SiO_2), generates an aqueous waste stream high in sodium sulfate. An average of 137,375 pounds per day and a maximum of 151,725 pounds per day of sodium sulfate will be generated by the silica process, in an annual average flow of 840,000 to 940,000 gallons per day. This waste stream will consequently be discharged to the District's WWTP, which has sufficient hydraulic capacity to handle the additional loading.

The District's WWTP cannot accept the proposed waste stream from the silica process without exceeding the existing adjusted water quality limits for total dissolved solids (TDS) and sulfates on the receiving stream, Thorn Creek, and subsequently the Little Calumet River. There are three reaches on Thorn Creek that will be impacted by the proposed expansion, and a potential fourth reach on the Little Calumet River under peak loading and low flow conditions.

Reach #1 is from the WWTP to the merger with Deer Creek. Reach #2 continues from the merger with Deer Creek to the USGS Station at Thornton, while Reach #3 is from the USGS Station to the merger with the Little Calumet River. The fourth reach is from the Thorn Creek confluence, with the Little Calumet River to the confluence of the Little Calumet River and the Calumet-Sag Channel. TDS levels, under the worst case scenario (low flow and peak loading) will increase to 2,650 mg/L in Reach #1, 2,620 mg/L in Reach #2, declining to 2,360 mg/L in Reach #3. The peak TDS level projected under the worst case scenario for Reach #4 is 2,020 mg/L.

Sulfates will increase to 1,350 mg/L in Reach #1 under the worst case scenario, declining to 1,160 mg/L by Reach #3. The peak sulfate level for the worst case scenario in Reach #4 will be 1,000 mg/L.

Thorn Creek flows 19.5 miles from its headwaters in Monee, Illinois to the Little Calumet River. In addition to numerous wastewater treatment plant outfalls on Thorn Creek and its tributaries, the creek receives considerable stormwater runoff from urban and rural areas. TDS levels upstream of the Thorn Creek WWTP outfall currently exceed the 1,000 mg/L water quality standard. A

biological survey on Thorn Creek, including fish and benthic organisms, was conducted to determine the current aquatic quality. Thorn Creek, from upstream of the District's outfall to downstream of the Butterfield Creek confluence is classified as a Limited Aquatic Resource, a common classification for urban streams.

Based on the Huff & Huff stream surveys, the IBI and MBI values have not significantly changed after the increase in TDS discharge. Pre-elevated TDS discharge MBI values indicated that Thorn Creek was "fair" quality and a moderate aquatic resource. The pre-elevated TDS discharge IBI values indicated that Thorn Creek was also "fair" quality; however, this rating indicates a limited aquatic resource.

The post-elevated TDS discharge MBI values indicated that Thorn Creek was "fair" quality and a limited aquatic resource upstream of the discharge and "fair" quality and a moderate aquatic resource downstream of the discharge. The post-elevated TDS discharge IBI values indicated that Thorn Creek was also "fair" quality and a limited aquatic resource both upstream and downstream of the discharge.

Both upstream and downstream stations, as well as, pre- and post-elevated TDS discharge stream quality ratings indicate that Thorn Creek is a "fair" quality stream. The small fluctuation between a limited aquatic resource and a moderate aquatic resource is suggestive of the normal fluctuation due to other factors such as a precipitation and ambient temperatures.

Given its proximity to urban areas, there is limited potential for future improvements in the aquatic community in Thorn Creek. Similar conclusions were drawn by Michael Ander of Dames & Moore (1990) during an environmental impact study of Deer Creek. Deer Creek, a tributary of Thorn Creek was identified as having limited potential uses due to the limited amount of water and habitat available. The IEPA noted a similar water quality classification in its annual water quality report (IEPA, 2000) for Thorn Creek and the Little Calumet River which were characterized as partial support for overall use and aquatic life use.

A biological assessment done in support of the NutraSweet/CIWC petition in AS 89-3 concluded a

TDS water quality level of 3,000 mg/L would not cause any undue stress to the aquatic life (Dames & Moore, 1981). This opinion was supported by the Illinois EPA (Studer, 1990). A toxicity investigation by Reed and Evans (1981) concluded that water quality sulfate levels of 1,000 mg/L would not be harmful to the aquatic biota.

To confirm the previous findings and to specifically address any potential chronic toxicity associated with the levels of sodium sulfate anticipated, bioassay tests were conducted using water from Thorn Creek. Sulfate and TDS levels up to 1,380 mg/L and 2,790 mg/L, respectively, were evaluated. No chronic (or acute) toxicity was observed in any of the tests using water fleas and fathead minnows. The maximum levels tested are greater than 100 percent of the peak levels projected by the models in Thorn Creek, thus providing a "safety factor" with respect to any chronic toxicity concern. Based on the assessment of Thorn Creek and the projection of Thorn Creek water quality with the proposed silica plant expansion, the TDS and sulfide levels projected and the requested water quality standards are summarized in Table 8-1.

TABLE 8-1

CURRENT REQUESTED WATER QUALITY STANDARDS

Reach Number	Current WQ Standard, mg/L	Requested WQ Standard, mg/L
TDS		
#1	2,100	2,650
#2	2,100	2,620
#3	1,900	2,360
#4	1,700	2,020
Sulfate		
#1	1,000	1,350
#2	1,000	1,340
#3	850	1,160
#4	750	1,000

Based upon the findings in this study, relief from the TDS and sulfate water quality standards on Thorn Creek and the Little Calumet River will not have any impact on the aquatic community in these streams. No other environmental impacts were identified herein. In summary, based upon the findings of this study; granting the changes in the water quality standard on the two waterways identified would allow Rhodia to expand the existing silica plant at its Illinois facility in Chicago Heights. No adverse environmental effects from the sodium sulfate discharge were identified in this study.

The economic benefits to this local community and to the State of Illinois from the proposed silica manufacturing facility warrants consideration of adapting the proposed water quality TDS and sulfate limits. The request for an adjusted standard to allow Rhodia to expand the silica plant at its Chicago Heights facility is consistent with historical water quality levels, existing (adjusted) water quality limits on a portion of Thorn Creek, and will not result in degrading the quality of aquatic community in Thorn Creek.

REFERENCES

American Public Works Association (APWA), Water Pollution Aspects of Urban Runoff, January, 1969.

Ander, M., Dames & Moore, IPCB Testimony, AS89-3, 1990.

Becker, G.C., Fishes of Wisconsin, University of Wisconsin Press, 1983.

Bertrand, B., Des Plaines River Basin Fisheries Assessment, Illinois Department of Conservation, Division of Fish and Wildlife Resources, 1984.

Bishop, P.L. and N.E. Kinner, "Rotating Biological Contractor Treatment of Hypersaline Wastes," Proceedings of the 36th Industrial Waste Conference, Purdue University, Ann Arbor Science, 1981.

Cunningham, Lee, IPCB Petition, AS89-3, 1990.

Dames & Moore, Stream Survey of Deer Creek, Park Forest South, Searle Chemicals, Inc., 1982.

Dames & Moore, Final Report, Evaluation of Potential Groundwater Impacts, Deer Creek Basin, Will and Cook Counties, Illinois, 1986.

Dames & Moore, Final Report, Irrigation Survey of Portions of Deer and Thorn Creek Basins, Will and Cook Counties, Illinois, 1989.

Dames & Moore, Final Report, Investigation of Total Dissolved Solids Levels in Deer and Thorn Creeks, Cook and Will Counties, Illinois, 1989.

Daugherty, J.L., Survey of Uses of Thorn Creek, May, 1989.

Dowden, B.F. and H.J. Bennett, "Toxicity of Selected Chemical to Certain Animals," JWPCF, Vol. 37, No. 9, 1965.

Eis, B. J., Ferguson, J. F., Benjamin, M. M. The Fate and Effect of Bisulfate in Anaerobic Treatment. Journal WPCF. Volume 55. Number 11. PP 1355-1365.

Environmental Protection Agency (EPA), Technical Support Document for Water Quality- based Toxics Control, EPA/505/2-90-11, March, 1991.

Higgins, M.J., L.A. Miller, and D. Sobeck, "Improving Industrial Wastewater Treatment Using Divalent Cation Addition", Water Environmental Federation, WEFTEC 99, New Orleans, LA, 1999.

Hill, D.O. and S.R. Gelman, "Effects of Chloride on Nitrification Rates in Activated Sludge Systems," Proceedings of the 32nd Industrial Waste Conference, Purdue University, Ann Arbor Science, 1977.

Hilton, B. L., Oleszkiewicz, J. A., "Toxicity of Sulfides to The Anaerobic Treatment Process". Purdue University Industrial Waste Conference Proceedings. Volume 42. PP739-747.

Hilsenhoff, W.L., The Aquatic Insects of Wisconsin, Natural History Council, 1981.

Hockenbury, M.R. D. Burstein, and E.S. Jamro, "Total Dissolved Solids Effects on Biological Treatment, "Proceedings of the 32nd Industrial Waste Conference, Purdue University, Ann Arbor Science, 1977.

Huff & Huff, Inc. Environmental Assessment for the Proposed Total Dissolved Solids Discharged from the Thorn Creek Basin Sanitary District, 1993.

Huff & Huff, Inc. Biological Survey of Thorn Creek, 1994.

Huff & Huff, Inc. Biological Survey of Thorn Creek Late Summer, 1997, 1997.

Illinois Environmental Protection Agency (IEPA), Illinois Water Quality Report, IEPA/WPC 184-024, 1984.

Illinois Environmental Protection Agency (IEPA), Illinois Water Quality Report, 1990-1991, IEPA/WPC/92-055, 1992.

Illinois Environmental Protection Agency (IEPA), Biological and Water Quality Survey of Thorn Creek (HBD) in the Vicinity of the Thorn Creek Basin Sanitary District Sewage Treatment Plant, Cook County, Illinois, Staff Report, 1988.

Illinois Environmental Protection Agency (IEPA), Stream Characterization (BSC): A Biological Assessment of Illinois Stream Quality, Special Report #13 of the Illinois State Water Plan Task Force, IEPA/WPC/89-275, 1989.

Illinois Environmental Protection Agency (IEPA), W. Matsunuga, telephone conversation, January, 1993.

Illinois Environmental Protection Agency, Illinois Water Quality Report, 1992-1993, IEPA/WPC/94-160, 1994.

Illinois Environmental Protection Agency, Illinois Water Quality Report, 1994-1995, IEPA/BOW/96-060a, 1996.

Illinois Environmental Protection Agency, Illinois Water Quality Report, 2000, IEPA/BOW/00-005, April 2000.

Loomis, K.S. and J.E. Huff, Biological Survey of North Kent Creek, Huff & Huff, Inc., 1988.

Maree, J. P., Gerber, A., Hill, E. "An Intergrated Process For Biological Treatment Of Sulfate-Containing Industrial Effluents". Journal WPCF. Volume 59. Number 12. PP 1069-1074.

McCafferty, W. Patrick, Aquatic Entomology, Science Books International, 1981.

Merritt, R. W. and K. W. Cummins, (eds.), An Introduction to Aquatic Insects, Kendall/Hunt Publishing Co., 1984.

Middleton, A. C., Lawrence, A. W., "Kinetics of Microbial Sulfate Reduction". Journal WPCF. 1966. PP1659-1670.

Pennak, R. W., Freshwater Invertebrates of the United States: Protozoa to Mollusca, John Wiley & Sons, Inc., 1989.

Pollution Control Board - Opinion and Order of the Board (by D. Anderson); PBC83-73, G.D. Searle, et al., v IEPA, December 29, 1983.

Pope, D.H et al. "Microbiologically Influenced Corrosion and Hydrogen Sulfide Production in Gas Industry Facilities". American Gas Association Operating Section Proceedings 1989

Reed, P. and R. Evans, Acute Toxicity of Chlorides, Sulfates, and Total Dissolved Solids to Some Fishes of Illinois, SWS Contract Report 283, September, 1981.

Schmeelk, W.G., S.G. Dennison, P. O'Brien, 1983 Annual Summary Report, Water Quality Within the Waterways System of the Metropolitan Sanitary District of Greater Chicago, Vol 2, Biological, Report 85-23-B, MSDGC, 1986.

Smith, P. W., The Fishes of Illinois, University of Illinois Press, 1979.

Studer, D., Agency Testimony, AS89-3, 1990.

Tchobanoglous, G., Burton, F. G., Metcalf & Eddy, Inc. "Wastewater Engineering Treatment, Disposal, and Reuse 3rd Edition". McGraw-Hill Publishing Company. New York. 1991.

Tokuz, R.Y. and W.W. Eckenfelder, "The Effect of F/M Ratio on Activated Sludge System Treating High Salinity Wastewater", Proceeding of the 23rd Industrial Waste Conference, Purdue University, May 1978.

Trama, F.B., "The Acute Toxicity of Some Common Salts of Sodium, Potassium, and Calcium to the Common Bluegill," Proceedings of the Academy of Natural Sciences of Philadelphia, Vol. 106, 1954.

Uberoi, V., Bhattacharya, S. K. "Sulfate-Reducing Bacteria In Anaerobic PropionateSystems". Journal of Environmental Engineering. July 1997. PP 675-682.

U.S. Geological Survey (USGS), River Mileages and Drainage Areas for Illinois Streams - Volume 2, Illinois River Basin, USGS Water-Resources Investigation, 79-111, 1979.

