Appendix C
Wastewater Characterization Data

Table C-1
Visitation Data From USACE Recreational Area (Francingues 1976, Middleton USACE)

Parameter	Min. Value	Max. Value	Range
Number of people per site	2	6	4
Length of stay (day)	1	3	2
Size of Camping Party (People)	Frequency of Occurrence	Length of Stay (Days)	Frequency of Occurrence
1	0	1	19
2	17	2	22
3	15	3	36
4	28	4	15
5	22	5	7
6	14	6	3
7	8	7	3
8	3	8	2
9	2	9	1
10	2	10	3
11	0	11	0
12	0	12	0
13	1	13	0
14	1	14 (limit)	3
15	1		

Note: The average size of camping party was calculated to be 4.78 campers per party.
The average length of stay was calculated to be 3.53 days per party.

Table C-2
Factors Contributing to Water Usage

Overnight	Day Use
Camping (trailer, houseboat, tent)	Picnic areas
Water hookups	Comfort stations
Hydrants for tank filling	Privy vaults
Pad for trailers, boat docks, and pier for boats	Chemical toilets
Primitive camping (water limited)	Low- and high-volume flush toilets
Other facilities	Washhouse, shower, change room
Hotels, motels	Swimming pools
Cabins	Fish-cleaning stations
Trailers parked in quasi-permanent manner	Spigots
	Scoffol disposal
	Water hydrants
	Drinking fountains
	Sprinkler for irrigation
Camping Facilities That Lead To Water Use	**Miscellaneous Buildings**
Comfort station	Headquarters
Privy vault	Ranger's office
Chemical toilets	Visitor center
Low- and high-volume flush toilets	Officials' homes
Washroom shower change room	Janitorial building
Laundry facilities (sinks, washers)	
Sanitary disposal stations	
Trailer	
Marinas	
Fish-cleaning stations	
Spigots	
Scoffol disposal	
Swimming pool	
Water hydrant	

Table C-3
Design Criteria Information (Metcalf & Eddy 1972)

		Range of Values Used							
		Turnover Rate		No. Persons per Unit		Water Quantity L/d/c (gpcd)		Sewage Quantity L/d/c (gpcd)	
Type of Area	Type of Facility	Range	Median	Range	Median	Range	Median	Range	Median
Day Use	Picnic (comfort station)	1-1.5	1.5	3-6	4	11.4-37 (3-10)	18.9 (5)	7.6-30 (2-8)	15.2 (4)
	Overlook (comfort station)	1-3	--	4-8	4	7.6-18.9 (2-5)	15.2 (4)	7.6-15.2 (2-4)	11.4 (3)
	Boat launching ramp (comfort station)	--	1	2-4	3	7.6-18.9 (2-5)	15.2 (4)	7.6-15.2 (2-4)	11.4 (3)
Overnight	Camping (tent) water hydrant	--	--	--	5	--	95 (25)	--	72 (19)
	Camping (trailer) water hydrant	--	1	4-5	5	52-189 (15-50)	114 (30)	--	95 (25)
	Camping comfort station	--	1	4-5	--	--	95 (25)	--	76 (20)
	Camping water hydrant plus washers	--	--	5	--	--	114 (30)	--	95 (25)
	Camping water hydrant plus trailer hookups	--	1	--	--	--	132 (35)	--	114 (30)
Maintenance	Shops	--	--	--	--	--	18.9 (5)	--	15.2 (4)
Visitor	Information Center	--	--	--	--	--	7.6 (2)	--	3.8 (1)

Table C-4
Average Wastewater Flows From Recreation Areas (EPA-625-R-92/005, Matherly 1975, and Metcalf & Eddy 1972)

