REPORT ON

VOLTAGE DROP STUDY

FOR 208/120 VOLT SAFETY RELATED LOADS

FOR

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT

UNIT NO. 2

BY

UNITED ENGINEERS & CONSTRUCTORS INC.

REVISIONS					
No.	Date	Prep. By	Chkd By	Q/A	Appr. By

Job Order No. 9527-089

Date: October 31, 1980

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1.0 PURPOSE

1.1 This study is to review the voltages on various 208/120V Auxiliary Distribution Panels and the equipment connected to these panels to assure proper voltage at the terminals of each safety related load. The distribution transformer tap settings were chosen to assure proper operation of the safety related equipment under conditions of an accident on one unit and a false accident signal on the other unit (2X LOCA).

DEFINITION

1. 2X LOCA: Cases are those initiated by a Loss of Coolant Accident on Unit 2 and a false LOCA signal from Unit 1, resulting in the running of both Units' ESS loads.

2. SAT Light Load: This represents the minimum auxiliary load with the plant shutdown and all auxiliary loads fed from the SAT.

2.0 SUMMARY OF RESULTS

For the 2X LOCA Run, the Voltage Criteria were chosen to ensure that all safety related instrumentation would function and the relay coils and solenoids would pick up. The voltage limit would be above 90% of the equipment rated voltage.

It is recommended for the operating conditions shown, the source voltage to be held within the restrictions tabulated in 2.1.

2.1 OPERATING VOLTAGE LIMITS (Ref. 7.3)

CASE	BUS	BASE VOLTAGE	PER UNIT VOLTAGE	ACTUAL VOLTAGE
SAT Light Load	SWYD	230,000	1.009	232,068
	E7	480	1.0813	519
	E8	480	1.0765	517
2X LOCA Run	SWYD	230,000	.9351	215,073*
	E7	480	.8876	426
	E8	480	.8803	423

*This operating voltage limit does not supersede the minimum recommended voltage of 0.9550 per unit (219,655 volts) listed in Section 2.1.2 of Voltage Drop Study (Ref. 7.3 2X LOCA Run, Reactor Building closed cooling water pumps 2A and 2C start)

2.2 SUMMARY OF VOLTAGE REQUIREMENTS

RESULTS

PANEL NAME		MINIMUM VOLTAGE 2X LOCA RUN		MAXIMUM VOLTAGE SAT LIGHT LOAD	
	BASE VOLTAGE	PER UNIT VOLTAGE	ACTUAL VOLTAGE	PER UNIT VOLTAGE	ACTUAL VOLTAGE
UNIT SUB E7	480	.8876	426	1.0813	519
MAIN DIST. PNL. 2E7	208	.8916	185	1.1017	229
PNL. 2CA	480	.8677	417	1.0733	515
PNL. DGC	480	.8851	425	1.0807	519
PNL. 2A	208	.8911	185	1.1015	229
PNL. 2C	208	.8915	185	1.1017	229
PNL. 32AB	208	.8911	185	1.1015	229
PNL. 32A	208	.8874	185	1.0999	229
PNL. 2ADG	208	.8854	184	1.1000	229
UNIT SUB E8	480	.8803	423	1.0765	517
MAIN DIST. PNL. 2E8	208	.8916	185	1.0994	229
PNL. 2CD	480	.8523	409	1.0650	511
PNL. DGD	480	.8782	422	1.0761	517
PNL. 2B	208	.8913	185	1.0993	229
PNL. 2D	208	.8915	185	1.0994	229
PNL. 32B	208	.8701	181	1.0909	227
PNL. 2BDG	208	.8742	182	1.0940	228

WORST CASE VOLTAGE

COIL OR SOLENOID TERMINALS

	UNIT SUB. E7		UNIT SUB. E8	
	P.U. Voltage	Actual Voltage	P.U. Voltage	Actual Voltage
Minimum Voltage	0.9235	106.2V	0.9026	103.8V
Maximum Voltage	1.1478	132V	1.1492	132.16V

2.3 TAP SETTINGS

Recommended transformer high voltage tap settings are as follows:

TRANSFORMER	NODE	TAP SETTINGS
150 KVA, 3Ø 480 - 208/120V	GF4 GF6	(-2.5%) (-2.5%)
[illegible] KVA, 1Ø 480 - 208/120V	GE8 FJ7 GE7 FJ6	(-2.5%) (-2.5%) (-2.5%) (-2.5%)

3.0 CRITERIA

Voltage at the load terminals should be maintained at 90% of the rated voltage during "2λ LOCA Run" condition and voltage at the load terminals should not exceed 110% of rated voltage during "SAT Light Load" condition.

4.0 DISCUSSION

4.1 TAP SETTINGS

The criteria used to choose transformer tap settings was to determine, for each set of tap settings, the voltage to fall in the limits of safe operation of all safety related equipment. To accomplish this, for each tap setting combination, voltage drop calculations were performed at SAT Light Load and 2X LOCA Run. The tap settings chosen are those most closely approach the desired voltage requirement. For the recommended tap settings, see Article 2.3.

4.2 ALLOWABLE LOAD VOLTAGE RANGE

Unit substations were specified for 480V, power distribution panels for 280V and operating voltage for relay coils and solenoids are 90% - 110% of rated voltage (115V). The minimum pick up voltage 103.5V.

4.2.1 For 2X LOCA Run, the voltage drop between the Unit Substation and the power distribution panels is significant. The voltage drop between the distribution panel buses and terminals of relay coils, solenoids were determined for three parameters

a. Longest length of cable run in 1 - Ø circuit

b. Maximum load in 1 - Ø circuit

c. Cable length 50% more than "a." and load above 50% of "b.".

The voltage drop for SAT Light Load was determined for shortest length of cable run from the distribution panel buses to the terminals of relay coils and solenoids. It was found that if the voltages at Unit Substation E7 is above .8876 p.u. (426 Volts) and E8 is above .8803 p.u. (423 Volts), then all relay coils, solenoid and instrumentation voltages will be above 90% of the rated Voltages.

Operation at voltages higher than the rated Voltage of coils would probably result in abnormal heating of coils and shorten their life span. The over voltage case could occur when a unit is shutdown.

When units are tripped the switchyard voltage is expected to drop to 98% (225,400 Volts) (Ref. 7.5). This in turn improves the case of over voltage condition since this study was based on switchyard voltage of 100.9% (232.070 Volts) when the unit is shutdown - SAT Light Load (Ref. 7.3).

4.2.2 Running loads on 480V system were taken from 480V Load Study (Ref. 7.2). Running loads on 208/120V system were calculated based on actual loads from the drawings (Ref. 7.9).

4.3 METHOD OF ANALYSIS

4.3.1 The UE&C Computer Program 'VOLTS' was used to calculate bus voltages. This program performs a GAUSS - SIEDAL load flow calculation, up to 25 buses can be modeled. Transformer with tap changes can be represented. Bus voltages are computed by the program to a tolerance of $\pm$.0001.

4.3.2 Per Unit Values

Calculations were performed using a per unit scheme with base values as follows:

SYSTEM	BASE VOLTS	BASE MVA
480V	480V	100
208V	208V	100

4.3.3 Impedances

The transformer impedances are assumed. Cable impedances were calculated based on actual length of cable run and cable size. Impedance from 480V Unit Substation to 208V System were taken from report on Voltage Drop Study (Ref. 7.3). Transformer impedances were combined with cable impedance between two buses.

5.0 DATA

5.1 480V SYSTEM

480V Unit Substation Per Unit Voltages

E7	2X LOCA Run	.8876 p.u.	P.F. - .85
	SAT Light Load	1.0813 p.u.	P.F. - .85
E8	2X LOCA Run	.8803 p.u.	P.F. - .85
	SAT Light Load	1.0765 p.u.	P.F. - .85

The above data was taken from the report on Voltage Drop Study (Ref. 7.3).

5.2 DISTRIBUTION TRANSFORMER

Rated KVA - 150 KVA

Nominal Impedance - 3.3% ± 7.5% tolerance

X/R Ratio - 2.5

Voltage Ratio - 480 - 208/120V

5.3 DISTRIBUTION TRANSFORMER

Rated KVA - 10 KVA

Nominal Impedance - 1.95% ± 7.5% tolerance

X/R Ratio - 2

Voltage Ratio - 480 - 208/120V

5.4 RELAY COILS

Type: CR2810 G.E.