United States Environmental Protection Agency, Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Water, EPA/600/4-90/030, 1990

Von Ende, Carl N. and Darryl J. Beckett, Biological Survey of Thorn Creek for Huff & Huff, Inc., 1993

Wallen, I.E., W.C. Greer, and R. Lasater, "Toxicity to *Gambusia affinis* of Certain Pure Chemical in Turbid Waters," Sewage and Industrial Wastes, Vol. 29, No.6, 1957.

WEF Manual of Practice No. 8. ASCE Manual and Report on Engineering Practice No. 76. Design of Municipal Wastewater Treatment Plants Volume I: Chapters 1-12.

AVERAGE CONDITIONS

FLOWRATE vs. TDS CONCENTRATION at THORNTON STATION

Reach #2

Thorn Creek			Deer Creek			Thorn Creek (at Sta. 05536275)		
Flow, mgd	TDS, mg/l	TDS, lbs/d	Flow, mgd	TDS, mg/l	TDS, lbs/d	Flow, mgd	TDS, mg/l	TDS, lbs/d
11.4	2156	204433	0.20	689	1149	11.57	2131	205583
15.4	1777	228564	3	689	23175	18	1642	251739
19.5	1555	252695	6	689	39009	25	1388	291704
23.5	1410	276826	8	689	54843	32	1242	331669
27.6	1308	300957	11	689	70677	39	1148	371634
31.7	1231	325087	14	689	86511	46	1082	411598
32.9	1210	332512	17	689	102345	50	1050	434857
34.2	1190	339936	19	689	118179	54	1022	458115
35.5	1172	347360	22	689	134014	58	999	481373
36.8	1155	354784	25	689	149848	62	979	504632
38.1	1139	362208	26	689	154173	64	969	516381
39.4	1125	369632	27	689	159189	66	960	528821
40.7	1111	377057	27	689	164205	68	952	541262
42.0	1098	384481	28	689	169222	70	944	553702
43.3	1086	391905	29	689	174238	73	936	566143
44.6	1074	399329	30	689	179254	75	929	578583
45.9	1063	406753	31	689	184271	77	922	591024
47.2	1053	414177	32	689	189287	79	916	603464
48.5	1043	421602	33	689	194303	81	910	615905
49.7	1034	429026	34	689	199320	83	904	628345
51.0	1025	436450	34	689	204336	86	898	640786
52.3	1017	443874	35	689	209352	88	893	653226
53.6	1009	451298	36	689	214369	90	888	665667
54.9	1002	458722	37	689	219385	92	884	678107
56.2	994	466147	38	689	224401	94	879	690548
57.5	988	473571	39	689	229418	96	875	702988
58.8	981	480995	40	689	234434	99	871	715429
60.1	975	488419	41	689	239450	101	867	727869
61.4	969	495843	41	689	244467	103	863	740310
62.7	963	503267	42	689	249483	105	860	752750
64.0	957	510692	43	689	254499	107	856	765191
65.2	952	518116	44	689	259516	109	853	777631
66.5	947	525540	45	689	264532	111	850	790072
67.8	942	532964	46	689	269548	114	847	802512
69.1	937	540388	47	689	274565	116	844	814953
70.4	933	547812	48	689	279581	118	841	827393
71.7	928	555237	48	689	284597	120	838	839834
73.0	924	562661	49	689	289614	122	835	852274
74.3	920	570085	50	689	294630	124	833	864715
75.6	916	577509	51	689	299646	127	830	877155
76.9	912	584933	52	689	304662	129	828	889596
78.2	909	592357	53	689	309679	131	826	902036
79.5	905	599782	54	689	314695	133	824	914477
80.8	902	607206	55	689	319711	135	821	926917
82.0	898	614630	55	689	324728	137	819	939358
83.3	895	622054	56	689	329744	140	817	951798
84.6	892	629478	57	689	334760	142	815	964239
85.9	889	636902	58	689	339777	144	813	976679
87.2	886	644327	59	689	344793	146	812	989120
88.5	883	651751	60	689	349809	148	810	1001560
89.8	880	659175	61	689	354826	150	808	1014001
91.1	877	666599	62	689	359842	153	806	1026441
92.4	875	674023	62	689	364858	155	805	1038882
93.7	872	681447	63	689	369875	157	803	1051322
95.0	870	688872	64	689	374891	159	802	1063763
96.3	867	696296	65	689	379907	161	800	1076203
97.5	865	703720	66	689	384924	163	799	1088644
98.8	863	711144	67	689	389940	166	797	1101084
100.1	860	718568	68	689	394956	168	796	1113525
101.4	858	725992	69	689	399973	170	794	1125965
102.7	856	733417	69	689	404989	172	793	1138406
104.0	854	740841	70	689	410005	174	792	1150846

Deer Creek loading calculated from Deer Creek flow less average CIWC discharge and 689 mg/l (avg. Thorn Cr. TDS upstream of Thorn Cr. WWTP) plus average CIWC loading (13,374 lbs/d).

Thorn Creek values from Reach #1 model for average Rhodia TDS loadings

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[TCR2AT2.xls]Table
03/15/2000 10:47

AVERAGE CONDITIONS

FLOWRATE,mgd vs. TDS, mg/l BEYOND THORNTON STATION

Reach #3

Thorn Creek			Rhodia			Projected Loadings		
Flow, mgd	Average TDS, mg/l	TDS, lbs/d	Average Flow, mgd	Average TDS, mg/l	Average TDS, lbs/d	Flow, mgd	TDS, mg/l	TDS, lbs/d
13.2	531	58457	0.84	19614	137375	14	1672	195832
14	531	62000	0.84	19614	137375	15	1611	199375
16	531	70857	0.84	19614	137375	17	1483	208232
18	531	79714	0.84	19614	137375	19	1382	217089
20	531	88571	0.84	19614	137375	21	1300	225946
22	531	97428	0.84	19614	137375	23	1233	234803
24	531	106285	0.84	19614	137375	25	1176	243660
26	531	115142	0.84	19614	137375	27	1128	252517
28	531	123999	0.84	19614	137375	29	1087	261374
30	531	132856	0.84	19614	137375	31	1051	270231
32	531	141713	0.84	19614	137375	33	1019	279088
34	531	150570	0.84	19614	137375	35	991	287945
36	531	159427	0.84	19614	137375	37	966	296802
38	531	168285	0.84	19614	137375	39	944	305660
40	531	177142	0.84	19614	137375	41	923	314517
42	531	185999	0.84	19614	137375	43	905	323374
44	531	194856	0.84	19614	137375	45	888	332231
46	531	203713	0.84	19614	137375	47	873	341088
48	531	212570	0.84	19614	137375	49	859	349945
50	531	221427	0.84	19614	137375	51	846	358802
55	531	243570	0.84	19614	137375	56	818	380945
60	531	265712	0.84	19614	137375	61	794	403087
65	531	287855	0.84	19614	137375	66	774	425230
70	531	309998	0.84	19614	137375	71	757	447373
75	531	332141	0.84	19614	137375	76	742	469516
80	531	354283	0.84	19614	137375	81	729	491658
85	531	376426	0.84	19614	137375	86	718	513801
90	531	398569	0.84	19614	137375	91	707	535944
95	531	420711	0.84	19614	137375	96	698	558086
100	531	442854	0.84	19614	137375	101	690	580229
105	531	464997	0.84	19614	137375	106	682	602372
110	531	487139	0.84	19614	137375	111	676	624514
115	531	509282	0.84	19614	137375	116	669	646657
120	531	531425	0.84	19614	137375	121	664	668800
125	531	553568	0.84	19614	137375	126	658	690943
130	531	575710	0.84	19614	137375	131	653	713085
135	531	597853	0.84	19614	137375	136	649	735228
140	531	619996	0.84	19614	137375	141	645	757371
145	531	642138	0.84	19614	137375	146	641	779513
150	531	664281	0.84	19614	137375	151	637	801656
155	531	686424	0.84	19614	137375	156	634	823799
160	531	708566	0.84	19614	137375	161	631	845941
165	531	730709	0.84	19614	137375	166	628	868084
170	531	752852	0.84	19614	137375	171	625	890227
175	531	774995	0.84	19614	137375	176	622	912370
180	531	797137	0.84	19614	137375	181	620	934512
185	531	819280	0.84	19614	137375	186	617	956655
190	531	841423	0.84	19614	137375	191	615	978798
195	531	863565	0.84	19614	137375	196	613	1000940
200	531	885708	0.84	19614	137375	201	611	1023083
205	531	907851	0.84	19614	137375	206	609	1045226
210	531	929993	0.84	19614	137375	211	607	1067368
215	531	952136	0.84	19614	137375	216	605	1089511
220	531	974279	0.84	19614	137375	221	604	1111654
225	531	996422	0.84	19614	137375	226	602	1133797
230	531	1018564	0.84	19614	137375	231	600	1155939
235	531	1040707	0.84	19614	137375	236	599	1178082
240	531	1062850	0.84	19614	137375	241	598	1200225
245	531	1084992	0.84	19614	137375	246	596	1222367
250	531	1107135	0.84	19614	137375	251	595	1244510

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[TCR3AVT.xls]Table
03/15/2000 10:52

Notes:

Thorn Creek

Flow values start at 7Q10 (13.2 mgd) and increase by 2 until 50 mgd where values increase by 5 mgd. TDS concentration is average summation of major ions currently in Thorn Creek (Obtained from USGS 1991 water year Thornton station data)

Rhodia

Rhodia values are annual average values

AVERAGE CONDITIONS

FLOWRATE, mgd vs. TDS, mg/l in the LITTLE CALUMET RIVER
Reach #4

Thorn Creek			Little Calumet River at Munster, In			Projected Loading		
		Average			Average			
Flow, mgd	TDS, mg/l	TDS, lbs/d	Flow, mgd	TDS, mg/l	TDS, lbs/d	Flow, mgd	TDS, mg/l	TDS, lbs/d
14	1672	195832	4.85	1000	40449	19	1500	236281
15	1611	199375	8	464	29449	22	1222	228823
17	1483	208232	10	464	40129	27	1094	248361
19	1382	217089	13	464	50810	32	1005	267899
21	1300	225946	16	464	61490	37	938	287436
23	1233	234803	19	464	72171	41	887	306974
25	1176	243660	21	464	82852	46	846	326512
27	1128	252517	24	464	93532	51	813	346049
29	1087	261374	27	464	104213	56	786	365587
31	1051	270231	30	464	114893	61	763	385124
33	1019	279088	32	464	125574	65	743	404662
35	991	287945	35	464	136254	70	726	424200
37	966	296802	38	464	146935	75	711	443737
39	944	305660	41	464	157615	80	698	463275
41	923	314517	43	464	168296	84	686	482812
43	905	323374	46	464	178976	89	676	502350
45	888	332231	49	464	189657	94	667	521888
47	873	341088	52	464	200337	99	658	541425
49	859	349945	55	464	211018	103	651	560963
51	846	358802	57	464	221699	108	644	580501
56	818	380945	60	464	232379	116	635	613324
61	794	403087	65	464	251728	126	624	654815
66	774	425230	70	464	271077	136	614	696307
71	757	447373	75	464	290425	146	606	737798
76	742	469516	80	464	309774	156	599	779290
81	729	491658	85	464	329123	166	593	820781
86	718	513801	90	464	348472	176	588	862273
91	707	535944	95	464	367821	186	583	903764
96	698	558086	100	464	387169	196	579	945256
101	690	580229	105	464	406518	206	575	986747
106	682	602372	110	464	425867	216	571	1028239
111	676	624514	115	464	445216	226	568	1069730
116	669	646657	120	464	464565	236	565	1111222
121	664	668800	125	464	483913	246	562	1152713
126	658	690943	130	464	503262	256	560	1194205
131	653	713085	135	464	522611	266	557	1235696
136	649	735228	140	464	541960	276	555	1277188
141	645	757371	145	464	561309	286	553	1318679
146	641	779513	150	464	580657	296	551	1360171
151	637	801656	155	464	600006	306	549	1401662
156	634	823799	160	464	619355	316	548	1443154
161	631	845941	165	464	638704	326	546	1484645
166	628	868084	170	464	658053	336	545	1526137
171	625	890227	175	464	677401	346	543	1567628
176	622	912370	180	464	696750	356	542	1609120
181	620	934512	185	464	716099	366	541	1650611
186	617	956655	190	464	735448	376	540	1692103
191	615	978798	195	464	754797	386	539	1733594
196	613	1000940	200	464	774145	396	538	1775086
201	611	1023083	205	464	793494	406	537	1816577
206	609	1045226	210	464	812843	416	536	1858069
211	607	1067368	215	464	832192	426	535	1899560
216	605	1089511	220	464	851541	436	534	1941052
221	604	1111654	225	464	870889	446	533	1982543
226	602	1133797	230	464	890238	456	532	2024035
231	600	1155939	235	464	909587	466	532	2065526
236	599	1178082	240	464	928936	476	531	2107018
241	598	1200225	245	464	948285	486	530	2148509
246	596	1222367	250	464	967633	496	530	2190001
251	595	1244510	255	464	986982	506	529	2231492

Notes:

Thorn Creek:
Flow and TDS values are from Reach #3 for Average TDS loading

Little Calumet River
Flow values start at the 7Q10 for the Munster Station and increase by 2.76 mgd until 60 mgd, the average flow. This corresponds to Thorn Creeks median flow of 56 mgd.
TDS level is the average TDS for the Munster Station and at low flow is 1000 mg/l, the water quality standard.