			Flow (L/d/unit (gpd/unit))	
Source		Unit	Typical	Range
Apartment, resort		Person	220 (58.1)	200-280 (52.8-74)
Bathhouse		Person	38 (10)	--
Cabin, resort		Person	160 (42.3)	130-190 (34.3-50.2)
Cafeteria		Customer	6.0 (1.6)	4.2-9.5 (1.1-2.5)
		Employee	41 (10.8)	30-50 (7.9-13.2)
Camps	Camping, tent	Person	76 (20)	--
	Camping, trailer	Person	95 (25)	--
	Day camp (no meals)	Person	49 (13)	--
	Resort, limited plumbing	Person	189 (50)	--
	Tourist, central bath, and toilet facilities	Person	132 (35)	--
Cottages (seasonal occupancy)		Person	189 (50)	--
Cocktail Lounge		Seat	75 (19.8)	50-100 (13.2-26.4)
Coffee Shop		Customer	20 (5.3)	15-30 (4.0-7.9)
		Employee	41 (10.8)	30-50 (7.9-13.2)
Country Club		Member present	401 (106)	250-500 (66-132)
		Employee	50 (13.2)	40-60 (10.6-15.9)
Dining Hall		Meal served	30 (7.9)	15-50 (4.0-13.2)
Dormitory, bunkhouse		Person	150 (39.6)	75-175 (19.8-46.2)
Hotel, resort		Person	200 (52.8)	150-240 (39.6-63.4)
Laundromat		Machine	2199 (581)	1802-2525 (476-667)
Store, resort		Customer	10 (2.6)	4.9-20 (1.3-5.3)
		Employee	40 (10.6)	30-50 (7.9-13.2)
Swimming Pool		Customer	40 (10.6)	20-50 (5.3-13.2)
		Employee	40 (10.6)	30-50 (7.9-13.2)
Theater		Seat	9.5 (2.5)	7.6-15.2 (2.0-4.0)
Visitor Center		Visitor	20 (5.3)	15.2-30 (4.0-7.9)
Parks	Overnight, flush toilet	Person	76 (20)	--
	Trailers, individual bath	Person	189 (50)	--
Picnics	Bathhouse, showers, and flush toilets	Person	76 (20)	--
	Toilet, only	Person	15 (4)	--
	Vault	Person	1.1 (0.28)	--
Marinas	Toilet, only	Person	38 (10)	--
	Toilet and Shower	Person	60 (16)	--

Table C-5
Typical Rates of Water Use For Various Devices (Corbitt 1990)

Device		Range of Flow	
		SI Units	Customary Units
Automatic home laundry machine		110-200 L/load	39-53 gal/load
Automatic home-type dishwasher		15-30 L/load	4-8 gal/load
Automatic home-type washing machine		130-200 L/use	34-53 gal/use
Bathtub		90-110 L/use	24-29 gal/use
Continuous-flow drinking fountain		4-5 L/min	1 gal/min
Dishwashing machine, commercial*:	Conveyor type, at 100 kN/m^2	15-25 L/min	4-7 gal/min
	Stationary rack type, at 100 kN/m^2	25-35 L/min	7-9 gal/min
Fire hose, 36 mm, 13-mm nozzle, 20-m head		140-160 L/min	37-42 gal/min
Garbage disposal unit, home-type		6000-7500 L/wk	1600-2000 gal/wk
Garden grinder		4-8 L/person/day	1-2 gal/person/day
Garden-hose, 16 mm, 8-m head		10-12 L/min	3 gal/min
Garden hose, 19 mm, 8-mm head		16-20 L/min	4-5 gal/min
Lawn sprinkler		6-8 L/min	2 gal/use
Lawn sprinkler, 280 m^2 lawn, 25 mm/wk		6000-7500 L/wk	1600-2000 gal/wk
Shower head, 16 mm, 8-m head		90-110 L/use	24-29 gal/use
Washbasin		4-8 L/use	1-2 gal/use
Water closet, flush valve, 170 kN/m^2		90-110 L/min	24-29 gal/use
Water closet, tank		15-25 L/use	4-7 gal/use

* Does not include water to fill wash tank.