Rated Voltage - 115V

Frequency - 60 Hz

VA - 130

Watts - 4.18

5.5 SOLENOIDS

Rated Voltage - 115V

Wattage - 30 Watts

Frequency - 60 Hz

6.0 ASSUMPTIONS

6.1 The nominal impedance and X/R ratio of distribution transformer 150 KVA is 3.3% and 2.5.

6.2 The nominal impedance and X/R ratio of 1Ø - 10 KVA transformer is 1.95% and 2.

6.3 The power factor of power distribution panels is 0.85.

6.4 The wattage of solenoids is 30 watts.

7.0 REFERENCES

7.1 UE&C User Guide for Volts Program.

25 Bus Load Flow Analysis and Voltage Regulation Program, July 15, 1980.

7.2 480V Load Study for Carolina Power and Light Company, Brunswick Steam Electric Plant, Units Nos. 1 and 2, dated March 1, 1978, Revision 1.

7.3 Report on Voltage Drop Study for Carolina Power and Light Company, Unit No. 2, dated February 6, 1978, Revision 1.

7.4 Industrial Power System Handbook - Beeman (McGraw Hill).

7.5 CP&L letter to NRC Serial No. NO-80-1093 dated September 26, 1980.

7.6 9527-F-3005 Single Line Diagram

480V System Unit Substations 2E, 2F, E7, E8 and Common "D"

7.7 9527-F-3053 Single Line Diagram

480V System MCC 2CA, 2CB, 2PA, 2PB and 2SA

7.8 9527-F-3057 Single Line Diagram

480V System MCC DGA, DGB, DGC and DGD

7.9 9527-F-9331 Single Line Diagram

Emergency Power System
120/208V Distribution Panels 3Ø, 4 Wire

7.10 G.E. Catalog Control GEP 1260C

7.11 Solenoid ASCO Catalog No. 30.

APPENDIX

VOLTAGE DROP STUDY

FOR

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VOLTAGES

AND

IMPEDANCE DIAGRAMS

VOLTAGE DROP STUDY

APPENDIX

2X LOCA RUN

BUS NAMES	P.U. VOLTAGE MINIMUM	ACTUAL VOLTAGE
480V Unit Substation E7	.8876	426
208 Main Dist. PNL 2E7	.8916	185
480V PNL 2CA	.8677	417
480V PNL DGC	.8851	425
208 PNL 2A	.8911	185
208 PNL 2C	.8915	185
208 PNL 32AB	.8911	185
208 PNL 32A	.8874	185
208 PNL 2ADG	.8854	184
480V Unit Substation E8	.8803	423
208V Main Dist. PNL 2E8	.8916	185
480V PNL 2CD	.8523	409
480V PNL DGD	.8782	422
208 PNL 2B	.8913	185
208 PNL 2D	.8915	185
208 PNL 32B	.8701	181
208 PNL 2BDG	.8742	182

NOTE: BASE VOLTAGES FOR ALL BUSES ARE THE RATED VOLTAGES SHOWN IN THE LEFT HAND COLUMN

VOLTAGE DROP STUDY

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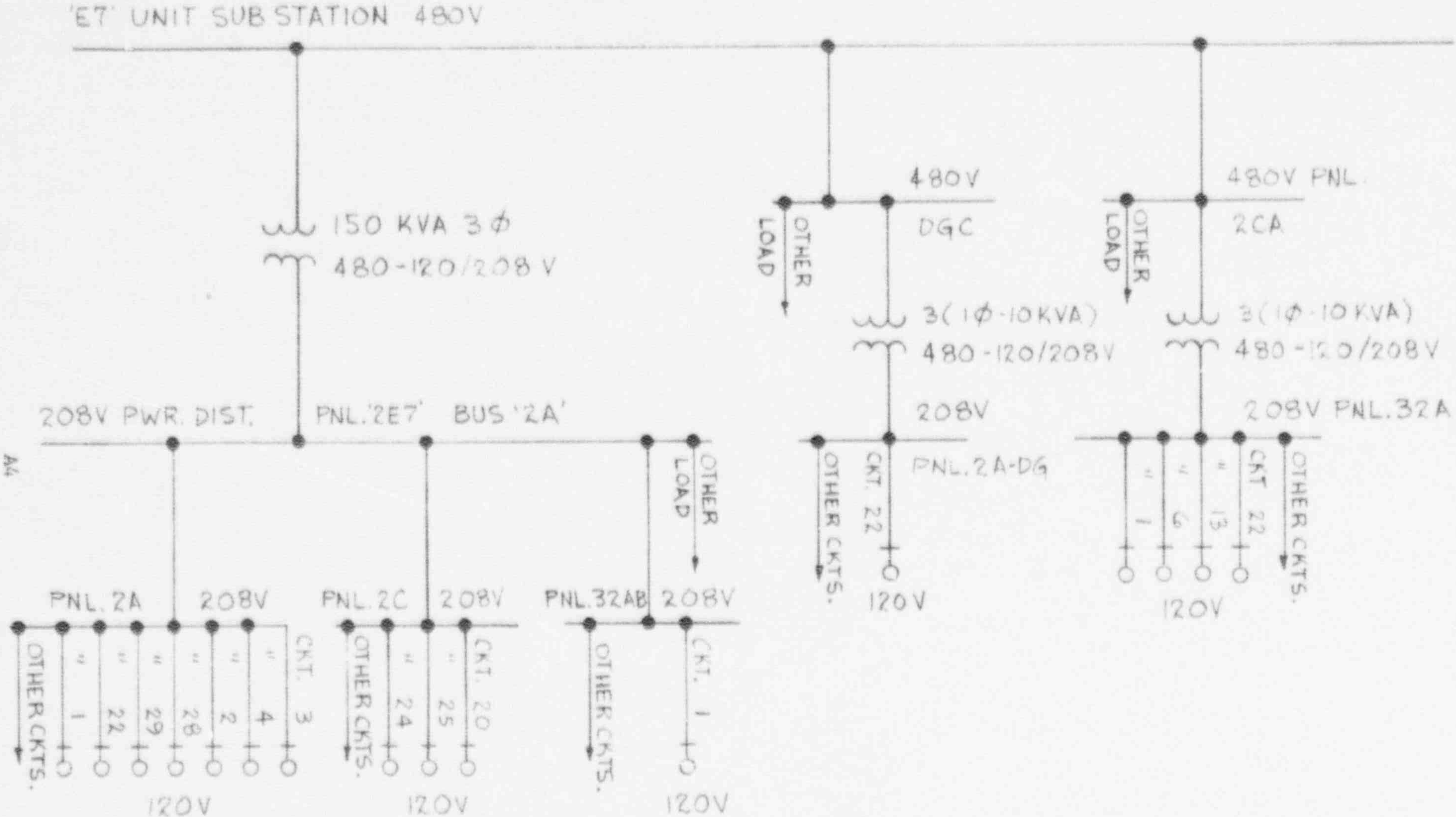
SAT LIGHT LOAD

BUS NAMES	P.U. VOLTAGE MAXIMUM	ACTUAL VOLTAGE
480V Unit Substation E7	1.0813	519
208 Main Dist. PNL 2E7	1.1017	229
480V PNL 2CA	1.0733	515
480V PNL DGC	1.0807	519
208V PNL 2A	1.1015	229
208V PNL 2C	1.1017	229
208V PNL 32AB	1.1015	229
208V PNL 32A	1.0999	229
208V PNL 2ADG	1.1000	229
480V Unit Substation E8	1.0765	517
208V Main Dist. PNL 2E8	1.0994	229
480V PNL 2CD	1.0650	511
480V PNL DGD	1.0761	517
208 PNL 2B	1.0993	229
208 PNL 2D	1.0994	229
208 PNL 32B	1.0909	227
208 PNL 2BDG	1.0940	228