AVERAGE CONDITIONS

Flowrate, mgd vs. Sulfate, mg/l

Reach #1

Upstream				Treatment Plant				Rhodia				USGS Station			
Flow, mgd	Flow, cfs	Average Sulfate, mg/l	Average Sulfate, lbs/d	Flow, mgd	Flow, cfs	Average Sulfate, mg/l	Average Sulfate, lbs/d	Flow, mgd	Flow, cfs	Average Sulfate, mg/l	Average Sulfate, lbs/d	Flow, mgd	Flow, cfs	Sulfate, mg/l	Sulfate, lbs/d
0.19	0.3	186	301	10.34	16	207	17844	0.84	1.3	13243	92750	11.37	18	1169	110894
2.96	5	186	4590	11.63	18	207	20074	0.84	1.3	13243	92750	15.43	24	913	117414
5.72	9	186	8879	12.92	20	207	22305	0.84	1.3	13243	92750	19.48	30	763	123933
8.49	13	186	13168	14.21	22	207	24535	0.84	1.3	13243	92750	23.54	36	664	130453
11.25	17	186	17457	15.50	24	207	26766	0.84	1.3	13243	92750	27.60	43	595	136972
14.02	22	186	21746	16.80	26	207	28996	0.84	1.3	13243	92750	31.65	49	544	143492
15.31	24	186	23750	16.80	26	207	28996	0.84	1.3	13243	92750	32.95	51	530	145496
16.60	26	186	25754	16.80	26	207	28996	0.84	1.3	13243	92750	34.24	53	517	147500
17.89	28	186	27758	16.80	26	207	28996	0.84	1.3	13243	92750	35.53	55	505	149504
19.19	30	186	29762	16.80	26	207	28996	0.84	1.3	13243	92750	36.82	57	493	151509
20.48	32	186	31767	16.80	26	207	28996	0.84	1.3	13243	92750	38.11	59	483	153513
21.77	34	186	33771	16.80	26	207	28996	0.84	1.3	13243	92750	39.41	61	473	155517
23.06	36	186	35775	16.80	26	207	28996	0.84	1.3	13243	92750	40.70	63	464	157521
24.35	38	186	37779	16.80	26	207	28996	0.84	1.3	13243	92750	41.99	65	456	159525
25.65	40	186	39783	16.80	26	207	28996	0.84	1.3	13243	92750	43.28	67	447	161530
26.94	42	186	41788	16.80	26	207	28996	0.84	1.3	13243	92750	44.57	69	440	163534
28.23	44	186	43792	16.80	26	207	28996	0.84	1.3	13243	92750	45.87	71	433	165538
29.52	46	186	45796	16.80	26	207	28996	0.84	1.3	13243	92750	47.16	73	426	167542
30.81	48	186	47800	16.80	26	207	28996	0.84	1.3	13243	92750	48.45	75	420	169546
32.11	50	186	49804	16.80	26	207	28996	0.84	1.3	13243	92750	49.74	77	414	171551
33.40	52	186	51809	16.80	26	207	28996	0.84	1.3	13243	92750	51.03	79	408	173555
34.69	54	186	53813	16.80	26	207	28996	0.84	1.3	13243	92750	52.33	81	402	175559
35.98	56	186	55817	16.80	26	207	28996	0.84	1.3	13243	92750	53.62	83	397	177563
37.27	58	186	57821	16.80	26	207	28996	0.84	1.3	13243	92750	54.91	85	392	179568
38.57	60	186	59825	16.80	26	207	28996	0.84	1.3	13243	92750	56.20	87	387	181572
39.86	62	186	61830	16.80	26	207	28996	0.84	1.3	13243	92750	57.49	89	383	183576
41.15	64	186	63834	16.80	26	207	28996	0.84	1.3	13243	92750	58.79	91	379	185580
42.44	66	186	65838	16.80	26	207	28996	0.84	1.3	13243	92750	60.08	93	374	187584
43.73	68	186	67842	16.80	26	207	28996	0.84	1.3	13243	92750	61.37	95	370	189589
45.03	70	186	69846	16.80	26	207	28996	0.84	1.3	13243	92750	62.66	97	367	191593
46.32	72	186	71851	16.80	26	207	28996	0.84	1.3	13243	92750	63.95	99	363	193597
47.61	74	186	73855	16.80	26	207	28996	0.84	1.3	13243	92750	65.25	101	359	195601
48.90	76	186	75859	16.80	26	207	28996	0.84	1.3	13243	92750	66.54	103	356	197605
50.19	78	186	77863	16.80	26	207	28996	0.84	1.3	13243	92750	67.83	105	353	199610
51.49	80	186	79867	16.80	26	207	28996	0.84	1.3	13243	92750	69.12	107	350	201614
52.78	82	186	81872	16.80	26	207	28996	0.84	1.3	13243	92750	70.41	109	347	203618
54.07	84	186	83876	16.80	26	207	28996	0.84	1.3	13243	92750	71.71	111	344	205622
55.36	86	186	85880	16.80	26	207	28996	0.84	1.3	13243	92750	73.00	113	341	207626
56.65	88	186	87884	16.80	26	207	28996	0.84	1.3	13243	92750	74.29	115	338	209631
57.95	90	186	89888	16.80	26	207	28996	0.84	1.3	13243	92750	75.58	117	336	211635
59.24	92	186	91893	16.80	26	207	28996	0.84	1.3	13243	92750	76.87	119	333	213639
60.53	94	186	93897	16.80	26	207	28996	0.84	1.3	13243	92750	78.17	121	331	215643
61.82	96	186	95901	16.80	26	207	28996	0.84	1.3	13243	92750	79.46	123	328	217647
63.11	98	186	97905	16.80	26	207	28996	0.84	1.3	13243	92750	80.75	125	326	219652
64.41	100	186	99909	16.80	26	207	28996	0.84	1.3	13243	92750	82.04	127	324	221656
65.70	102	186	101914	16.80	26	207	28996	0.84	1.3	13243	92750	83.33	129	322	223660
66.99	104	186	103918	16.80	26	207	28996	0.84	1.3	13243	92750	84.63	131	320	225664
68.28	106	186	105922	16.80	26	207	28996	0.84	1.3	13243	92750	85.92	133	318	227668
69.57	108	186	107926	16.80	26	207	28996	0.84	1.3	13243	92750	87.21	135	316	229673
70.87	110	186	109930	16.80	26	207	28996	0.84	1.3	13243	92750	88.50	137	314	231677
72.16	112	186	111935	16.80	26	207	28996	0.84	1.3	13243	92750	89.79	139	312	233681
73.45	114	186	113939	16.80	26	207	28996	0.84	1.3	13243	92750	91.09	141	310	235685
74.74	116	186	115943	16.80	26	207	28996	0.84	1.3	13243	92750	92.38	143	309	237689
76.03	118	186	117947	16.80	26	207	28996	0.84	1.3	13243	92750	93.67	145	307	239694
77.33	120	186	119951	16.80	26	207	28996	0.84	1.3	13243	92750	94.96	147	305	241698
78.62	122	186	121956	16.80	26	207	28996	0.84	1.3	13243	92750	96.25	149	304	243702
79.91	124	186	123960	16.80	26	207	28996	0.84	1.3	13243	92750	97.55	151	302	245706
81.20	126	186	125964	16.80	26	207	28996	0.84	1.3	13243	92750	98.84	153	301	247710
82.49	128	186	127968	16.80	26	207	28996	0.84	1.3	13243	92750	100.13	155	299	249715
83.79	130	186	129973	16.80	26	207	28996	0.84	1.3	13243	92750	101.42	157	298	251719
85.08	132	186	131977	16.80	26	207	28996	0.84	1.3	13243	92750	102.71	159	296	253723
86.37	134	186	133981	16.80	26	207	28996	0.84	1.3	13243	92750	104.01	161	295	255727

\\Darlene\C\IDOC\Thorncrk\Rhodia99Tab\[TCR1AVS.xls]Table
3/15/00 15:09

Notes:

Upstream:
Flow values for upstream start from 7Q10 (0.3 cfs) and increase to average (21.7 cfs).
Average upstream flow occurs simultaneously with average Thorn Creek Basin WWTP flow (25.9 cfs).
Flows then increase by 2 cfs.
Sulfate taken as 27% TDS

Treatment Plant:
Flow values start from 7Q10 low flow at downstream USGS station. This assumes that all downstream flow during low flow conditions (prior to Rhone-Poulenc additional flow) is from treatment plant.
As this model is predicting downstream conditions during average treatment plant performance, once the average flow (25.9 cfs) is reached, it is held constant.
Sulfate taken as 27% TDS

Rhodia:
Rhodia flow is the flow (1.3 cfs) during the max. loading (92,750 lbs/d).
Sulfate taken as 68% TDS (TDS is 100% from sodium sulfate)

Sources:

Upstream and treatment plant TDS/Sulfate values from Thorn Creek Basin Monitoring (NOV. 92 - APR. 93)
Upstream and treatment plant 7Q10 values from 1SWS 1993 report
Upstream average flow obtained from USGS 1979 Water Resource data
Treatment plant average flow from 1992 DMRs
Rhone-Poulenc values are annual average values.

AVERAGE CONDITIONS

FLOWRATE vs. SULFATE CONCENTRATION at THORNTON STATION

Reach #2

Thorn Creek			Deer Creek			Thorn Creek (at Sta. 05536275)		
Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d
11.37	1169	110894	0.20	106	177	11.57	1151	111071
15.43	913	117414	3	106	6257	18	807	123671
19.48	763	123933	6	106	10531	25	640	134465
23.54	664	130453	8	106	14806	32	544	145259
27.60	595	136972	11	106	19080	39	482	156053
31.65	544	143492	14	106	23355	46	438	166847
32.95	530	145496	17	106	27629	50	418	173125
34.24	517	147500	19	106	31904	54	400	179404
35.53	505	149504	22	106	36178	58	385	185683
36.82	493	151509	25	106	40453	62	372	191962
38.11	483	153513	26	106	41621	64	366	195133
39.41	473	155517	27	106	42975	66	360	198492
40.70	464	157521	27	106	44329	68	355	201850
41.99	456	159525	28	106	45683	70	350	205209
43.28	447	161530	29	106	47037	73	345	208567
44.57	440	163534	30	106	48391	75	340	211925
45.87	433	165538	31	106	49746	77	336	215284
47.16	426	167542	32	106	51100	79	332	218642
48.45	420	169546	33	106	52454	81	328	222001
49.74	414	171551	34	106	53808	83	324	225359
51.03	408	173555	34	106	55162	86	321	228717
52.33	402	175559	35	106	56517	88	317	232076
53.62	397	177563	36	106	57871	90	314	235434
54.91	392	179568	37	106	59225	92	311	238793
56.20	387	181572	38	106	60579	94	308	242151
57.49	383	183576	39	106	61933	96	306	245509
58.79	379	185580	40	106	63288	99	303	248868
60.08	374	187584	41	106	64642	101	300	252226
61.37	370	189589	41	106	65996	103	298	255584
62.66	367	191593	42	106	67350	105	296	258943
63.95	363	193597	43	106	68704	107	293	262301
65.25	359	195601	44	106	70059	109	291	265660
66.54	356	197605	45	106	71413	111	289	269018
67.83	353	199610	46	106	72767	114	287	272376
69.12	350	201614	47	106	74121	116	285	275735
70.41	347	203618	48	106	75475	118	284	279093
71.71	344	205622	48	106	76829	120	282	282452
73.00	341	207626	49	106	78184	122	280	285810
74.29	338	209631	50	106	79538	124	279	289168
75.58	336	211635	51	106	80892	127	277	292527
76.87	333	213639	52	106	82246	129	275	295885
78.17	331	215643	53	106	83600	131	274	299244
79.46	328	217647	54	106	84955	133	273	302602
80.75	326	219652	55	106	86309	135	271	305960
82.04	324	221656	55	106	87663	137	270	309319
83.33	322	223660	56	106	89017	140	268	312677
84.63	320	225664	57	106	90371	142	267	316036
85.92	318	227668	58	106	91726	144	266	319394
87.21	316	229673	59	106	93080	146	265	322752
88.50	314	231677	60	106	94434	148	264	326111
89.79	312	233681	61	106	95788	150	263	329469
91.09	310	235685	62	106	97142	153	261	332827
92.38	309	237689	62	106	98496	155	260	336186
93.67	307	239694	63	106	99851	157	259	339544
94.96	305	241698	64	106	101205	159	258	342903
96.25	304	243702	65	106	102559	161	257	346261
97.55	302	245706	66	106	103913	163	256	349619
98.84	301	247710	67	106	105267	166	256	352978
100.13	299	249715	68	106	106622	168	255	356336
101.42	298	251719	69	106	107976	170	254	359695
102.71	296	253723	69	106	109330	172	253	363053
104.01	295	255727	70	106	110684	174	252	366411

Deer Creek 7Q10 sulfate concentration set at 500 mg/l water quality standard
Loadings for flows higher than 7Q10 calculated from Deer Creek flow
less average CIWC flow (1.25 mgd) and 186 mg/l sulfate (27% of upstream TDS
concentration of 689 mg/l) plus average CIWC sulfate loading of 3611 lbs/day
(27% of average TDS loading of 13374 lbs/d)

Thorn Creek values from Reach #1 model for average Rhodia
sulfate loadings.