Table C-6
Minimum Required Number of Sanitary Fixtures (Penn Bureau of Resources and USDOI 1958)

	Types of Fixtures							
	Water Closets			Urinals[4]		Lavatories		
Types of Building Occupancy	Number of Sites	No. of Fixtures[3] Male	No. of Fixtures[3] Female	Number of Sites	No. of Fixtures[3]	Number of Sites	No. of Fixtures[3] Male	No. of Fixtures[3] Female
Comfort stations[1] for campgrounds	1-20	1	2	1-20	1	1-20	1	1
	21-30	2	3	21-30	2	21-30	2	2
	Number of Car Parking Spaces	No. of Fixtures[3] Male	No. of Fixtures[3] Female	Number of Car Parking Spaces	No. of Fixtures[3]	Number of Car Parking Spaces	No. of Fixtures[3] Male	No. of Fixtures[3] Female
Comfort stations[1] for picnic areas	1-40	1	2	1-40	1	1-40	1	1
	41-80	2	4	41-80	2	41-80	2	2
	81-120	3	6	81-120	3	81-120	3	3
	Number of Seasonal Slips	No. of Commodes Male	No. of Commodes Female	No. of Urinals	No. of Lavatories Male	No. of Lavatories Female	No. of Showers Male	No. of Showers Female
Comfort stations for marinas[2]	0-49	1	1	0	1	1	0	0
	50-99	1	2	1	1	1	0	0
	100-149	2	3	1	2	2	1	1
	150-199	2	4	2	3	3	2	2
	200-249	3	5	2	4	4	2	2
	Number of Transient Slips							
	0-24	1	1	1	1	1	1	1
	25-49	1	2	1	2	2	2	2
	50-74	2	3	1	2	2	2	2
	75-100	2	4	2	3	3	3	3

1 A comfort station should contain 2 water closets, 2 lavatories, and 1 urinal for males, and 3 water closets and 2 lavatories for females. A sani-stand substituted for 1 water closet is desired for females. A comfort station should provide facilities for 60 percent of users inside a 91-meter (300-foot) radius, 90 percent inside a 137-meter (450-foot) radius, and 100 percent inside a 183-meter (600-foot) radius except where conformance with local health codes might require a smaller radius.

2 For marinas comfort stations where piped water is available, the facility shall consist of a minimum of one commode and one lavatory for each male and female for every 100 seasonal slips. Sanitary facilities may consist of privys where piped water is not available.

3 All fixtures are subject to possible malfunction and vandalism; therefore, stand-by fixtures should be provided even though user ratio would require only one fixture.

4 Drinking fountains should not be installed in toilet rooms. Where urinals are provided for women, the same number should be provided as for men.

Table C-7
Calculation of Design Flow For Fixture Unit Method (Penn Bureau of Resources and USDOI 1958)

		Duration (hr/day)		
Item	Rate L/hr/fixture (gal/hr/fixture)	Camping	Picnic	Fishing
Water Closet	136 (36)	8	10	--
Water Fountain	38 (10)	4	8	--
Urinal	38 (10)	8	10	--
Laundry	189 (50)	4	--	--
Lavatory	57 (15)	8	10	--
Dump Station	38 (10)	4	--	--
Shower	380 (100)	3	--	--
Fish Cleaning Station	189 (50)	--	--	4
Service Sink	38 (10)	2	2	--

Table C-8
Monthly Flow Distribution

Month	Percent of Peak Flow
January-March	20
April	21
May	42
June-August	100
September	42
October	21
November-December	20

Table C-9
Recreation Areas and Domestic Wastewater Characteristics (Francingues 1976, Matherly 1975, and Metcalf & Eddy 1972)