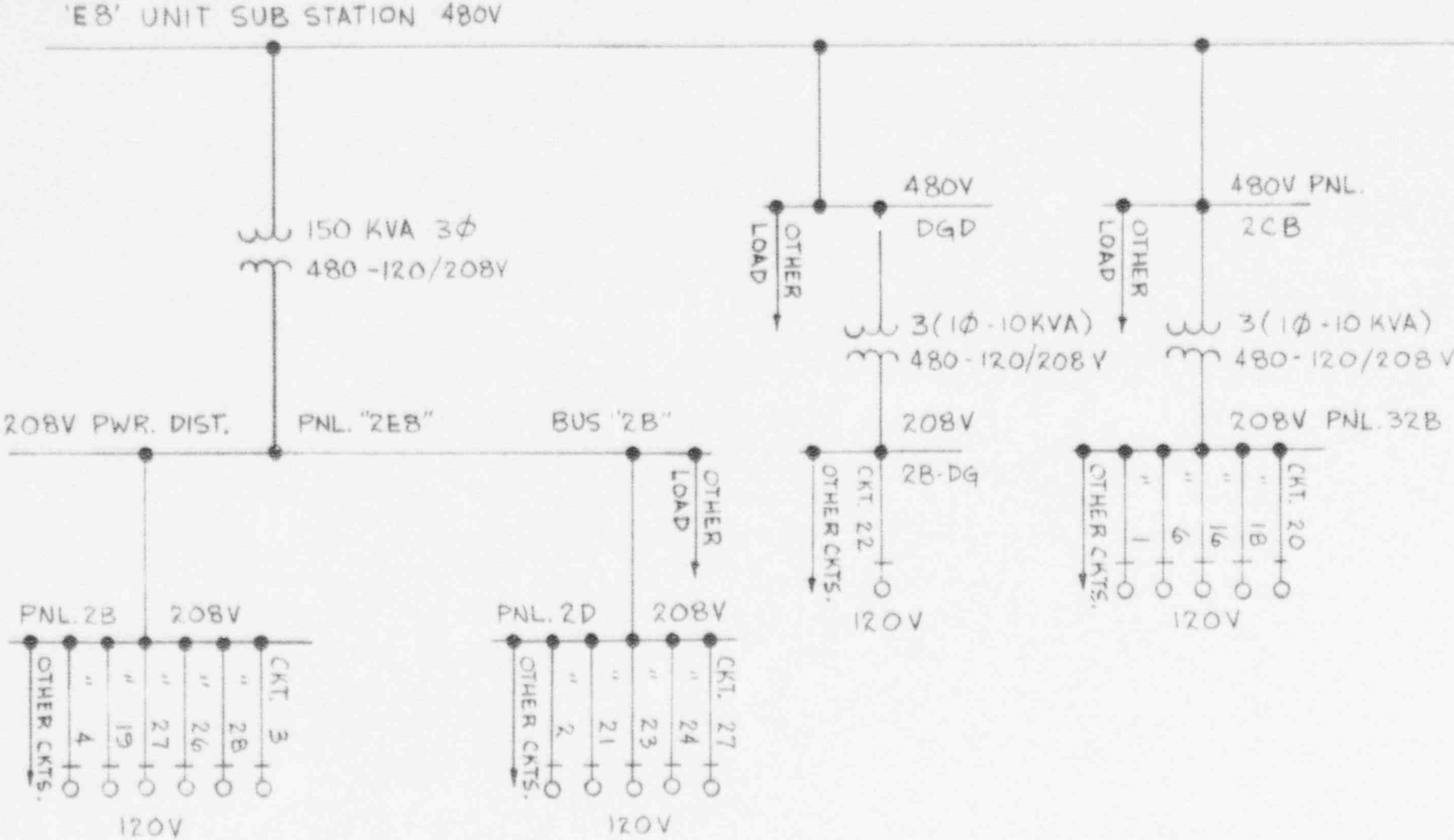
NOTE: BASE VOLTAGES FOR ALL BUSES ARE THE RATED VOLTAGES SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY



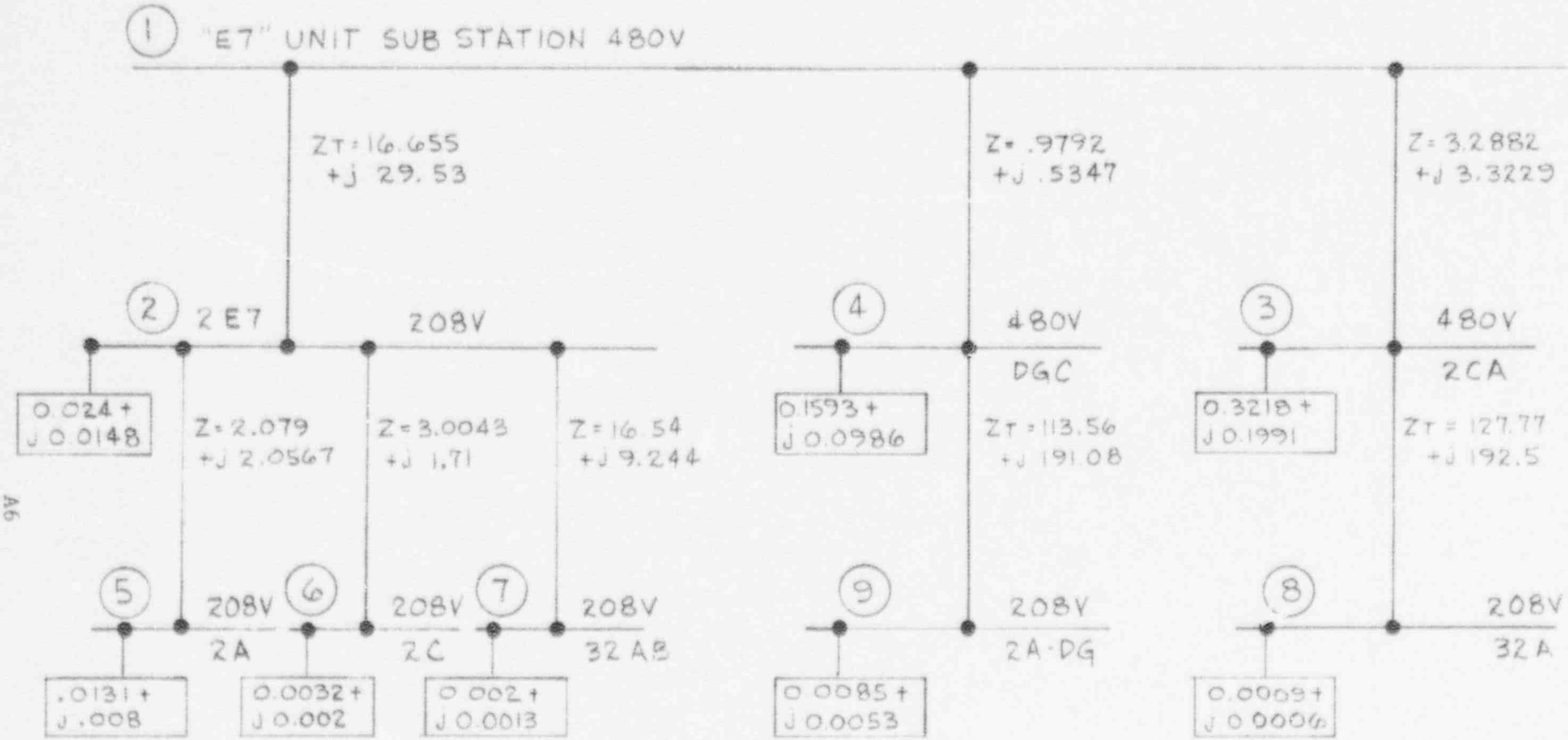
LOW VOLTAGE AUXILIARY SYSTEM DIAGRAM
UNIT SUB STATION "E7"