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[TCR2AVS.xls]Table
03/15/2000 10:57

AVERAGE CONDITIONS

FLOWRATE,mgd vs. SULFATE, mg/l BEYOND THORNTON STATION

Reach #3

Thorn Creek			Rhodia			Projected Loadings		
Flow, mgd	Average Sulfate, mg/l	Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Average Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d
13.2	149	16403	0.84	13243	92750	14	932	109153
14	149	17397	0.84	13243	92750	15	890	110147
16	149	19883	0.84	13243	92750	17	802	112633
18	149	22368	0.84	13243	92750	19	733	115118
20	149	24853	0.84	13243	92750	21	677	117603
22	149	27339	0.84	13243	92750	23	630	120089
24	149	29824	0.84	13243	92750	25	592	122574
26	149	32309	0.84	13243	92750	27	559	125059
28	149	34794	0.84	13243	92750	29	530	127544
30	149	37280	0.84	13243	92750	31	506	130030
32	149	39765	0.84	13243	92750	33	484	132515
34	149	42250	0.84	13243	92750	35	465	135000
36	149	44736	0.84	13243	92750	37	447	137486
38	149	47221	0.84	13243	92750	39	432	139971
40	149	49706	0.84	13243	92750	41	418	142456
42	149	52192	0.84	13243	92750	43	406	144942
44	149	54677	0.84	13243	92750	45	394	147427
46	149	57162	0.84	13243	92750	47	384	149912
48	149	59648	0.84	13243	92750	49	374	152398
50	149	62133	0.84	13243	92750	51	365	154883
55	149	68346	0.84	13243	92750	56	346	161096
60	149	74560	0.84	13243	92750	61	330	167310
65	149	80773	0.84	13243	92750	66	316	173523
70	149	86986	0.84	13243	92750	71	304	179736
75	149	93200	0.84	13243	92750	76	294	185950
80	149	99413	0.84	13243	92750	81	285	192163
85	149	105626	0.84	13243	92750	86	277	198376
90	149	111839	0.84	13243	92750	91	270	204589
95	149	118053	0.84	13243	92750	96	264	210803
100	149	124266	0.84	13243	92750	101	258	217016
105	149	130479	0.84	13243	92750	106	253	223229
110	149	136693	0.84	13243	92750	111	248	229443
115	149	142906	0.84	13243	92750	116	244	235656
120	149	149119	0.84	13243	92750	121	240	241869
125	149	155333	0.84	13243	92750	126	236	248083
130	149	161546	0.84	13243	92750	131	233	254296
135	149	167759	0.84	13243	92750	136	230	260509
140	149	173972	0.84	13243	92750	141	227	266722
145	149	180186	0.84	13243	92750	146	224	272936
150	149	186399	0.84	13243	92750	151	222	279149
155	149	192612	0.84	13243	92750	156	220	285362
160	149	198826	0.84	13243	92750	161	217	291576
165	149	205039	0.84	13243	92750	166	215	297789
170	149	211252	0.84	13243	92750	171	213	304002
175	149	217466	0.84	13243	92750	176	212	310216
180	149	223679	0.84	13243	92750	181	210	316429
185	149	229892	0.84	13243	92750	186	208	322642
190	149	236105	0.84	13243	92750	191	207	328855
195	149	242319	0.84	13243	92750	196	205	335069
200	149	248532	0.84	13243	92750	201	204	341282
205	149	254745	0.84	13243	92750	206	202	347495
210	149	260959	0.84	13243	92750	211	201	353709
215	149	267172	0.84	13243	92750	216	200	359922
220	149	273385	0.84	13243	92750	221	199	366135
225	149	279599	0.84	13243	92750	226	198	372349
230	149	285812	0.84	13243	92750	231	197	378562
235	149	292025	0.84	13243	92750	236	196	384775
240	149	298238	0.84	13243	92750	241	195	390988
245	149	304452	0.84	13243	92750	246	194	397202
250	149	310665	0.84	13243	92750	251	193	403415

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[TCR3AVS.xls]Table
03/15/2000 10:59

Notes:

Thorn Creek

Flow values start at 7Q10 (13.2 mgd) and increase by 2 until 50 mgd where values increase by 5 mgd. Sulfate concentration is average of sulfate ion concentrations.
(Obtained from USGS 1991 water year Thornton station data)

Rhodia

Rhodia values are annual average values
Sulfate is taken as 68% of average TDS loading based on molecular weight (TDS is 100% from sodium sulfate)

AVERAGE CONDITIONS

FLOWRATE, mgd vs. SULFATE, mg/l in the LITTLE CALUMET RIVER

Reach #4

Thorn Creek			Little Calumet River at Munster, In			Projected Loading		
Flow, mgd	Sulfate, mg/l	Average Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Average Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d
14	932	109153	4.85	500	20225	19	821	129378
15	890	110147	8	132	8378	22	633	118525
17	802	112633	10	132	11416	27	547	124049
19	733	115118	13	132	14455	32	486	129572
21	677	117603	16	132	17493	37	441	135096
23	630	120089	19	132	20531	41	406	140620
25	592	122574	21	132	23570	46	379	146144
27	559	125059	24	132	26608	51	357	151667
29	530	127544	27	132	29647	56	338	157191
31	506	130030	30	132	32685	61	322	162715
33	484	132515	32	132	35724	65	309	168239
35	465	135000	35	132	38762	70	297	173762
37	447	137486	38	132	41800	75	287	179286
39	432	139971	41	132	44839	80	278	184810
41	418	142456	43	132	47877	84	271	190334
43	406	144942	46	132	50916	89	264	195857
45	394	147427	49	132	53954	94	257	201381
47	384	149912	52	132	56993	99	252	206905
49	374	152398	55	132	60031	103	246	212429
51	365	154883	57	132	63069	108	242	217952
56	346	161096	60	132	66108	116	235	227204
61	330	167310	65	132	71612	126	228	238922
66	316	173523	70	132	77117	136	221	250640
71	304	179736	75	132	82621	146	216	262357
76	294	185950	80	132	88125	156	211	274075
81	285	192163	85	132	93630	166	207	285793
86	277	198376	90	132	99134	176	203	297510
91	270	204589	95	132	104639	186	199	309228
96	264	210803	100	132	110143	196	196	320946
101	258	217016	105	132	115647	206	194	332663
106	253	223229	110	132	121152	216	191	344381
111	248	229443	115	132	126656	226	189	356099
116	244	235656	120	132	132161	236	187	367817
121	240	241869	125	132	137665	246	185	379534
126	236	248083	130	132	143169	256	183	391252
131	233	254296	135	132	148674	266	182	402970
136	230	260509	140	132	154178	276	180	414687
141	227	266722	145	132	159683	286	179	426405
146	224	272936	150	132	165187	296	178	438123
151	222	279149	155	132	170691	306	176	449840
156	220	285362	160	132	176196	316	175	461558
161	217	291576	165	132	181700	326	174	473276
166	215	297789	170	132	187205	336	173	484994
171	213	304002	175	132	192709	346	172	496711
176	212	310216	180	132	198213	356	171	508429
181	210	316429	185	132	203718	366	170	520147
186	208	322642	190	132	209222	376	170	531864
191	207	328855	195	132	214727	386	169	543582
196	205	335069	200	132	220231	396	168	555300
201	204	341282	205	132	225735	406	168	567017
206	202	347495	210	132	231240	416	167	578735
211	201	353709	215	132	236744	426	166	590453
216	200	359922	220	132	242249	436	166	602171
221	199	366135	225	132	247753	446	165	613888
226	198	372349	230	132	253257	456	165	625606
231	197	378562	235	132	258762	466	164	637324
236	196	384775	240	132	264266	476	164	649041
241	195	390988	245	132	269771	486	163	660759
246	194	397202	250	132	275275	496	163	672477
251	193	403415	255	132	280779	506	162	684194

Notes:

Thorn Creek:
Flow values are from Reach #3 for Average Sulfate loading

Little Calumet River
Flow values start at the 7Q10 for the Munster Station and increase by 2.76 mgd until 60 mgd the average flow. This corresponds to Thorn Creeks median flow of 56 mgd
Sulfate level is the average sulfate for the Munster Station and at low flow is 500 mg/l, the water quality standard.

PEAK CONDITIONS

Flowrate, mgd vs. TDS, mg/l

Reach #1

Upstream				Treatment Plant				Rhodia				USGS Station			
		Average				Average				Peak	Peak				
Flow, mgd	Flow, cfs	TDS, mg/l	TDS, lbs/d	Flow, mgd	Flow, cfs	TDS, mg/l	TDS, lbs/d	Flow, mgd	Flow, cfs	TDS, mg/l	TDS, lbs/d	Flow, mgd	Flow, cfs	TDS, mg/l	TDS, lbs/d
0.19	0.3	2093	3383	10.34	16	1186	102236	1.10	1.7	16566	151725	11.63	18	2654	257344
2.96	5	2093	51646	11.63	18	1186	115015	1.10	1.7	16566	151725	15.68	24	2434	318386
5.72	9	2093	99908	12.92	20	1186	127795	1.10	1.7	16566	151725	19.74	31	2305	379428
8.49	13	2093	148171	14.21	22	1186	140574	1.10	1.7	16566	151725	23.80	37	2219	440470
11.25	17	2093	196434	15.50	24	1186	153354	1.10	1.7	16566	151725	27.86	43	2159	501512
14.02	22	2093	244696	16.80	26	1186	166133	1.10	1.7	16566	151725	31.91	49	2114	562555
15.31	24	2093	267249	16.80	26	1186	166133	1.10	1.7	16566	151725	33.20	51	2113	585107
16.60	26	2093	289802	16.80	26	1186	166133	1.10	1.7	16566	151725	34.50	53	2112	607660
17.89	28	2093	312354	16.80	26	1186	166133	1.10	1.7	16566	151725	35.79	55	2111	630213
19.19	30	2093	334907	16.80	26	1186	166133	1.10	1.7	16566	151725	37.08	57	2111	652765
20.48	32	2093	357460	16.80	26	1186	166133	1.10	1.7	16566	151725	38.37	59	2110	675318
21.77	34	2093	380012	16.80	26	1186	166133	1.10	1.7	16566	151725	39.66	61	2110	697871
23.06	36	2093	402565	16.80	26	1186	166133	1.10	1.7	16566	151725	40.96	63	2109	720423
24.35	38	2093	425118	16.80	26	1186	166133	1.10	1.7	16566	151725	42.25	65	2109	742976
25.65	40	2093	447670	16.80	26	1186	166133	1.10	1.7	16566	151725	43.54	67	2108	765529
26.94	42	2093	470223	16.80	26	1186	166133	1.10	1.7	16566	151725	44.83	69	2108	788081
28.23	44	2093	492776	16.80	26	1186	166133	1.10	1.7	16566	151725	46.12	71	2107	810634
29.52	46	2093	515328	16.80	26	1186	166133	1.10	1.7	16566	151725	47.42	73	2107	833187
30.81	48	2093	537881	16.80	26	1186	166133	1.10	1.7	16566	151725	48.71	75	2107	855739
32.11	50	2093	560434	16.80	26	1186	166133	1.10	1.7	16566	151725	50.00	77	2106	878292
33.40	52	2093	582986	16.80	26	1186	166133	1.10	1.7	16566	151725	51.29	79	2106	900845
34.69	54	2093	605539	16.80	26	1186	166133	1.10	1.7	16566	151725	52.58	81	2106	923397
35.98	56	2093	628092	16.80	26	1186	166133	1.10	1.7	16566	151725	53.88	83	2105	945950
37.27	58	2093	650644	16.80	26	1186	166133	1.10	1.7	16566	151725	55.17	85	2105	968503
38.57	60	2093	673197	16.80	26	1186	166133	1.10	1.7	16566	151725	56.46	87	2105	991055
39.86	62	2093	695750	16.80	26	1186	166133	1.10	1.7	16566	151725	57.75	89	2104	1013608
41.15	64	2093	718302	16.80	26	1186	166133	1.10	1.7	16566	151725	59.04	91	2104	1036161
42.44	66	2093	740855	16.80	26	1186	166133	1.10	1.7	16566	151725	60.34	93	2104	1058713
43.73	68	2093	763408	16.80	26	1186	166133	1.10	1.7	16566	151725	61.63	95	2104	1081266
45.03	70	2093	785960	16.80	26	1186	166133	1.10	1.7	16566	151725	62.92	97	2103	1103819
46.32	72	2093	808513	16.80	26	1186	166133	1.10	1.7	16566	151725	64.21	99	2103	1126371
47.61	74	2093	831066	16.80	26	1186	166133	1.10	1.7	16566	151725	65.50	101	2103	1148924
48.90	76	2093	853618	16.80	26	1186	166133	1.10	1.7	16566	151725	66.80	103	2103	1171476
50.19	78	2093	876171	16.80	26	1186	166133	1.10	1.7	16566	151725	68.09	105	2103	1194029
51.49	80	2093	898724	16.80	26	1186	166133	1.10	1.7	16566	151725	69.38	107	2103	1216582
52.78	82	2093	921276	16.80	26	1186	166133	1.10	1.7	16566	151725	70.67	109	2102	1239134
54.07	84	2093	943829	16.80	26	1186	166133	1.10	1.7	16566	151725	71.96	111	2102	1261687
55.36	86	2093	966382	16.80	26	1186	166133	1.10	1.7	16566	151725	73.26	113	2102	1284240
56.65	88	2093	988934	16.80	26	1186	166133	1.10	1.7	16566	151725	74.55	115	2102	1306792
57.95	90	2093	1011487	16.80	26	1186	166133	1.10	1.7	16566	151725	75.84	117	2102	1329345
59.24	92	2093	1034040	16.80	26	1186	166133	1.10	1.7	16566	151725	77.13	119	2102	1351898
60.53	94	2093	1056592	16.80	26	1186	166133	1.10	1.7	16566	151725	78.42	121	2101	1374450
61.82	96	2093	1079145	16.80	26	1186	166133	1.10	1.7	16566	151725	79.72	123	2101	1397003
63.11	98	2093	1101697	16.80	26	1186	166133	1.10	1.7	16566	151725	81.01	125	2101	1419556
64.41	100	2093	1124250	16.80	26	1186	166133	1.10	1.7	16566	151725	82.30	127	2101	1442108
65.70	102	2093	1146803	16.80	26	1186	166133	1.10	1.7	16566	151725	83.59	129	2101	1464661
66.99	104	2093	1169355	16.80	26	1186	166133	1.10	1.7	16566	151725	84.88	131	2101	1487214
68.28	106	2093	1191908	16.80	26	1186	166133	1.10	1.7	16566	151725	86.18	133	2101	1509766
69.57	108	2093	1214461	16.80	26	1186	166133	1.10	1.7	16566	151725	87.47	135	2101	1532319
70.87	110	2093	1237013	16.80	26	1186	166133	1.10	1.7	16566	151725	88.76	137	2100	1554872
72.16	112	2093	1259566	16.80	26	1186	166133	1.10	1.7	16566	151725	90.05	139	2100	1577424
73.45	114	2093	1282119	16.80	26	1186	166133	1.10	1.7	16566	151725	91.34	141	2100	1599977
74.74	116	2093	1304671	16.80	26	1186	166133	1.10	1.7	16566	151725	92.64	143	2100	1622530
76.03	118	2093	1327224	16.80	26	1186	166133	1.10	1.7	16566	151725	93.93	145	2100	1645082
77.33	120	2093	1349777	16.80	26	1186	166133	1.10	1.7	16566	151725	95.22	147	2100	1667635
78.62	122	2093	1372329	16.80	26	1186	166133	1.10	1.7	16566	151725	96.51	149	2100	1690188
79.91	124	2093	1394882	16.80	26	1186	166133	1.10	1.7	16566	151725	97.80	151	2100	1712740
81.20	126	2093	1417435	16.80	26	1186	166133	1.10	1.7	16566	151725	99.10	153	2100	1735293
82.49	128	2093	1439987	16.80	26	1186	166133	1.10	1.7	16566	151725	100.39	155	2100	1757846
83.79	130	2093	1462540	16.80	26	1186	166133	1.10	1.7	16566	151725	101.68	157	2099	1780398
85.08	132	2093	1485093	16.80	26	1186	166133	1.10	1.7	16566	151725	102.97	159	2099	1802951
86.37	134	2093	1507645	16.80	26	1186	166133	1.10	1.7	16566	151725	104.26	161	2099	1825504