	Waste Source Number [a]					
Parameter	#1	#2	#3	#4	#5	#6
TOC (mg/L)	120	158	144	1980	--	200
BOD (mg/L)	203	229	196	3320	145	200
COD (mg/L)	430	439	336	6370	388	500
BOD/TOC	1.69	1.45	1.36	1.68	--	1.00[b]
COD/TOC	3.58	2.78	2.33	3.22	--	2.50[b]
Total P (mg/L)	--	10.6	10.3	166	10	10
Ortho-PO_4 (mg/L)	--	8.0	7.5	72	8	7
TKN (mg/L)	48.1	44.9	82.8	1040	114	40
NH_3 (mg/L)	39.4	40.5	82.4	1000	64	25
Cl[c]	--	84.4	91.9	1070	--	50
pH range (S. U.)	--	(7.2-8.7)	(7.3-8.3)	(8.0-8.3)	--	--
Alkalinity (mg/L)	356	--	--	--	--	100
TS (mg/L)	613	680	634	9100	--	700
TVS (mg/L)	332	352	--	--	--	250
TSS (mg/L)	252	281	285	2860	--	200
TVSS (mg/L)	161	185	--	--	--	50
Settleable solids (mg/L)	17	--	--	--	--	10

Note: (a) #1 denotes camping area without trailer dump waste.
#2 denotes camping area with trailer dump waste.
#3 denotes picnic area waste.
#4 denotes picnic area waste.
#5 denotes average of three combination picnic and camping areas, Shelbyville, IL
#6 denotes typical domestic waste, medium concentraiton (Metcalf & Eddy 1972 and USAEWES)
(b) Slightly lower than values in other principal tests.
(c) Should be adjusted for Cl in supply water.

Table C-10
Characteristics of a 3 785 L (1 000 gal) load of Nonwater Carriage Wastes (Smith 1973)

	BOD kg (lb)	Solids kg (lb)	Volatile Solids kg (lb)	Chemical Formulations: Formaline Forest Area kg (lb)	Chemical Formulations: Zinc Marine kg (lb)
Septage	26 (58)	136 (300)	102 (225)	--	--
Vault wastes[a]	73 (160)	152 (335)	146 (320)	--	--
Low-volume wastes	57 (125)	118 (260)	68 (150)	--	--
Recirculating and portable chemical toilet wastes[a]	73 (160)	152 (335)	146 (320)	2.3-4.6 (5-10)	2.3-4.6 (5-10)

(a) Assuming waste strength diluted by half to facilitate pumping and cleaning

Table C-11
Characteristics of Vault Wastes at CE Facility (Harrison 1972 and Simmons 1972)

	Vault Wastes With Short Detention Times and no Chemical Additives			Vault Wastes With Longer Detention Times and Chemical Additives			
Parameter	Min.	Avg.	Max.	Min.	Avg.	Max.	Standard Vault (Nonleaking)[a, b]
BOD, mg/L	5900	8780	12 900	390	3895	9450	20 000
Total solids, mg/L	6520	9675	20 080	2022	10 169	21 292	55 000
Suspended solids, mg/L	700	3660	10 680	610	2667	6450	25 000
Dissolved solids, mg/L	3628	6015	10 640	570	7001	12 080	---
pH, S.U.	---	---	---	7.1	---	8.5	---
COD, mg/L	---	---	---	---	---	---	40 000

Note: (a) Standard vaults with chemcial or oil-recirculation toilet--use same values.
(b) Standard vaults with low-volume flush toilet--use 25% of values

.

Table C-12
Estimated Undiluted Vault Waste Characteristics (USAEWES)

Parameter	Estimated Values
BOD_5, mg/L	2640
COD, mg/L	9100
Total solids, mg/L	11 180
Suspended solids, mg/L	4150
Dissolved solids, mg/L	8060
Total volatile solids, mg/L	4340
Total volatile suspended solids, mg/L	220
Total P, mg/L	230
O-PO_4, mg/L	290
Total N, mg/L	890
NO_2-N, mg/L	<0.05
NO_3-N, mg/L	590
Total organic carbon, mg/L	1120
CO_3 (as CaO_3), mg/L	110
HCO_3 (as CaO_3), mg/L	2880
pH, S.U.	8.5
Total coliforms (MPN/100 mL)	2.4×10^5