VOLTAGE DROP STUDY



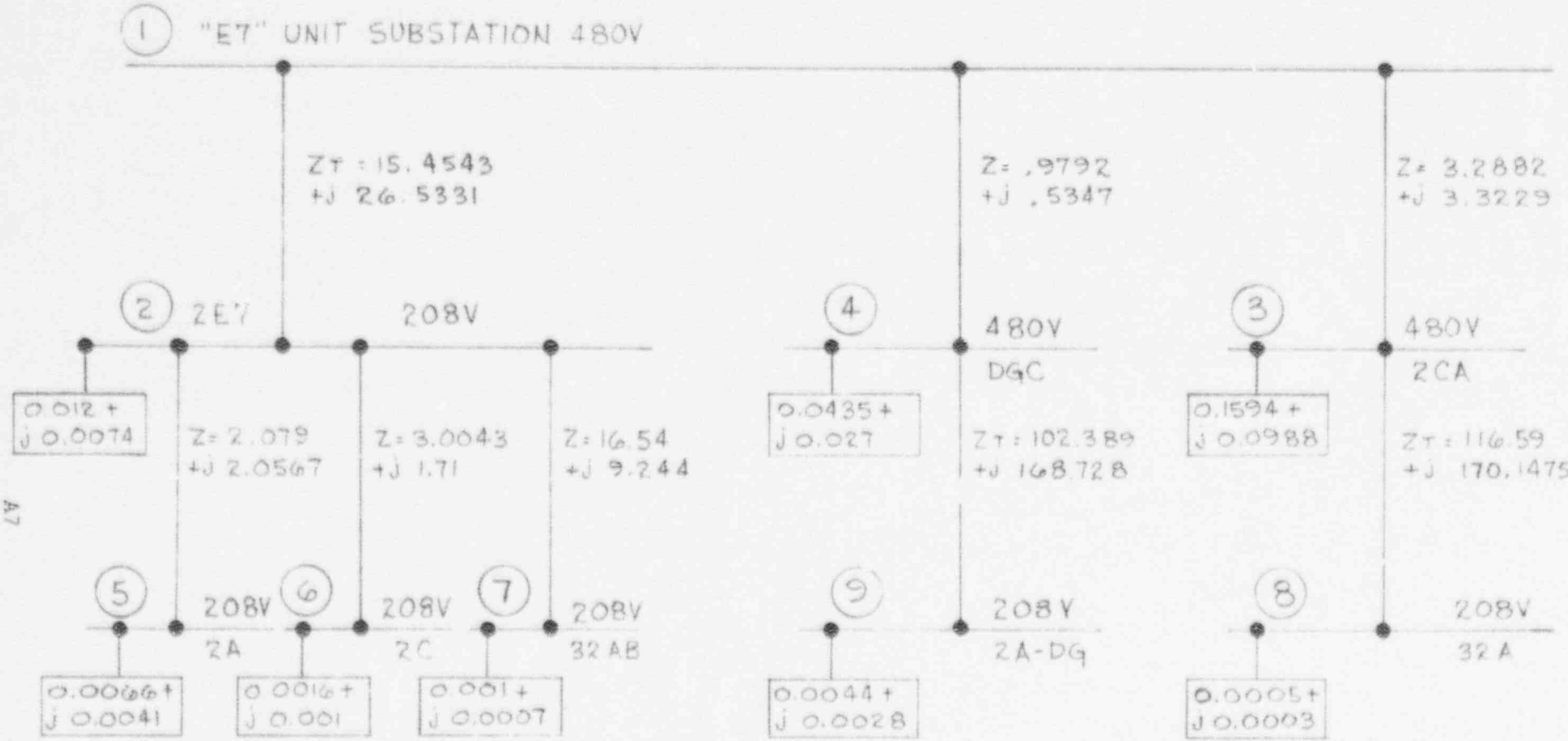
LOW VOLTAGE AUXILIARY SYSTEM DIAGRAM
UNIT SUB STATION "E8"