\\Darlene\C\IDOC\Thornerk\Rhodia99Tab\[TCR1PT2.xls]Table
3/15/00 15:33

Notes:

Upstream:
Flow values for upstream start from 7Q10 (0.3 cfs) and increase to average (21.7 cfs).
Average upstream flow occurs simultaneously with average Thorn Creek Basin WWTP flow (25.9 cfs).
Flows then increase by 2 cfs.
TDS Concentration is maximum TDS measured (1308 mg/l) multiplied by a factor (1.6) from EPA Doc. (EPA/505/2-90-001)

Treatment Plant:
Flow values start from 7Q10 low flow at downstream USGS station. This assumes that all downstream flow during low flow conditions (prior to Rhone-Poulenc additional flow) is from treatment plant.
As this model is predicting downstream conditions during average treatment plant performance, once the average flow (25.9 cfs) is reached, it is held constant.
TDS Concentration is maximum TDS measured (1031 mg/l) multiplied by a factor (1.51) from EPA Doc. (EPA/505/2-90-001)

Rhodia:
Rhodia flow is the flow (1.7 cfs) during the max. loading (151,725 lbs/d).

Sources:

Upstream and treatment plant TDS values from Thorn Creek Basin Monitoring (Nov. 92 - Apr. 93)
Upstream and treatment plant 7Q10 values from ISWS 1993 report
Upstream average flow obtained from USGS 1979 Water Resource data
Treatment plant average flow from 1992 DMRs
Rhone-Poulenc values from maximum loading values as calculated by Rhone-Poulenc.

PEAK CONDITIONS

FLOWRATE vs. TDS CONCENTRATION at THORNTON STATION

Reach #2

Thorn Creek			Deer Creek			Thorn Creek (at Sta. 05536275)		
Flow, mgd	TDS, mg/l	TDS, lbs/d	Flow, mgd	TDS, mg/l	TDS, lbs/d	Flow, mgd	TDS, mg/l	TDS, lbs/d
11.63	2654	257344	0.20	689	1149	11.83	2620	258493
15.68	2434	318386	3	689	23175	19	2197	341560
19.74	2305	379428	6	689	39009	25	1971	418437
23.80	2219	440470	8	689	54843	32	1841	495313
27.86	2159	501512	11	689	70677	39	1756	572189
31.91	2114	562555	14	689	86511	46	1696	649066
33.20	2113	585107	17	689	102345	50	1651	687453
34.50	2112	607660	19	689	118179	54	1612	725839
35.79	2111	630213	22	689	134014	58	1579	764226
37.08	2111	652765	25	689	149848	62	1550	802613
38.37	2110	675318	26	689	155176	64	1549	830494
39.66	2110	697871	27	689	160192	66	1548	858063
40.96	2109	720423	28	689	165209	69	1547	885632
42.25	2109	742976	29	689	170225	71	1547	913201
43.54	2108	765529	29	689	175241	73	1546	940770
44.83	2108	788081	30	689	180258	75	1546	968339
46.12	2107	810634	31	689	185274	77	1545	995908
47.42	2107	833187	32	689	190290	79	1545	1023477
48.71	2107	855739	33	689	195307	82	1544	1051046
50.00	2106	878292	34	689	200323	84	1544	1078615
51.29	2106	900845	35	689	205339	86	1543	1106184
52.58	2106	923397	36	689	210356	88	1543	1133753
53.88	2105	945950	36	689	215372	90	1542	1161322
55.17	2105	968503	37	689	220388	92	1542	1188891
56.46	2105	991055	38	689	225405	95	1542	1216460
57.75	2104	1013608	39	689	230421	97	1541	1244029
59.04	2104	1036161	40	689	235437	99	1541	1271598
60.34	2104	1058713	41	689	240454	101	1541	1299167
61.63	2104	1081266	42	689	245470	103	1540	1326736
62.92	2103	1103819	43	689	250486	105	1540	1354305
64.21	2103	1126371	43	689	255503	108	1540	1381874
65.50	2103	1148924	44	689	260519	110	1540	1409443
66.80	2103	1171476	45	689	265535	112	1539	1437012
68.09	2103	1194029	46	689	270551	114	1539	1464581
69.38	2103	1216582	47	689	275568	116	1539	1492150
70.67	2102	1239134	48	689	280584	118	1539	1519719
71.96	2102	1261687	49	689	285600	121	1538	1547288
73.26	2102	1284240	49	689	290617	123	1538	1574857
74.55	2102	1306792	50	689	295633	125	1538	1602426
75.84	2102	1329345	51	689	300649	127	1538	1629995
77.13	2102	1351898	52	689	305666	129	1538	1657564
78.42	2101	1374450	53	689	310682	131	1538	1685133
79.72	2101	1397003	54	689	315698	134	1537	1712702
81.01	2101	1419556	55	689	320715	136	1537	1740270
82.30	2101	1442108	56	689	325731	138	1537	1767839
83.59	2101	1464661	56	689	330747	140	1537	1795408
84.88	2101	1487214	57	689	335764	142	1537	1822977
86.18	2101	1509766	58	689	340780	144	1537	1850546
87.47	2101	1532319	59	689	345796	147	1536	1878115
88.76	2100	1554872	60	689	350813	149	1536	1905684
90.05	2100	1577424	61	689	355829	151	1536	1933253
91.34	2100	1599977	62	689	360845	153	1536	1960822
92.64	2100	1622530	63	689	365862	155	1536	1988391
93.93	2100	1645082	63	689	370878	157	1536	2015960
95.22	2100	1667635	64	689	375894	160	1536	2043529
96.51	2100	1690188	65	689	380911	162	1536	2071098
97.80	2100	1712740	66	689	385927	164	1535	2098667
99.10	2100	1735293	67	689	390943	166	1535	2126236
100.39	2100	1757846	68	689	395960	168	1535	2153805
101.68	2099	1780398	69	689	400976	170	1535	2181374
102.97	2099	1802951	70	689	405992	173	1535	2208943
104.26	2099	1825504	70	689	411009	175	1535	2236512

Deer Creek loading calculated from Deer Creek flow less average CIWC discharge (1.25 mgd) and 689 mg/l (avg. Thorn Cr. TDS upstream of Thorn Cr. WWTP) plus average CIWC loading (13374 lbs/d).

Thorn Creek values from Reach #1 model for peak Rhodia TDS loadings.

PEAK CONDITIONS

FLOWRATE,mgd vs. TDS, mg/l BEYOND THORNTON STATION

Reach #3

Thorn Creek			Rhodia			Projected Loadings		
Flow, mgd	Peak TDS, mg/l	TDS, lbs/d	Flow, mgd	Peak TDS, mg/l	TDS, lbs/d	Flow, mgd	TDS, mg/l	TDS, lbs/d
13.2	1183	130234	1.10	16566	151725	14	2364	281959
14	1183	138127	1.10	16566	151725	15	2302	289852
16	1183	157860	1.10	16566	151725	17	2171	309585
18	1183	177592	1.10	16566	151725	19	2068	329317
20	1183	197324	1.10	16566	151725	21	1984	349049
22	1183	217057	1.10	16566	151725	23	1914	368782
24	1183	236789	1.10	16566	151725	25	1856	388514
26	1183	256522	1.10	16566	151725	27	1806	408247
28	1183	276254	1.10	16566	151725	29	1764	427979
30	1183	295987	1.10	16566	151725	31	1726	447712
32	1183	315719	1.10	16566	151725	33	1693	467444
34	1183	335451	1.10	16566	151725	35	1664	487176
36	1183	355184	1.10	16566	151725	37	1638	506909
38	1183	374916	1.10	16566	151725	39	1615	526641
40	1183	394649	1.10	16566	151725	41	1594	546374
42	1183	414381	1.10	16566	151725	43	1575	566106
44	1183	434114	1.10	16566	151725	45	1558	585839
46	1183	453846	1.10	16566	151725	47	1542	605571
48	1183	473579	1.10	16566	151725	49	1527	625304
50	1183	493311	1.10	16566	151725	51	1514	645036
55	1183	542642	1.10	16566	151725	56	1484	694367
60	1183	591973	1.10	16566	151725	61	1459	743698
65	1183	641304	1.10	16566	151725	66	1439	793029
70	1183	690635	1.10	16566	151725	71	1421	842360
75	1183	739967	1.10	16566	151725	76	1405	891692
80	1183	789298	1.10	16566	151725	81	1391	941023
85	1183	838629	1.10	16566	151725	86	1379	990354
90	1183	887960	1.10	16566	151725	91	1368	1039685
95	1183	937291	1.10	16566	151725	96	1359	1089016
100	1183	986622	1.10	16566	151725	101	1350	1138347
105	1183	1035953	1.10	16566	151725	106	1342	1187678
110	1183	1085284	1.10	16566	151725	111	1335	1237009
115	1183	1134615	1.10	16566	151725	116	1329	1286340
120	1183	1183946	1.10	16566	151725	121	1323	1335671
125	1183	1233278	1.10	16566	151725	126	1317	1385003
130	1183	1282609	1.10	16566	151725	131	1312	1434334
135	1183	1331940	1.10	16566	151725	136	1307	1483665
140	1183	1381271	1.10	16566	151725	141	1303	1532996
145	1183	1430602	1.10	16566	151725	146	1299	1582327
150	1183	1479933	1.10	16566	151725	151	1295	1631658
155	1183	1529264	1.10	16566	151725	156	1291	1680989
160	1183	1578595	1.10	16566	151725	161	1288	1730320
165	1183	1627926	1.10	16566	151725	166	1285	1779651
170	1183	1677257	1.10	16566	151725	171	1282	1828982
175	1183	1726589	1.10	16566	151725	176	1279	1878314
180	1183	1775920	1.10	16566	151725	181	1276	1927645
185	1183	1825251	1.10	16566	151725	186	1274	1976976
190	1183	1874582	1.10	16566	151725	191	1271	2026307
195	1183	1923913	1.10	16566	151725	196	1269	2075638
200	1183	1973244	1.10	16566	151725	201	1267	2124969
205	1183	2022575	1.10	16566	151725	206	1265	2174300
210	1183	2071906	1.10	16566	151725	211	1263	2223631
215	1183	2121237	1.10	16566	151725	216	1261	2272962
220	1183	2170568	1.10	16566	151725	221	1259	2322293
225	1183	2219900	1.10	16566	151725	226	1258	2371625
230	1183	2269231	1.10	16566	151725	231	1256	2420956
235	1183	2318562	1.10	16566	151725	236	1255	2470287
240	1183	2367893	1.10	16566	151725	241	1253	2519618
245	1183	2417224	1.10	16566	151725	246	1252	2568949
250	1183	2466555	1.10	16566	151725	251	1250	2618280

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[TCR3PKT.xls]Table
3/15/00 11:24

Notes:

Thorn Creek

Flow values start at 7Q10 (13.2 mgd) and increase by 2 until 50 mgd where values increase by 5 mgd. TDS concentration is maximum summation of major ions currently in Thorn Creek (Obtained from USGS 1991 water year Thornton station data)
No factor was used from EPA Doc (EPA/505/2-90-001) as the number of data was greater than 20.