Table C-13
Wastewater Characteristics of Dump Stations (USEPA-1)

	Sample Number											
Characteristics	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	Range
Total solids, wt %	--	1.90	1.33	0.21	0.92	1.11	1.85	--	0.51	--	--	0.21-4.40
Suspended solids, wt %	--	0.98	1.03	0.04	0.65	0.55	1.20	--	0.20	--	--	0.04-5.85
Filterable residue, wt %	--	0.92	0.30	0.17	0.27	0.56	0.65	--	0.31	--	--	0.17-6.60
Fixed residue, wt %	--	0.81	0.55	0.11	0.47	0.41	1.64*	--	0.26	--	--	0.11-5.80
pH, S.U.	8.0	8.6	8.2	7.0	6.0	6.1	6.6	8.3	8.3	7.6	6.4	6.0-8.6
Conductivity, $^{\mu\,ohms}/_{cm}$	40 000	26 000	12 000	1400	4410	10 800	9900	9800	13 000	42 000	--	1400-42 000
COD, mg/L	2576	20 360	16 500	9900	24 400	24 400	42 800	38 700	4680	1296	102 650*	1296-102 650
Soluble COD, mg/L	1240	7008	3760	9900	1820	5440	9680	2300	3600	634	23 600	684-23 600
Total chromium, mg/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Hexavalent chromium, mg/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Copper, mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/L	<1.0	<1.0	<1.0	2.6	34	181*	79	28	<1.0	<1.0	8.5	<1.0-181
Nickel, mg/L	<0.1	<0.1	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01-0.1
Chlorides, mg/L	13 490*	4383	2350	<2.0	6.0	<2.0	<2.0	<2.0	1821	11 780	30	<2.0-13 490
Sulfate, mg/L	860	1050	220	190	1650	713	710	650	330	1350	4125*	190-4125
Total phosphorous, mg/L	12	350	3956	23	138	164	166	138	1620	85	1625	12-1625
Total Kjeldahl Nitrogen, mg/L	4285	8487*	100	506	467	2317	1803	1695	2303	1804	--	467-8487
Total organic nitrogen, mg/L	907*	100	100	84.2	56.9	325	222	273	3.0	4.1	--	3.0-907
Total inorganic nitrogen, mg/L	3378	8500	22.0	421.7	410	1992	1 581	1422	2300	1930	4000	410-8500
Nitrates-nitrogen, mg/L	0.5	13.0	<0.1	1.7	2.0	12	1.0	22	<1.0	130*	<1.0	0.5-130
Nitrites-nitrogen, mg/L	<0.1	<0.1	3956	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ammonia nitrogen, mg/L	3378	8847*	3956	420	408	1980	1580	1400	2300	1800	4000	408-8847
Anionic detergents, mg/L	<0.05	2.4	<0.05	30*	<0.05	<0.05	3.2	3.0	5.6	<1.0	4000	<0.05-30
Iodine and iodides mg/L	0.02	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Note: Sample #4 not analyzed because of excessive amount of oil in sample
* The values are considered outliers based on the Dixon method at the 95% confidence level. Average values should be calculated without the outliers (AOAC 1982).

Table C-14
Waste Characterization from Watercraft Pumpage (Robin and Green)

Parameter	Concentration Value
TSS, mg/L	1400-2400
TOC, mg/L	1500-3900
BOD_5, mg/L	1700-3500
COD, mg/L	4400-7099
Total Nitrogen, mg/L	1600-2000
Coliforms, MPN/100 mL	10^2-10^{10}
Zinc, mg/L	25-250

Table C-15
Characteristics of Fish-Cleaning Station Effluent (Matherly 1975)

Parameter	Minimum	Mean	Maximum
pH (S. U.)	6.9	--	8.5
COD (mg/L)	130	200	750
BOD_5	85	100	500
SS (mg/L)	15	25	75