VOLTAGE DROP STUDY



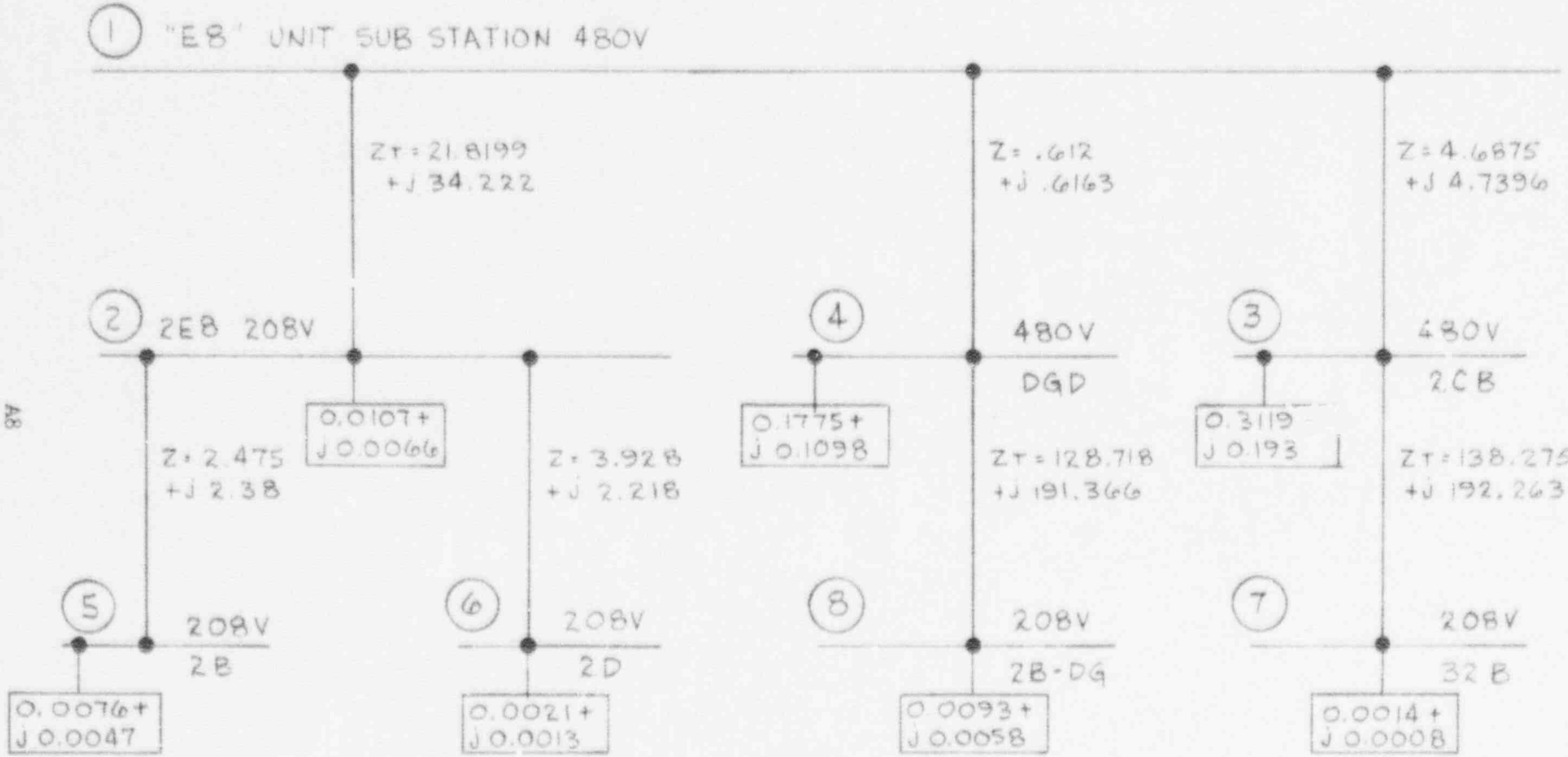
IMPEDANCE DIAGRAM
LOW VOLTAGE SYSTEM "E7"
2X-LOCA RUN

VOLTAGE DROP STUDY



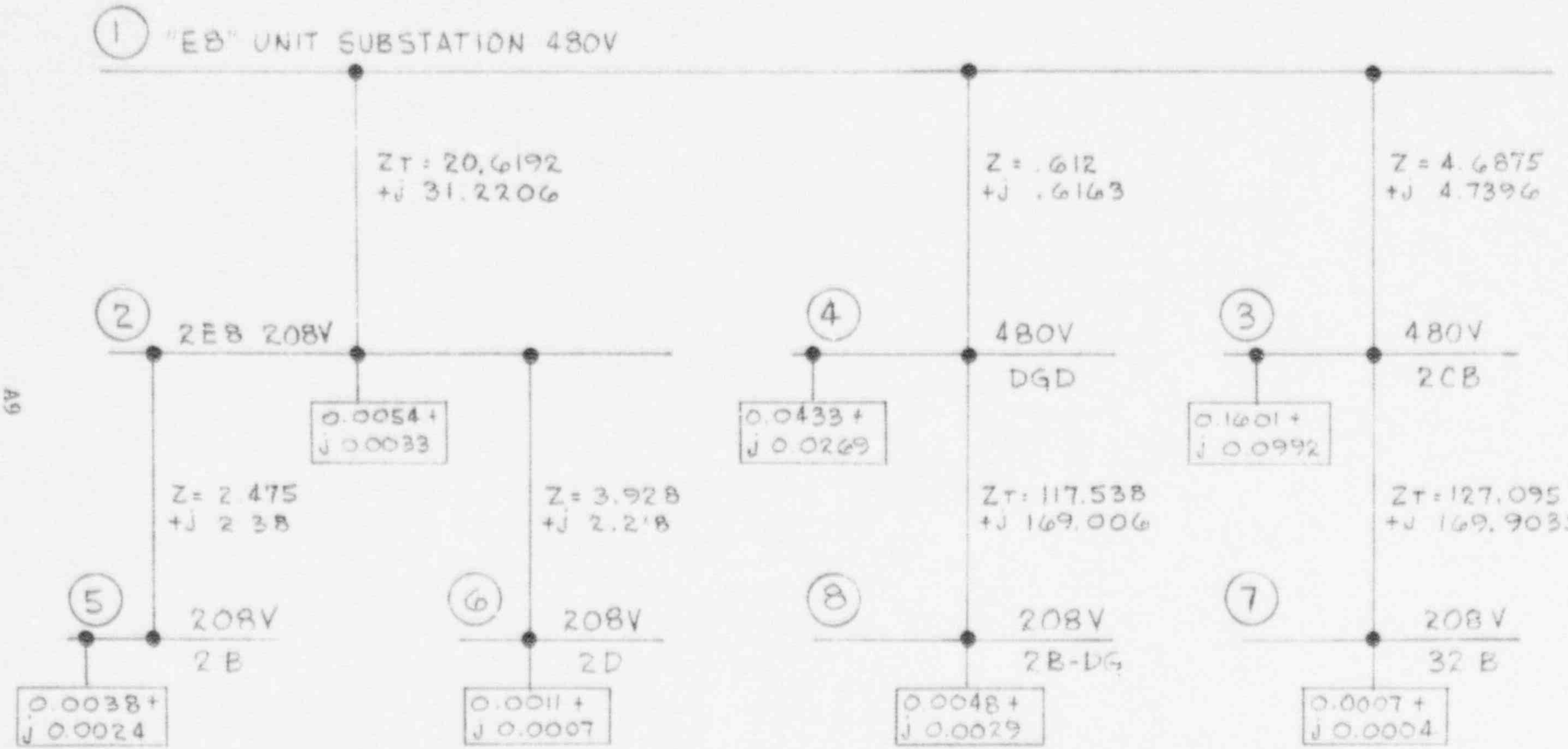
IMPEDANCE DIAGRAM
LOW VOLTAGE SYSTEM "E7"
SAT LIGHT LOAD

VOLTAGE DROP STUDY



IMPEDANCE DIAGRAM
LOW VOLTAGE SYSTEM "E8"
2X LOCA RUN

VOLTAGE DROP STUDY



IMPEDANCE DIAGRAM
LOW VOLTAGE SYSTEM "E8"
SAT LIGHT LOAD

VOLTAGE DROP STUDY

APPENDIX

TOTAL RUNNING LOAD MW AND MVAR

UNIT SUBSTATION E7   POWER FACTOR - .85

BUS NO.	LOAD IN KW	2X LOCA RUN MW	2X LOCA RUN MVAR	SAT LIGHT LOAD (50% of 2X LOCA RUN LOAD) MW	SAT LIGHT LOAD (50% of 2X LOCA RUN LOAD) MVAR	
2	PNL. 2A-TB(H12) - 9.075 PNL. 2A-RX(HØ9) - 3.125 PNL. 2AB-RX(H11) - 4.8 PNL. 2AB(HØ8) - 6.98	0.024	0.0148	0.012	0.0074	
3	PNL. 2CA (other load)	0.3218	0.1991	0.1594	0.0988	*
4	PNL. DGC (other load)	0.1593	0.0986	0.0435	0.027	*
5	PNL. 2A(HØ6) - 13.055	0.0131	0.008	0.0066	0.0041	
6	PNL. 2C(HYØ) - 3.157	0.0032	0.002	0.0016	0.001	
7	PNL. 32AB(HX0) - 2.029	0.002	0.0013	0.001	0.0007	
8	PNL. 32A(HW8) - 0.92	0.0009	0.0006	0.0005	0.0003	
9	PNL. 2A-DG - 8.525	0.0085	0.0053	0.0044	0.0028	

*Refer (7.2)
Unit Substation E7, Shutdown Condition and LOCA Condition

VOLTAGE DROP STUDY

APPENDIX

TOTAL RUNNING LOAD MW AND MVAR

UNIT SUBSTATION E8 POWER FACTOR - .85

BUS NO.	LOAD (IN KWS)	2X LOCA RUN		SAT LIGHT LOAD (50% of 2X LOCA RUN LOAD)		
		MW	MVAR	MW	MVAR	
2	PNL. 2AB-TB(H12) - 2.09 PNL. 2B-RX(H1Ø) - 3.21 PNL. 2B-TB(H13) - 5.535	0.0107	0.0066	0.0054	0.0033	
3	PNL. 2CB (other loads)	0.3119	0.193	0.1601	0.099[illegible]	*
4	PNL. DGD (other loads)	0.1775	0.1098	0.0433	0.0269	*
5	PNL. 2B(HØ7) - 7.55	0.0076	0.0047	0.0038	0.0024	
6	PNL. 2D(HY1) - 2.07	0.0021	0.0013	0.0011	0.0007	
7	PNL. 32B(HW9) - 1.41	0.0014	0.0008	0.0007	0.0004	
8	PNL. 2B-DG - 9.32	0.0093	0.0058	0.0048	0.0029	

*Refer (7.2)
Unit Substation E8, Shutdown Condition and LOCA Condition

VOLTAGE DROP STUDY

APPENDIX A

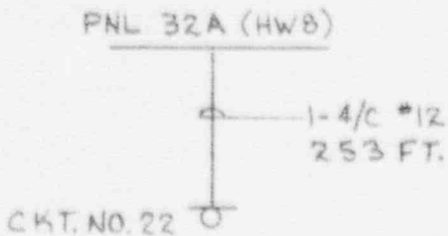
UNIT SUBSTATION "E7"

VOLTAGE DROP IN 1-ϕ CIRCUITS

2X LOCA RUN

A

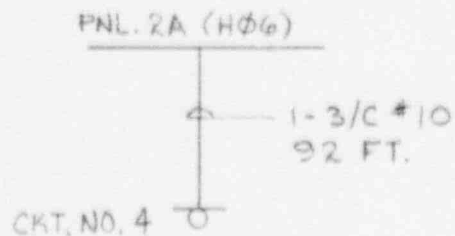
CASE (a)



Z = 0.522 + j 0.0115

LOAD = 30 WATTS

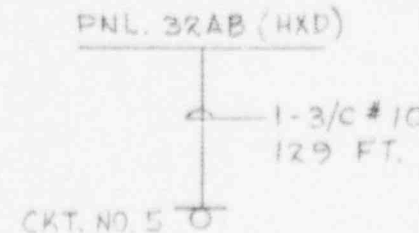
CASE (b)



Z = 0.12 + j 0.0041

LOAD = 240 WATTS

CASE (c)

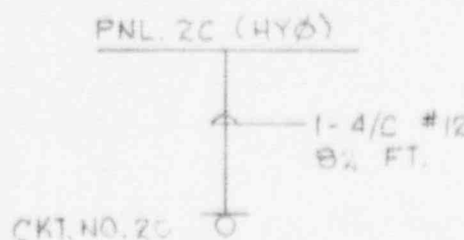


Z = 0.167 + j0.0058

LOAD = 238 WATTS

B

SAT LIGHT LOAD



Z = .1694 + j .0037

LOAD - 25 WATTS

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E7

VOLTAGE DROP IN 1 - Ø CIRCUITS

A 2X LOCA RUN

	RESISTANCE	REACTANCE	LOAD (WATTS)	VOLTAGE DROP	VOLTAGE AT TERMINALS
Case (a) PNL. 32A(HW8) CKT. NO. 22	0.522	0.0115	30	0.2V	106.6V
Case (b) PNL. 2A(HØ6) CKT. NO. 4	0.12	0.00041	240	0.4V	106.4V
Case (c) PNL. 32AB(HXD) CKT. NO. 5	0.167	0.0058	238	0.6V	106.2V