Rhodia

Rhodia values are peak daily values

PEAK CONDITIONS

FLOWRATE, mgd vs. TDS, mg/l in the LITTLE CALUMET RIVER
Reach #4

Thorn Creek			Little Calumet River at Munster, In			Projected Loading		
Peak								
Flow, mgd	TDS, mg/l	TDS, lbs/d	Flow, mgd	TDS, mg/l	TDS, lbs/d	Flow, mgd	TDS, mg/l	TDS, lbs/d
14	2364	281959	4.85	1000	40449	19	2019	322408
15	2302	289852	8	464	29449	23	1686	319301
17	2171	309585	10	464	40129	27	1527	349714
19	2068	329317	13	464	50810	32	1414	380127
21	1984	349049	16	464	61490	37	1331	410540
23	1914	368782	19	464	72171	42	1266	440953
25	1856	388514	21	464	82852	47	1215	471366
27	1806	408247	24	464	93532	51	1174	501779
29	1764	427979	27	464	104213	56	1139	532192
31	1726	447712	30	464	114893	61	1110	562605
33	1693	467444	32	464	125574	66	1085	593018
35	1664	487176	35	464	136254	70	1063	623431
37	1638	506909	38	464	146935	75	1044	653844
39	1615	526641	41	464	157615	80	1028	684257
41	1594	546374	43	464	168296	85	1013	714670
43	1575	566106	46	464	178976	89	1000	745083
45	1558	585839	49	464	189657	94	988	775496
47	1542	605571	52	464	200337	99	977	805909
49	1527	625304	55	464	211018	104	968	836322
51	1514	645036	57	464	221699	108	959	866735
56	1484	694367	60	464	232379	116	957	926746
61	1459	743698	65	464	251728	126	946	995426
66	1439	793029	70	464	271077	136	937	1064106
71	1421	842360	75	464	290425	146	929	1132786
76	1405	891692	80	464	309774	156	923	1201466
81	1391	941023	85	464	329123	166	917	1270146
86	1379	990354	90	464	348472	176	911	1338826
91	1368	1039685	95	464	367821	186	907	1407505
96	1359	1089016	100	464	387169	196	902	1476185
101	1350	1138347	105	464	406518	206	899	1544865
106	1342	1187678	110	464	425867	216	895	1613545
111	1335	1237009	115	464	445216	226	892	1682225
116	1329	1286340	120	464	464565	236	889	1750905
121	1323	1335671	125	464	483913	246	886	1819585
126	1317	1385003	130	464	503262	256	884	1888265
131	1312	1434334	135	464	522611	266	882	1956945
136	1307	1483665	140	464	541960	276	880	2025625
141	1303	1532996	145	464	561309	286	878	2094304
146	1299	1582327	150	464	580657	296	876	2162984
151	1295	1631658	155	464	600006	306	874	2231664
156	1291	1680989	160	464	619355	316	872	2300344
161	1288	1730320	165	464	638704	326	871	2369024
166	1285	1779651	170	464	658053	336	870	2437704
171	1282	1828982	175	464	677401	346	868	2506384
176	1279	1878314	180	464	696750	356	867	2575064
181	1276	1927645	185	464	716099	366	866	2643744
186	1274	1976976	190	464	735448	376	865	2712424
191	1271	2026307	195	464	754797	386	864	2781103
196	1269	2075638	200	464	774145	396	863	2849783
201	1267	2124969	205	464	793494	406	862	2918463
206	1265	2174300	210	464	812843	416	861	2987143
211	1263	2223631	215	464	832192	426	860	3055823
216	1261	2272962	220	464	851541	436	859	3124503
221	1259	2322293	225	464	870889	446	858	3193183
226	1258	2371625	230	464	890238	456	857	3261863
231	1256	2420956	235	464	909587	466	857	3330543
236	1255	2470287	240	464	928936	476	856	3399223
241	1253	2519618	245	464	948285	486	855	3467902
246	1252	2568949	250	464	967633	496	855	3536582
251	1250	2618280	255	464	986982	506	854	3605262

Notes:

Thorn Creek:
Flow and TDS values are from Reach #3 for Peak TDS loading

Little Calumet River
Flow values start at the 7Q10 for the Munster Station and increase by 2.76 mgd until 60 mgd, the average flow. This corresponds to Thorn Creeks median flow of 56 mgd.
TDS level is the average TDS for the Munster Station and at low flow is 1000 mg/l, the water quality standard.

PEAK CONDITIONS

Flowrate, mgd vs. Sulfate, mg/l

Reach #1

Upstream				Treatment Plant				Rhodia				USGS Station			
		Peak				Peak				Peak	Peak				
Flow, mgd	Flow, cfs	Sulfate, mg/l	Sulfate, lbs/d	Flow, mgd	Flow, cfs	Sulfate, mg/l	Sulfate, lbs/d	Flow, mgd	Flow, cfs	Sulfate, mg/l	Sulfate, lbs/d	Flow, mgd	Flow, cfs	Sulfate, mg/l	Sulfate, lbs/d
0.19	0.3	565	913	10.34	16	323	27800	1.10	1.7	11206	102638	11.63	18	1354	131351
2.96	5	565	13937	11.63	18	323	31275	1.10	1.7	11206	102638	15.68	24	1130	147850
5.72	9	565	26960	12.92	20	323	34750	1.10	1.7	11206	102638	19.74	31	998	164349
8.49	13	565	39984	14.21	22	323	38225	1.10	1.7	11206	102638	23.80	37	911	180848
11.25	17	565	53008	15.50	24	323	41700	1.10	1.7	11206	102638	27.86	43	849	197346
14.02	22	565	66032	16.80	26	323	45175	1.10	1.7	11206	102638	31.91	49	803	213845
15.31	24	565	72118	16.80	26	323	45175	1.10	1.7	11206	102638	33.20	51	794	219931
16.60	26	565	78204	16.80	26	323	45175	1.10	1.7	11206	102638	34.50	53	786	226017
17.89	28	565	84289	16.80	26	323	45175	1.10	1.7	11206	102638	35.79	55	778	232103
19.19	30	565	90375	16.80	26	323	45175	1.10	1.7	11206	102638	37.08	57	770	238189
20.48	32	565	96461	16.80	26	323	45175	1.10	1.7	11206	102638	38.37	59	763	244275
21.77	34	565	102547	16.80	26	323	45175	1.10	1.7	11206	102638	39.66	61	757	250360
23.06	36	565	108633	16.80	26	323	45175	1.10	1.7	11206	102638	40.96	63	751	256446
24.35	38	565	114719	16.80	26	323	45175	1.10	1.7	11206	102638	42.25	65	745	262532
25.65	40	565	120805	16.80	26	323	45175	1.10	1.7	11206	102638	43.54	67	740	268618
26.94	42	565	126891	16.80	26	323	45175	1.10	1.7	11206	102638	44.83	69	735	274704
28.23	44	565	132976	16.80	26	323	45175	1.10	1.7	11206	102638	46.12	71	730	280790
29.52	46	565	139062	16.80	26	323	45175	1.10	1.7	11206	102638	47.42	73	725	286876
30.81	48	565	145148	16.80	26	323	45175	1.10	1.7	11206	102638	48.71	75	721	292962
32.11	50	565	151234	16.80	26	323	45175	1.10	1.7	11206	102638	50.00	77	717	299047
33.40	52	565	157320	16.80	26	323	45175	1.10	1.7	11206	102638	51.29	79	713	305133
34.69	54	565	163406	16.80	26	323	45175	1.10	1.7	11206	102638	52.58	81	710	311219
35.98	56	565	169492	16.80	26	323	45175	1.10	1.7	11206	102638	53.88	83	706	317305
37.27	58	565	175578	16.80	26	323	45175	1.10	1.7	11206	102638	55.17	85	703	323391
38.57	60	565	181663	16.80	26	323	45175	1.10	1.7	11206	102638	56.46	87	700	329477
39.86	62	565	187749	16.80	26	323	45175	1.10	1.7	11206	102638	57.75	89	697	335563
41.15	64	565	193835	16.80	26	323	45175	1.10	1.7	11206	102638	59.04	91	694	341649
42.44	66	565	199921	16.80	26	323	45175	1.10	1.7	11206	102638	60.34	93	691	347734
43.73	68	565	206007	16.80	26	323	45175	1.10	1.7	11206	102638	61.63	95	688	353820
45.03	70	565	212093	16.80	26	323	45175	1.10	1.7	11206	102638	62.92	97	686	359906
46.32	72	565	218179	16.80	26	323	45175	1.10	1.7	11206	102638	64.21	99	683	365992
47.61	74	565	224265	16.80	26	323	45175	1.10	1.7	11206	102638	65.50	101	681	372078
48.90	76	565	230350	16.80	26	323	45175	1.10	1.7	11206	102638	66.80	103	679	378164
50.19	78	565	236436	16.80	26	323	45175	1.10	1.7	11206	102638	68.09	105	677	384250
51.49	80	565	242522	16.80	26	323	45175	1.10	1.7	11206	102638	69.38	107	675	390336
52.78	82	565	248608	16.80	26	323	45175	1.10	1.7	11206	102638	70.67	109	673	396421
54.07	84	565	254694	16.80	26	323	45175	1.10	1.7	11206	102638	71.96	111	671	402507
55.36	86	565	260780	16.80	26	323	45175	1.10	1.7	11206	102638	73.26	113	669	408593
56.65	88	565	266866	16.80	26	323	45175	1.10	1.7	11206	102638	74.55	115	667	414679
57.95	90	565	272952	16.80	26	323	45175	1.10	1.7	11206	102638	75.84	117	665	420765
59.24	92	565	279038	16.80	26	323	45175	1.10	1.7	11206	102638	77.13	119	664	426851
60.53	94	565	285123	16.80	26	323	45175	1.10	1.7	11206	102638	78.42	121	662	432937
61.82	96	565	291209	16.80	26	323	45175	1.10	1.7	11206	102638	79.72	123	660	439023
63.11	98	565	297295	16.80	26	323	45175	1.10	1.7	11206	102638	81.01	125	659	445109
64.41	100	565	303381	16.80	26	323	45175	1.10	1.7	11206	102638	82.30	127	657	451194
65.70	102	565	309467	16.80	26	323	45175	1.10	1.7	11206	102638	83.59	129	656	457280
66.99	104	565	315553	16.80	26	323	45175	1.10	1.7	11206	102638	84.88	131	655	463366
68.28	106	565	321639	16.80	26	323	45175	1.10	1.7	11206	102638	86.18	133	653	469452
69.57	108	565	327725	16.80	26	323	45175	1.10	1.7	11206	102638	87.47	135	652	475538
70.87	110	565	333810	16.80	26	323	45175	1.10	1.7	11206	102638	88.76	137	651	481624
72.16	112	565	339896	16.80	26	323	45175	1.10	1.7	11206	102638	90.05	139	649	487710
73.45	114	565	345982	16.80	26	323	45175	1.10	1.7	11206	102638	91.34	141	648	493796
74.74	116	565	352068	16.80	26	323	45175	1.10	1.7	11206	102638	92.64	143	647	499881
76.03	118	565	358154	16.80	26	323	45175	1.10	1.7	11206	102638	93.93	145	646	505967
77.33	120	565	364240	16.80	26	323	45175	1.10	1.7	11206	102638	95.22	147	645	512053
78.62	122	565	370326	16.80	26	323	45175	1.10	1.7	11206	102638	96.51	149	644	518139
79.91	124	565	376412	16.80	26	323	45175	1.10	1.7	11206	102638	97.80	151	643	524225
81.20	126	565	382497	16.80	26	323	45175	1.10	1.7	11206	102638	99.10	153	642	530311
82.49	128	565	388583	16.80	26	323	45175	1.10	1.7	11206	102638	100.39	155	641	536397
83.79	130	565	394669	16.80	26	323	45175	1.10	1.7	11206	102638	101.68	157	640	542483
85.08	132	565	400755	16.80	26	323	45175	1.10	1.7	11206	102638	102.97	159	639	548568
86.37	134	565	406841	16.80	26	323	45175	1.10	1.7	11206	102638	104.26	161	638	554654

\\Darlene\C\1DOC\Thornork\Rhodia99Tab\[TCR1PEA.xls]Table
3/15/00 15:33

Notes:

Upstream:
Flow values for upstream start from 7Q10 (0.3 cfs) and increase to average (21.7 cfs).
Average upstream flow occurs simultaneously with average Thorn Creek Basin WWTP flow (25.9 cfs).
Flows then increase by 2 cfs.
Sulfate Concentration is maximum sulfate determined (353 mg/l) multiplied by a factor (1.6) from EPA Doc. (EPA/505/2-90-001)
Sulfate taken as 27% of TDS

Treatment Plant:
Flow values start from 7Q10 low flow at downstream USGS station. This assumes that all downstream flow during low flow conditions (prior to Rhone-Poulenc additional flow) is from treatment plant.
As this model is predicting downstream conditions during average treatment plant performance, once the average flow (25.9 cfs) is reached, it is held constant.
Sulfate Concentration is maximum sulfate determined (278 mg/l) multiplied by a factor (1.16) from EPA Doc. (EPA/505/2-90-001)
Sulfate taken as 27% of TDS

Rhodia:
Rhodia flow is the flow (1.7 cfs) during the max. loading (102,638 lbs/d).
Sulfate taken as 68% TDS (TDS is 100% from sodium sulfate)

Sources:

Upstream and treatment plant TDS/Sulfate values from Thorn Creek Basin Monitoring (NOV. 92 - APR. 93)
Upstream and treatment plant 7Q10 values from ISWS 1993 report
Upstream average flow obtained from USGS 1979 Water Resource data
Treatment plant average flow from 1992 DMRs
Rhone-Poulenc values from maximum loading values as calculated by Rhone-Poulenc.

PEAK CONDITIONS

FLOWRATE vs. SULFATE CONCENTRATION at THORNTON STATION

Reach #2

Thorn Creek			Deer Creek			Thorn Creek (at Sta. 05536275)		
Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d
11.63	1354	131351	0.20	186	310	11.83	1335	131661
15.68	1130	147850	3	186	6257	19	991	154107
19.74	998	164349	6	186	10531	25	824	174880
23.80	911	180848	8	186	14806	32	727	195653
27.86	849	197346	11	186	19080	39	664	216427
31.91	803	213845	14	186	23355	46	620	237200
33.20	794	219931	17	186	27629	50	594	247560
34.50	786	226017	19	186	31904	54	573	257921
35.79	778	232103	22	186	36178	58	554	268281
37.08	770	238189	25	186	40453	62	538	278642
38.37	763	244275	26	186	41891	64	534	286166
39.66	757	250360	27	186	43246	66	530	293606
40.96	751	256446	28	186	44600	69	526	301046
42.25	745	262532	29	186	45954	71	522	308486
43.54	740	268618	29	186	47308	73	519	315926
44.83	735	274704	30	186	48662	75	516	323366
46.12	730	280790	31	186	50017	77	513	330806
47.42	725	286876	32	186	51371	79	510	338246
48.71	721	292962	33	186	52725	82	508	345686
50.00	717	299047	34	186	54079	84	505	353127
51.29	713	305133	35	186	55433	86	503	360567
52.58	710	311219	36	186	56787	88	501	368007
53.88	706	317305	36	186	58142	90	499	375447
55.17	703	323391	37	186	59496	92	497	382887
56.46	700	329477	38	186	60850	95	495	390327
57.75	697	335563	39	186	62204	97	493	397767
59.04	694	341649	40	186	63558	99	491	405207
60.34	691	347734	41	186	64913	101	489	412647
61.63	688	353820	42	186	66267	103	488	420087
62.92	686	359906	43	186	67621	105	486	427527
64.21	683	365992	43	186	68975	108	485	434967
65.50	681	372078	44	186	70329	110	483	442407
66.80	679	378164	45	186	71684	112	482	449847
68.09	677	384250	46	186	73038	114	481	457287
69.38	675	390336	47	186	74392	116	479	464728
70.67	673	396421	48	186	75746	118	478	472168
71.96	671	402507	49	186	77100	121	477	479608
73.26	669	408593	49	186	78454	123	476	487048
74.55	667	414679	50	186	79809	125	475	494488
75.84	665	420765	51	186	81163	127	474	501928
77.13	664	426851	52	186	82517	129	473	509368
78.42	662	432937	53	186	83871	131	472	516808
79.72	660	439023	54	186	85225	134	471	524248
81.01	659	445109	55	186	86580	136	470	531688
82.30	657	451194	56	186	87934	138	469	539128
83.59	656	457280	56	186	89288	140	468	546568
84.88	655	463366	57	186	90642	142	467	554008
86.18	653	469452	58	186	91996	144	466	561448
87.47	652	475538	59	186	93351	147	465	568888
88.76	651	481624	60	186	94705	149	465	576329
90.05	649	487710	61	186	96059	151	464	583769
91.34	648	493796	62	186	97413	153	463	591209
92.64	647	499881	63	186	98767	155	462	598649
93.93	646	505967	63	186	100122	157	462	606089
95.22	645	512053	64	186	101476	160	461	613529
96.51	644	518139	65	186	102830	162	460	620969
97.80	643	524225	66	186	104184	164	460	628409
99.10	642	530311	67	186	105538	166	459	635849
100.39	641	536397	68	186	106892	168	459	643289
101.68	640	542483	69	186	108247	170	458	650729
102.97	639	548568	70	186	109601	173	457	658169
104.26	638	554654	70	186	110955	175	457	665609

Deer Creek 7Q10 sulfate concentration set at 500 mg/l water quality standard
Loadings for flows higher than 7Q10 calculated from Deer Creek flow
less average CIWC flow (1.25 mgd) and 186 mg/l sulfate (27% of upstream TDS
concentration of 689 mg/l) plus average CIWC sulfate loading of 3611 lbs/day
(27% of average TDS loading of 13374 lbs/d)

Thorn Creek values from Reach #1 model for peak Rhodia
sulfate loadings.

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[TCR2PKS.xls]Table
3/15/00 11:37

PEAK CONDITIONS

FLOWRATE,mgd vs. SULFATE, mg/l BEYOND THORNTON STATION

Reach #3

Thorn Creek			Rhodia			Projected Loadings		
Flow, mgd	Peak Sulfate, mg/l	Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Peak Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d
13.2	330	36329	1.10	11208	102638	14	1165	138967
14	330	38531	1.10	11208	102638	15	1121	141169
16	330	44035	1.10	11208	102638	17	1029	146673
18	330	49540	1.10	11208	102638	19	955	152178
20	330	55044	1.10	11208	102638	21	896	157682
22	330	60548	1.10	11208	102638	23	847	163186
24	330	66053	1.10	11208	102638	25	806	168691
26	330	71557	1.10	11208	102638	27	771	174195
28	330	77062	1.10	11208	102638	29	740	179700
30	330	82566	1.10	11208	102638	31	714	185204
32	330	88070	1.10	11208	102638	33	691	190708
34	330	93575	1.10	11208	102638	35	670	196213
36	330	99079	1.10	11208	102638	37	652	201717
38	330	104584	1.10	11208	102638	39	635	207222
40	330	110088	1.10	11208	102638	41	621	212726
42	330	115592	1.10	11208	102638	43	607	218230
44	330	121097	1.10	11208	102638	45	595	223735
46	330	126601	1.10	11208	102638	47	584	229239
48	330	132106	1.10	11208	102638	49	573	234744
50	330	137610	1.10	11208	102638	51	564	240248
55	330	151371	1.10	11208	102638	56	543	254009
60	330	165132	1.10	11208	102638	61	525	267770
65	330	178893	1.10	11208	102638	66	511	281531
70	330	192654	1.10	11208	102638	71	498	295292
75	330	206415	1.10	11208	102638	76	487	309053
80	330	220176	1.10	11208	102638	81	477	322814
85	330	233937	1.10	11208	102638	86	469	336575
90	330	247698	1.10	11208	102638	91	461	350336
95	330	261459	1.10	11208	102638	96	454	364097
100	330	275220	1.10	11208	102638	101	448	377858
105	330	288981	1.10	11208	102638	106	443	391619
110	330	302742	1.10	11208	102638	111	438	405380
115	330	316503	1.10	11208	102638	116	433	419141
120	330	330264	1.10	11208	102638	121	429	432902
125	330	344025	1.10	11208	102638	126	425	446663
130	330	357786	1.10	11208	102638	131	421	460424
135	330	371547	1.10	11208	102638	136	418	474185
140	330	385308	1.10	11208	102638	141	415	487946
145	330	399069	1.10	11208	102638	146	412	501707
150	330	412830	1.10	11208	102638	151	409	515468
155	330	426591	1.10	11208	102638	156	407	529229
160	330	440352	1.10	11208	102638	161	404	542990
165	330	454113	1.10	11208	102638	166	402	556751
170	330	467874	1.10	11208	102638	171	400	570512
175	330	481635	1.10	11208	102638	176	398	584273
180	330	495396	1.10	11208	102638	181	396	598034
185	330	509157	1.10	11208	102638	186	394	611795
190	330	522918	1.10	11208	102638	191	393	625556
195	330	536679	1.10	11208	102638	196	391	639317
200	330	550440	1.10	11208	102638	201	389	653078
205	330	564201	1.10	11208	102638	206	388	666839
210	330	577962	1.10	11208	102638	211	387	680600
215	330	591723	1.10	11208	102638	216	385	694361
220	330	605484	1.10	11208	102638	221	384	708122
225	330	619245	1.10	11208	102638	226	383	721883
230	330	633006	1.10	11208	102638	231	382	735644
235	330	646767	1.10	11208	102638	236	381	749405
240	330	660528	1.10	11208	102638	241	380	763166
245	330	674289	1.10	11208	102638	246	379	776927
250	330	688050	1.10	11208	102638	251	378	790688

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[TCR3PKS.xls]Table
3/15/00 11:34

Notes:

Thorn Creek

Flow values start at 7Q10 (13.2 mgd) and increase by 2 until 50 mgd where values increase by 5 mgd. Sulfate concentration is maximum sulfate ion concentrations.
(Obtained from USGS 1991 water year Thornton station data)
No factor was used from EPA Doc. (EPA/505/2-90-001) as the number of data was greater than 20.

Rhodia

Rhodia values are peak daily values
Sulfate is taken as 68% of peak TDS loading based on molecular weight (TDS is 100% from sodium sulfate)

PEAK CONDITIONS

FLOWRATE, mgd vs. SULFATE, mg/l in the LITTLE CALUMET RIVER

Reach #4

Thorn Creek			Little Calumet River at Munster, In			Projected Loading		
Flow, mgd	Sulfate, mg/l	Peak Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d	Flow, mgd	Sulfate, mg/l	Sulfate, lbs/d
14	1165	138967	4.85	500	20225	19	997	159192
15	1121	141169	8	132	8378	23	790	149546
17	1029	146673	10	132	11416	27	690	158089
19	955	152178	13	132	14455	32	620	166632
21	896	157682	16	132	17493	37	568	175175
23	847	163186	19	132	20531	42	528	183718
25	806	168691	21	132	23570	47	496	192261
27	771	174195	24	132	26608	51	470	200803
29	740	179700	27	132	29647	56	448	209346
31	714	185204	30	132	32685	61	430	217889
33	691	190708	32	132	35724	66	414	226432
35	670	196213	35	132	38762	70	401	234975
37	652	201717	38	132	41800	75	389	243518
39	635	207222	41	132	44839	80	379	252060
41	621	212726	43	132	47877	85	369	260603
43	607	218230	46	132	50916	89	361	269146
45	595	223735	49	132	53954	94	354	277689
47	584	229239	52	132	56993	99	347	286232
49	573	234744	55	132	60031	104	341	294775
51	564	240248	57	132	63069	108	336	303317
56	543	254009	60	132	66108	116	330	320117
61	525	267770	65	132	71612	126	323	339382
66	511	281531	70	132	77117	136	316	358648
71	498	295292	75	132	82621	146	310	377913
76	487	309053	80	132	88125	156	305	397178
81	477	322814	85	132	93630	166	301	416444
86	469	336575	90	132	99134	176	297	435709
91	461	350336	95	132	104639	186	293	454975
96	454	364097	100	132	110143	196	290	474240
101	448	377858	105	132	115647	206	287	493505
106	443	391619	110	132	121152	216	284	512771
111	438	405380	115	132	126656	226	282	532036
116	433	419141	120	132	132161	236	280	551302
121	429	432902	125	132	137665	246	278	570567
126	425	446663	130	132	143169	256	276	589832
131	421	460424	135	132	148674	266	274	609098
136	418	474185	140	132	154178	276	273	628363
141	415	487946	145	132	159683	286	271	647629
146	412	501707	150	132	165187	296	270	666894
151	409	515468	155	132	170691	306	269	686159
156	407	529229	160	132	176196	316	268	705425
161	404	542990	165	132	181700	326	266	724690
166	402	556751	170	132	187205	336	265	743956
171	400	570512	175	132	192709	346	264	763221
176	398	584273	180	132	198213	356	263	782486
181	396	598034	185	132	203718	366	263	801752
186	394	611795	190	132	209222	376	262	821017
191	393	625556	195	132	214727	386	261	840283
196	391	639317	200	132	220231	396	260	859548
201	389	653078	205	132	225735	406	259	878813
206	388	666839	210	132	231240	416	259	898079
211	387	680600	215	132	236744	426	258	917344
216	385	694361	220	132	242249	436	257	936610
221	384	708122	225	132	247753	446	257	955875
226	383	721883	230	132	253257	456	256	975140
231	382	735644	235	132	258762	466	256	994406
236	381	749405	240	132	264266	476	255	1013671
241	380	763166	245	132	269771	486	255	1032937
246	379	776927	250	132	275275	496	254	1052202
251	378	790688	255	132	280779	506	254	1071467

Notes:

Thorn Creek:
Flow values are from Reach #3 for Peak Sulfate loading

Little Calumet River
Flow values start at the 7Q10 for the Munster Station and increase by 2.76 mgd until 60 mgd the average flow. This corresponds to Thorn Creeks median flow of 56 mgd
Sulfate level is the average sulfate for the Munster Station and at low flow is 500 mg/l, the water quality standard.