B SAT LIGHT LOAD

	RESISTANCE	REACTANCE	LOAD (WATTS)	VOLTAGE DROP	VOLTAGE AT TERMINALS
PNL. 2C(HYØ) CKT. NO. 22	0.1694	0.0037	25	0.2V	132V

CALCULATION: Volt Drop = 2 $\left\{ I\ (R \cos\theta + x \sin\theta) \right\}$

VOLTAGE DROP STUDY

APPENDIX A

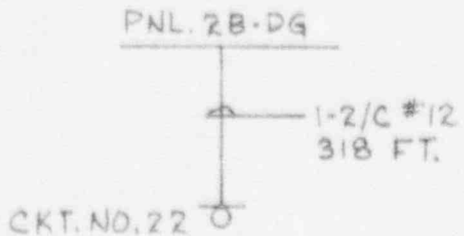
UNIT SUBSTATION "EB"

VOLTAGE DROP IN 1-ϕ CIRCUITS

2 X LOCA RUN

A

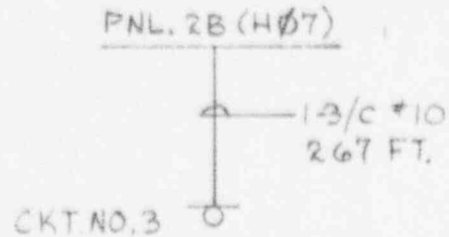
CASE (a)



Z=0.6571 + J 0.0145

LOAD - 100 WATTS

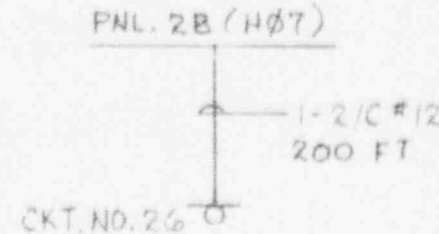
CASE (b)



Z = 0.3468 + J 0.01196

LOAD - 600 WATTS

CASE (c)

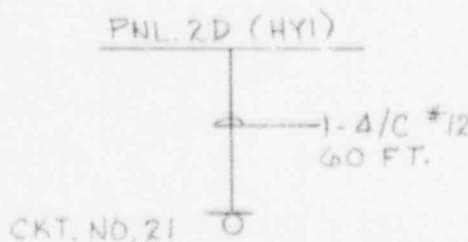


Z = 0.413 + J0.00912

LOAD - 120 WATTS

B

SAT LIGHT LOAD



Z = 0.1239 + J 0.00273

LOAD - 30 WATTS

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E8

VOLTAGE DROP IN 1 - Ø CIRCUITS

A 2X LOCA RUN

	RESISTANCE	REACTANCE	LOAD (WATTS)	VOLTAGE DROP	VOLTAGE AT TERMINALS
Case (a) PNL. 2B-DG CCKT. NO. 22	0.6571	0.0145	100	0.9V	104.18V
Case (b) PNL. 2B(HØ7) CKT. NO. 3	0.3468	0.01196	600	3V	103.8V
Case (c) PNL. 2B(HØ7) CKT. NO 26	0.413	0.00912	120	0.7V	106.1V

B SAT LIGHT LOAD

	RESISTANCE	REACTANCE	LOAD (WATTS)	VOLTAGE DROP	VOLTAGE AT TERMINALS
PNL. 2D(HY1) CKT. NO. 21	0.1239	0.00273	30	0.05V	132.16V

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION 17

IMPEDANCES

FROM BUS	TO BUS		CABLE AND TRANSFORMER IMPEDANDES			
			RESISTANCE		REACTANCE	
			2X LOCA RUN	SAT LIGHT LOAD	2X LOCA RUN	SAT LIGHT LOAD
1	2	Cable:	7.8950	7.8950	7.6345	7.6345
		Transformer:	8.76	7.5593	21.9	18.8986
		Total:	16.655	15.4543	29.53	26.5[illegible]
1	3		3.2882		3.3229	
1	4		0.9792		0.5347	
2	5		2.079		2.0557	
2	6		3.0043		1.71	
2	7		16.54		9.244	
			2X LOCA RUN	SAT LIGHT LOAD	2X LOCA RUN	SAT LIGHT LOAD
3	8	Cable:	10.06	10.06	0.7595	0.7595
		Cable:	23.80	23.80	3.928	3.928
		Transformer:	93.91	82.73	187.82	165.46
		Total:	127.77	116.59	192.5	170.1475
4	9	Cable:	9.722	9.722	1.605	1.605
		Cable:	9.937	9.937	1.663	1.663
		Transformer:	93.91	82.73	187.82	165.46
		Total:	113.56	102.389	191.08	168.728

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E8

IMPEDANCES

FROM BUS	TO BUS		CABLE AND TRANSFORMER IMPEDANCES			
			RESISTANCE		REACTANCE	
			2X LOCA RUN	SAT LIGHT LOAD	2X LOCA RUN	SAT LIGHT LOAD
1	2	Cable:	13.0599	13.0599	12.322	12.322
		Transformer:	8.76	7.5593	[illegible]	18.8986
		Total:	21.8199	20.6192	[illegible].222	31.2206
1	3		4.6875		4.7396	
1	4		0.612		0.6163	
2	5		2.475		2.38	
2	6		3.928		2.218	
			2X LOCA RUN	SAT LIGHT LOAD	2X LOCA RUN	SAT LIGHT LOAD
3	7	Cable:	32.464	32.464	2.4565	2.4565
		Cable:	11.901	11.901	1.987	1.987
		Transformer:	93.91	82.73	187.82	165.46
		Total:	138.275	127.095	192.263	169.9035
4	8	Cable:	24.825	24.825	1.883	1.883
		Cable:	9.983	9.983	1.663	1.663
		Transformer:	93.91	82.73	187.82	165.46
		Total:	128.718	117.538	191.366	169.006

VOLTAGE DROP STUDY

APPENDIX

IMPEDANCE CALCULATIONS

AUXILIARY TRANSFORMERS

BASE: 100 MVA

2X LOCA RUN

KVA	PERCENTAGE IMPEDANCE	TOLERANCE ± 7.5%	X/R RATIO	R PER UNIT	X PER UNIT
150	3.3%	3.54	2.5	8.76	21.9
10	1.95%	2.1	2	93.91	187.82

SAT LIGHT LOAD

150	3.3%	3.0525	2.5	7.5[illegible]93	18.8986
10	1.95%	1.8038	2	82.73	165.46

CALCULATIONS: $Z^2 = R^2 + x^2$

$$R.P.U. = Ohms \times \frac{New\ KVA}{Old\ KVA}$$

VOLTAGE DROP STUDY

APPENDIX

CABLE IMPEDANCES

BASE MVA = 100

P.U. Z 480V Cable = Z Ohms x $\frac{100}{.48^2}$ = Z Ohms x 434.02

P.U. Z 208V Cable = Z Ohms x $\frac{100}{.208^2}$ = Z Ohms x 2311

Resistance at 90°C = Resistance at 75°C x $\frac{234.5 + 90}{(234.5 + 75)}$ = Rx 1.048

UNIT SUBSTATION E7

FROM	TO	SIZE OF CABLE	LENGTH (FEET)	R/1000 Ft. in Ω (7.4)	X/1000 Ft. in Ω (7.4)	R in Ω	X in Ω	R P.U.	X P.U.
Unit Sub E7	Power Dist. PNL 2E7							7.8950	7.6345 *
PNL 2E7	PNL 2A	1-3/c 500 MCM	30	.0306	.0295	.0009	.0089	2.079	2.0567
PNL 2E7	PNL 2C	1-3/c 250 MCM	23	.0573	.0322	.0013	.00074	3.0043	1.710
PNL 2E7	PNL 32AB	1-3/c 250 MCM	125	.0573	.0322	.00716	.004	16.54	9.244
E7	2CA							3.2882	3.3229 *
2CA	Transf.	1-4/c #6 AWG	45	.516	.0391	.0232	.00175	10.06	.7595

FROM	TO	SIZE OF CABLE	LENGTH (FEET)	R/1000 Ft. in Ω	X/1000 Ft. in Ω	R in Ω	X in Ω	R P.U.	X P.U.
Transf.	PNL 32A	1-4/c #2/0	50	.206	.0344	.0103	.0017	23.80	3.928
E7	DGC							.9792	.5347 *
DGC	Transf.	1-4/c #2 AWG	109	.206	.0344	.0224	.0037	9.722	1.605
Transf.	2A-DG	1-4/c #2 AWG	21	.206	.0344	.0043	.00072	9.937	1.663

*P.U. Resistance and Reactances for E7-2E7, E7-2CA, E7-DGC were taken from the report on Voltage Drop Study dated February 6, 1978, Revision 1.