\\Darlene\c\1DOC\Thorncrk\Rhodia99Tabl\[TCR4PKS.xls]Table
3/15/00 11:35

HUFF & HUFF, INC.
Environmental Consultants

CALCULATION SHEET

Project ADJUSTED STANDARD-RHODIA Client TCBSD-RHODIA

Title FLOW VALUES FOR MODEL

Signature S. LaDieu Date 02-15-00 Sheet 1 of 9

COMPUTATION OF 7Q10 LOW FLOW VALUES (0% EXCEEDANCE)

REACH #1

THORN CREEK WWTP LOW FLOW (ASSUME DOWNSTREAM 7Q10)	=	10.3 mgd (1993 ISWS)
+ RHODIA INCREASE IN FLOW	=	0.8 mgd
		11.1 mgd

REACH #2

REACH #1 7Q10	=	11.1 mgd
+ DEER CREEK 7Q10	=	0.2 mgd
		11.3 mgd

REACH #3

THORN CREEK @ THORNTON	=	13.2 mgd (1993 ISWS)
+ RHODIA INCREASE IN FLOW	=	0.8 mgd
		14.0 mgd

REACH #4

REACH #3 7Q10	=	14.0 mgd
+ LITTLE CALUMET UPSTREAM OF MERGER	=	4.8
		18.8 mgd

HUFF & HUFF, INC.
Environmental Consultants

CALCULATION SHEET

Project ADJUSTED STANDARD - RHODIA Client TCBSD - RHODIA

Title FLOW VALUES FOR MODEL

Signature S. Lavien Date 02.15.00 Sheet 2 of 9

COMPARISON OF 10%, 50%, 90% BELOW FROM 1997 USGS WATER RESOURCE DATA.

FLOW VALUES mgd

REACH NO.	10% VALUE	50% VALUE	90% VALUE
#1 Thorn Creek at Glenwood	12	17	76
#2	12	25	90
#3 Thorn Creek @ Thornton	17	32	159
#4 Little Calumet @ Sauth Holland	28	58	273

(Based on 1996 Calendar Yr.).

DRAINAGE FOR REACH #3 IS 51% OF THORNTON DRAINAGE. USE THORNTON LEVELS TO GET REACH #2. FLOW VALUES, SUBTRACTING FLOW FROM THORN CREEK and CIWC WWTPs (TOTALLING 18 mgd).
FOR 10% VALUE → USE REACH #1 VALUE

50% ⇒ (32 - 18) (x 0.51) + 18 mgd = 25 mgd
90% ⇒ (159 - 18) (x 0.51) + 18 mgd = 90 mgd

COMPARISON OF WQ STANDARDS FOR REACHES

REACH #	WQ STANDARD BEFORE ADJ., mg/L		(EXISTING) WQ STANDARD WITH ADJ., mg/L		
	TDS	SULFATE	TDS	SULFATE	
1	1000	500	2100	1000	95%
2	2100	500	2100	1000	98%
3	1000	500	1900	850	
4	1000	500	1700	750	

BASED ON EXISTING STANDARDS AND WQ MODELS AT AVERAGE FLOWS FOR PROJECTED RHODIA INCREASES, DETERMINE FLOW (STREAM) AT WHICH WQ STANDARDS WILL BE EXCEEDED.

REACH #	TDS		SULFATE	
	STANDARD	CORR. FLOW, mgd	STANDARD	CORR FLOW, mgd
1	2100	11.37 mgd ⇒ TDS = 2156 15.43 mgd ⇒ = 1777	1000	11.37 mgd ⇒ 1169 15.43 mgd ⇒ 913
2	2100	11.57 mgd ⇒ 2131 18.00 mgd ⇒ 1642	1000	11.57 mgd ⇒ 1151 18 mgd ⇒ 807
3	1900	14.00 mgd ⇒ 1672 15.00 mgd ⇒ 1611	850	15 mgd ⇒ 890 17 mgd ⇒ 802
4	1700	19 mgd ⇒ 1500 23 mgd ⇒ 1222	750	19 mgd ⇒ 821 22 mgd ⇒ 633

INTERPOLATE TO FIND FLOW VALUES AT WHICH WQ STANDARD IS EXCEED

REACH #1 TDS

11.37 mgd = 2156.

2100 WQ STANDARD

15.43 mgd = 1777

$$\frac{\Delta \text{ FLOW}}{\Delta \text{ TDS}} = \frac{4.06}{379} = 0.011 \text{ mgd} / \Delta \text{ TDS conc, mg/L}$$

TDS ⇒ 2156 - 2100 = 56 mg/L

56 × 0.011 = 0.616

REACH #2 TDS

11.37 mgd + 0.616 = 11.9 mgd @ 2,100 mg/L TDS.

REACH #3, #4 FOR TDS ⇒ WQ STANDARD IS NOT EXCEEDED. FOR TDS @ 7Q10

REACH #1 - SULFATE

WQ = 1000 mg/L STANDARD

11.37 mgd = 1169 mg/L SULFATE

15.43 mgd 913 mg/L SULFATE

$$\frac{\Delta \text{FLOW}}{\Delta \text{ SULFATE}} = \frac{4.06}{256} = 0.016$$

1169 - 1000 = 169 mg/L

169 × 0.016 = 2.70 mgd

11.50 mgd + 2.7 mgd = 14.2 mgd

REACH #2 SULFATE

WQ - = 1000 mg/L STANDARD

11.57 mgd = 1151 mg/L

18.0 mgd = 807 mg/L

$$= \frac{6.4}{344} = 0.019$$

1151 - 1000 = 151 mg/L

151 × 0.019 = 2.87

11.51 mgd + 2.87 mgd = 14.4 mgd

REACH #2 TDS

11.57 mgd = 2131 2100 mg/L WQ STANDARD

18.00 Mgd = 1642

$$\frac{\Delta \text{FLOW}}{\Delta \text{ TDS}} = \frac{6.43}{489} = 0.013 \text{ mgd}/\Delta \text{TDS}$$

2131 - 2100 = 31 × 0.013 = 0.403 mgd

11.57 mgd + 0.403 = 12.0 mgd

REACH #3 - SULFATE

WQ STANDARD = 850 mg/L

15 mgd = 890 mg/L
17 mgd = 802 mg/L

$\frac{2 \text{ mgd}}{88 \text{ mg/L}} = 0.023$

890 mg/L - 850 mg/L = 40
40 × 0.023 = 0.91 mgd
15 mgd + 0.91 = 15.91 mgd

REACH #4 SULFATE

WQ STANDARD = 750 mg/L

19 mgd = 821
22 mgd = 633

$\frac{3 \text{ mgd}}{188 \text{ mg/L}} = 0.016$

821 mg/L - 750 mg/L = 71 mg/L
71 × 0.016 = 1.14 mgd
19 mgd + 1.14 = 20.1 mgd

SUMMARY

REACH NO.	FLOW AT WQ STANDARD TDS, mgd	SULFATE, mgd
1	11.9	14.2
2	12.0	14.4
3	less than 7Q10	15.9
4	less than 7Q10	20.1

DETERMINE PERCENT EQUIVALENT FOR FLOWRATE @ WQ STANDARD

REACH #1 : WQ STANDARD TDS = 2,100 mg/L @ 11.9 mgd

7Q10 (0%) = 11.1 mgd
X % = 11.9 mgd
10% = 12. mgd

$\frac{X-0}{10-0} = \frac{11.9-11.1}{12-11.1}$

$\frac{X}{10} = \frac{0.8}{0.9}$ X = 10%

WQ STANDARD SULFATE = 1,000 mg/L @ 14.2 mgd

10% = 12 mgd
X% = 14.2 mgd
50% = 17 mgd

$\frac{X-10}{50-10} = \frac{14.2-12}{17-12}$ X = 28%

$\frac{X-10}{40} = \frac{2.2}{5}$

REACH #2: WQ STANDARD TDS = 2,100 mg/L @ 12.0 mgd

10% = 12 mgd X = 10%

WQ STANDARD SULFATE = 1,000 mg/L @ 14.4 mgd

10% = 12 mgd
X% = 14.4 mgd
50% = 25 mgd.

$\frac{X-10}{50-10} = \frac{14.4-12}{25-12}$ X = 17%

REACH #3 WQ STANDARD TDS = 1900 mg/L at flows less than 7Q10

WQ STANDARD SULFATE = 850 mg/L @ 15.9 mgd

7Q10 (0%) = 14.0 mgd
X% = 15.9 mgd
10% = 17 mgd.

$\frac{X-0}{10-0} = \frac{15.9-14.0}{17.0-14.0}$

X = 6%

REACH # 4 WQ STANDARD TDS=1,700 mg/L NOT EXCEEDED @ 7Q10

WQ STANDARD SULFATE = 750 mg/L @ 20.1 mgd

7Q10 (0%.)	=	19 mgd	$\frac{X}{10}$	$= \frac{20.1 - 19}{28 - 19}$
X%	=	20.1 mgd		
10%	=	28 mgd		

$X = 1\%$

SUMMARY

	PERCENT TIME WQ STANDARD IS EXCEEDED	
	TDS	SULFATE
Reach #1	10%	28%
Reach #2	10%	17%
Reach #3	0%	6%
Reach #3	0%	1%

INTERPOLATE TDS & SULFATE LEVELS FOR PURPOSES OF DEVELOPING FIGURES @ 10%, 50% and 90% FLOW.

REACH #1

10% FLOW = 12 mgd

TDS @ 11.37 mgd = 2156 mg/L
TDS @ 15.43 mgd = 1777 mg/L
TDS @ 12.0 mgd = X mg/L

$\frac{2156 - 1777 \text{ mg/L}}{15.43 - 11.37 \text{ mgd}} = \frac{93 \text{ mg/L}}{1 \text{ mgd}}$

12.0 - 11.37 mgd = 0.63 mgd

$\frac{93 \text{ mg/L}}{1 \text{ mgd}} \times 0.63 \text{ mgd} = 59 \text{ mg/L}$

2156 mg/L - 59 = 2097 mg/L.
TDS = 2,100 mg/L.

SET UP EXCEL TO DO CALCULATIONS

10% FLOW = 12 mgd ⇒ SULFATE = 1,129 mg/L
50% FLOW = 17 mgd ⇒ TDS = 1691 mg/L
SULFATE = 855 mg/L
90% FLOW = 76 mgd ⇒ TDS = 915 mg/L
SULFATE = 335 mg/L

REACH # 2

10% FLOW = 12 mgd ⇒ TDS = 2,100 mg/L
SULFATE = 1,128 mg/L
50% FLOW = 25 mgd ⇒ TDS = 1,388 mg/L
SULFATE = 640 mg/L
90% FLOW = 90 mgd ⇒ TDS = 888 mg/L
SULFATE = 314 mg/L

REACH #3

10% FLOW = 17 mgd TDS = 1,483 mg/L
SULFATE = 802 mg/L

50% FLOW = 32 mgd TDS = 1,035 mg/L
SULFATE = 495 mg/L

90% FLOW = 159 mgd TDS = 632 mg/L
SULFATE = 218 mg/L

REACH #4

10% FLOW = 28 mgd TDS = 1,076 mg/L
SULFATE = 535 mg/L

50% FLOW = 58 mgd TDS = 777 mg/L
SULFATE = 332 mg/L

90% FLOW = 273 mgd TDS = 555 mg/L
SULFATE = 180 mg/L

SUMMARY - AVERAGE CONDITIONS

REACH #	7Q10		10% FLOW		50% FLOW		90% FLOW	
	FLOW, mgd	CONC., mg/L	FLOW	CONC.	FLOW	CONC.	FLOW	CONC.
TDS								
# 1	11.1	2156	12	2100	17	1691	76	915
# 2	11.3	2131	12	2100	25	1388	90	858
# 3	14.0	1672	17	1483	32	1035	159	632
# 4	18.8	1500	28	1076	58	777	273	555
SULFATE								
# 1	11.1	1169	12	1129	17	855	76	335
# 2	11.3	1151	12	1128	25	640	90	314
# 3	14.0	932	17	802	32	495	159	218
# 4	18.8	821	28	535	58	332	273	180

HUFF & HUFF, INC.
Environmental Consultants

CALCULATION SHEET

Project ADJUSTED STANDARD Client RBSD - RHODIA

Title CALC. OF PEAK UPSTREAM & EFFLUENT TDS

Signature S. LaDien Date 3-16-00 Sheet 1 of 1

AVAILABLE DATA

	WWTP EFFLUENT	THORN CREEK UPSTREAM
MAX TDS, mg/L	1031	1308
LOW FLOW	10.34	0.19
AVG TDS, mg/L	765.2	688.8
ST. DEVIATION	115.4	306.8
COEFF. VARIATION	0.151	0.445
AVG TDS + 1 ST. DEV.	880.6	995.6

FROM EPA DOC. EPA/505/2-90-001

FACTOR FOR MAX TDS	1.15	1.6
NO. DATA	13	9
MAX TDS (MAX × FACTOR)	1,186	2,093

HUFF & HUFF, INC.
Environmental Consultants

CALCULATION SHEET

Project ADJUSTED STANDARD Client TCBSD - RHODIA

Title CAL SAG TDS

Signature S. LaVien Date 03/16/00 Sheet 1 of 1

BASED ON PROCEDURES USED TO CALCULATE EXPECTED TDS CONC. IN CAL. SAG CHANNEL

MAXIMUM TDS IN REACH #4 = 2019 mg/L

LITTLE CALUMET TDS = 437 mg/L

FOR DETERMINING MAX LEVEL FROM LIMITED DATA USE FACTOR OF 1.15 (EPA TECH DOC. (EPA/SOS/2-90-001)

437 mg/L x 3.0 = 1311 mg/L

LOAD FROM REACH 4 : 19 mgd x 2019 mg/L x 8.34 = 322408

FROM LITTLE CAL. RIV. 208 mgd x 1311 mg/L x 8.34 = 2279660

TOTAL LOAD = 2602068

CONC. IN CAL SAG DUE TO LITTLE CAL / THORN CREEK

$$\frac{2602068 \text{ lbs/d}}{(227 \text{ mgd})(8.34)} = 1374 \text{ mg/L} < 1500 \text{ mg/L}$$

WQ STANDARD