VOLTAGE DROP STUDY

APPENDIX

CABLE IMPEDANCES

BASE MVA - 100

P.U. Z. 480V Cable = Z Ohms x $\frac{100}{.48^2}$ = Z Ohms x 434.02

P.U. Z. 208V Cable = Z Ohms x $\frac{100}{.208^2}$ = Z Ohms x 2311

Resistance at 90°C = Resistance at 75°C x $\frac{234.5 + 90}{234.5 + 75}$ = Rx 1.048

UNIT SUBSTATION E8

FROM	TO	SIZE OF CABLE	LENGTH (FEET)	R/1000 Ft. in Ω (7.4)	X/1000 Ft. in Ω (7.4)	R in Ω	X in Ω	R P.U.	X P.U.	
E8	PNL 2E8							13.0599	12.3220	*
2E8	PNL 2[illegible]	1-3/c 500 MCM	35	.0306	.0295	.00107	.00103	2.475	2.380	
2E8	PNL 2D	1-3/c 250 MCM	30	.0573	.0322	.0017	.00096	3.928	2.218	
E8	2CB							4.6875	4.7396	*
2CB	Transf.	1-4/c #6 AWG	145	.516	.0391	.0748	.00566	32.464	2.4565	
Transf.	PNL 32B	1-4/c #2/0	25	.206	.0344	.00515	.00086	11.901	1.987	
E8	DGD							.612	.6163	*
DGD	Transf.	1-4/c #6 AWG	111	.516	.0391	.0572	.00434	24.825	1.883	

FROM	TO	SIZE OF CABLE	LENGTH (FEET)	R/1000 Ft. in Ω (7.4)	X/1000 Ft. in Ω (7.4)	R in Ω	X in Ω	R P.U.	X P.U.
Transf.	PNL 2B-DG	1-4/c #2 AWG	21	.206	.0344	.00432	.00072	9.983	1.663

*P.U. Resistance and Reactance for F3-2E8, E8-2CB, E8-DGD were taken from the report on Voltage Drop Study, Revision 1 February 6, 1978.

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E7

PNL. 2C (HYØ)

DWG. 9527-F-9331

CKT NO.		LOAD WATTS
1		108
3		25
5		25
7		116
9		116
11		116
13		116
15		200
17		50
19		150
21		150
23		150
25		150
27		25
29		224
2		100
4		50
6		150
8		150
10		150
12		200
14		-
16		200
18		25
20		25
22		25
24		150
26		150
26A		36
28		25
	Total KW	3.157

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E7

PNL 2A-DG

DWG. 9527-F-9331

CKT NO.		LOAD WATTS
1		25
2		50
3		-
4		100
5		-
6		100
7		250
8		100
9		-
10		250
11		-
12		50
13		250
14		250
15		50
16		50
17		50
18		50
19		50
20		0
21		-
22		50
23		6800
24		-
	Total Kw	8.525

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E7

PNL 32AB (HXO)

DWG. 9527-F-9331

CKT NO.		LOAD WATTS
1		100
3		107
5		238
7		238
9		58
11		108
13		116
15		18.5
17		18.5
19		-
21		-
23		108
2		82
4		279
6		108
8		238
10		58
12		58
14		32
16		32
18		32
	Total KW	2.029

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E7

PNL 2A (H06)

DWG. 9527-F-9331

CKT NO.	LOAD WATTS
1	100
2	30
3	120
4	240
5	240
6	600
7	100
8	5250
9	100
10	-
11	1200
12	2000
13	120
14	100
15	2000
16	50
17	30
18	50
19	150
20	0
21	50
22	125
23	50
24	60
25	80
26	60
27	60
28	30
29	30
30	-
31	30
Total KW	13.055

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E7

PNL. 32A (MW8)

DWG. 9527-F-9331

CKT. NO.		LOAD WATTS
1		30
5		560
6		30
8		30
9		30
10		30
12		30
13		30
14		30
16		30
18		30
20		30
22		30
	Total KW	.92

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E7

PNL 2A-TB (H12)

DWG. 9527-F-9331

CKT NO.	LOAD WATTS
1	-
2	1250
3	95
4	3400
5	100
6	130
7	100
8	130
9	100
10	275
11	-
12	275
13	100
14	30
15	30
16	30
17	30
18	-
19	-
20	-
21	-
22	-
23	-
24	-
25	-
26	1500
27	-
28	1500
29	-
30	-
Total KW	9.075

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E7

PNL. 2A-RX (HØ9)

DWG. 9527-F-9331

CKT NO.	LOAD WATTS
1	-
2	-
3	360
4	-
5	-
6	100
7	-
8	100
9	100
10	100
11	-
12	-
13	-
14	-
15	-
16	-
17	-
18	-
19	700
20	100
21	100
22	100
23	75
24	100
25	75
26	100
27	100
28	100
29	50
30	175
31	50
32	100
33	-
34	100
35	240
36	100
Total KW	3.125

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E7

PNL. 2AB-RX (H11)

DWG. 9527-F-9331

CKT NO.	LOAD WATTS
1	-
2	-
3	-
4	240
5	100
6	1000
7	-
8	1000
9	-
10	-
11	100
12	240
13	240
14	240
15	-
16	-
17	-
18	-
19	-
20	-
21	100
22	100
23	-
24	240
25	1000
26	-
27	-
28	-
29	-
30	-
31	100
32	-
33	-
34	-
35	-
36	-
37	-
38	-
39	-
40	-
42	100
Total KW	4.800

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E7

PNL. 2AB (HØ8)

DWG. 9527-F-9331

CKT NO.		LOAD WATTS
2		100
5		100
6		100
7		360
10		100
11		240
12		240
13		100
14		1600
15		-
19		600
20		600
22		240
24		240
30		360
33		100
34		1200
36		-
42		700
	Total KW	6.980

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E8

PNL. 2AB-TB (H14)

DWG. 9527-F-9331

CKT NO.	LOAD WATTS
1	390
2	100
3	200
7	240
8	240
9	240
10	240
11	240
12	100
14	100
Total KW	2.090

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E8

PNL. 2B-RX (H1Ø)

DWG. 9527-F-9331

CKT NO.	LOAD WATTS
2	100
3	360
4	200
5	100
6	200
7	100
8	100
10	100
19	100
20	100
21	700
22	100
23	75
24	100
26	100
27	175
28	100
30	100
31	100
32	100
36	100
Total KW	3.210

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E8

PNL. 2B-TB (H13)

DWG. 9527-F-9331

CKT NO.		LOAD WATTS
2		1270
3		100
4		3400
5		390
6		75
7		100
8		100
9		100
	Total KW	5.535

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E8

PNL. 32B (HW9)

DWG. 9527-F-9331

CKT NO.	LOAD WATTS
1	100
2	30
3	50
4	100
5	-
6	30
7	-
8	-
9	-
10	-
11	-
12	-
13	-
14	100
15	100
16	100
17	100
18	100
19	100
20	100
21	100
22	200
23	100
24	-
Total KW	1.410

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E8

PNL. 2B-DC

DWG. 9527-F-9331

CKT NO.	LOAD WATTS
1	100
2	100
3	100
4	50
5	100
6	50
7	200
8	200
9	-
10	200
11	-
12	100
13	250
14	250
15	-
16	100
17	-
18	100
19	120
20	100
21	200
22	100
23	6800
24	100
Total KW	9.32

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E8

PNL. 2D (HY1)

DWG. 9527-F-9331

CKT NO.	LOAD WATTS
1	-
2	100
3	100
4	100
5	100
6	100
7	100
8	100
9	100
10	100
11	100
12	100
13	100
14	100
15	100
16	100
17	100
18	30
19	30
20	30
21	30
22	30
23	30
24	30
25	-
26	30
27	-
28	100
29	100
30	30
Total KW	2.070

VOLTAGE DROP STUDY

APPENDIX

UNIT SUBSTATION E8

PNL. 2B (HØ7)

DWG. 9527-F-9331

CKT NO.	LOAD WATTS
1	150
2	30
3	600
4	240
5	240
6	600
7	-
8	-
9	100
10	0
11	125
12	2000
13	2000
14	30
15	100
16	100
17	-
18	-
19	275
20	-
21	100
22	100
23	100
24	100
25	100
26	120
27	120
28	120
29	100
Total KW	7.55

REPORT ON

VOLTAGE DROP STUDY

FOR

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT

UNIT NO. 2

BY

UNITED ENGINEERS & CONSTRUCTORS INC.

Date: December 2, 1974

Rev. 1: February 6, 1978

Rev. 2: December 15, 1980

UE&C J.O. No. 9527.018

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INDEX

1.0 PURPOSE

1.1 This study is an analysis of the voltage regulation performance of the Brunswick Steam Electric Plant auxiliary distribution system. First, the optimum transformer tap settings were determined for the various auxiliary transformers. Second, using these tap settings, the voltage ranges at the various auxiliary load terminals were determined, for the expected generator and 230KV switchyard voltage variations, and for postulated variations in load conditions. Third, limitations on generator and 230KV switchyard voltage variations were determined. These limitations were established such that under expected normal operating conditions equipment design lifetimes would not be decreased. Under emergency operating conditions the limits were set to provide proper operation of all safety-related equipment.

2.0 SUMMARY OF RESULTS

2.1 SOURCE VOLTAGE RESTRICTIONS

2.1.1 Criteria

For those operating conditions which are expected to continue for long periods of time, the voltage criteria at the load buses were chosen to maximize motor life (90% to 110% of the motor rated voltage), and the source voltage restrictions for these cases were based on such criteria. (See Article 3.2.1). For the emergency operating conditions, the voltage criteria were chosen to ensure that all safety-related equipment would function, (85% to 110% of the motor control center voltage), with the possibility that motor life might be adversely affected if operation beyond either voltage limit continued for a long period of time. (See Article 3.2.1). For all motor starting cases, both accident-related and normal operation, the voltage criteria were chosen to ensure that the motors in question would start (70% or 75% for 4000-volt safety-related motors, 85% for all 460-volt motors and 4000-volt BOP motors), and that the 480-volt starters would not drop out (70%).

It is recommended, for the operating conditions shown, that the source voltages be held within the restrictions tabulated in 2.1.2 and 2.1.3.

2.1.2

GENERATOR AND SWITCHYARD VOLTAGES

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY (4160 VOLT BUSES COMMON B & COMMON A TIE BREAKER OPEN)

OPERATING VOLTAGE LIMITS

CASE	BUS	BASE VOLTAGE	PER-UNIT VOLTAGE	ACTUAL VOLT	
UAT, LIGHT LOAD					
	GEN	24ØØØ.	1.Ø365	24876.	Max.
UAT, SCREEN WASH PUMP 2 A STARTING (FULL LOAD)					
	GEN	24ØØØ.	Ø.9665	23198.	Min.
SAT, SHUTDOWN (LIGHT LOAD)					
	SWYD	23ØØØØ	1.ØØ9Ø	232Ø68.	Max.
SAT, UNIT LOADS FED FROM UAT					
	SWYD	23ØØØØ	1.Ø138	233185.	Max.
SAT, SCREEN WASH PUMP 2A STARTING (FULL LOAD)					
	SWYD	23ØØØØ	Ø.9727	223711.	Min.
SAT, 2X LOCA START (FULL LOAD)					
	SWYD	23ØØØØ	Ø.9593	22Ø639.	Min.

2.1.3

GENERATOR AND SWITCHYARD VOLTAGES

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY (4160 VOLT BUSES COMMON B & COMMON A TIE BREAKER CLOSED)

OPERATING VOLTAGE LIMITS

CASE	BUS	BASE VOLTAGE	PER-UNIT VOLTAGE	ACTUAL VOLTAGE
SAT, SCREEN WASH PUMP 2 A STARTING (FULL LOAD)				
	SWYD	230000.	0.9809	225607. Min.
SAT, 2X LOCA START (FULL LOAD)				
	SWYD	230000	0.9720	223560. Min.

2.2 TAP SETTINGS

Recommended transformer high-voltage winding tap settings are as follows:

UAT	1.00	(base)
SAT	.975	(-2.5%)
Unit Substations		
2E	.95	(-5%)
2F	.95	(-5%)
E7	.95	(-5%)
E8	.95	(-5%)
2SY	.975	(-2.5%)
Common D	.975	(-2.5%)
2L	1.00	(base)
4L	.975	(-2.5%)

The above tap settings will provide adequate voltage at the equipment terminals under the operating conditions evaluated and were used in calculating the source voltage limits govern in Table 2.1.2 and 2.1.3.

3.0 DISCUSSION

3.1 BASES FOR COMPARISON

3.1.1 Tap Settings

The criterion used to choose transformer tap settings was to determine, for each set of tap settings, the maximum 230 KV switchyard voltage required to meet the load voltage requirements. To accomplish this, for each tap setting combination, voltage drop calculations were performed for the SAT Shutdown (Light Load) case to determine the maximum switchyard voltage. The tap settings chosen are those which most closely approach the desired switchyard operating voltage range of 96.0 to 102%.[3.1] The tap settings chosen must also provide proper load voltages over the entire range of generator voltages from light load to full load. (See Article 3.2.1). The recommended tap settings do this. (See Article 2.2).

3.2 CRITERIA

3.2.1 Allowable Load Voltage Ranges

3.2.1.1 Motor voltage criteria vary with the class of the motor, as well as the voltage rating. For 4000-volt motors, non-Class-IE, the requirements are:(5.2)(5.3)

Running continuous	4000-V base	90%-110%	3600-4400V
Starting	4000-V base	85%-110%	3400-4400V
Running transient	4000-V base	85%-110%	3400-4400V

For 4000-volt motors, Class IE, specified and supplied by G.E., the requirements are:(5.4)(5.5)

Running continuous	4000-V base	90%-110%	3600-4400V
Starting	4000-V base	70%-110%	2800-4400V
Running transient	4000-V base	70%-110%	2800-4400V

For 4000-volt motors, Class IE, specified by UE&C, the requirements are:(5.6)

Running continuous	4000-V base	90%-110%	3600-4400V
Starting	4000-V base	75%-110%	3000-4400V
Running transient	4000-V base	75%-110%	3000-4400V

For 460-volt motors, the requirements for normal motor life are:(5.7)

Running continuous	460-V base	90%-110%	414-506V
Starting	460-V base	85%-110%	391-506V
Running transient	460-V base	*70.7%-110%	325-506V

*Based on 200% torque at rated voltage for NEMA design motors.

Motor control centers were specified for 480 volts, and the minimum hold-in voltage requirement for the starters is 70% of 480 volts, or 336 volts. The minimum pickup voltage requirement for starters is 85% of 480 volts, or 408 volts.(5.8)

3.2 CRITERIA (Cont'd)

3.2.1 Allowable Load Voltage Ranges (Cont'd)

3.2.1.2 For the normal operation cases, that is, for the UAT Full Load, SAT Full Load, UAT Light Load, and SAT Shutdown cases, the load voltage restrictions are based on the rated continuous running voltages of motors to achieve normal lifetimes (90% to 110% of rated voltage, 4000V or 460V). (See Articles 3.2.3 for definitions of these cases).

3.2.1.3 Operation at voltages higher than those given would probably result in abnormal heating of motors due to saturation. This heating would shorten the Mean Time Between Failures for the motors so exposed. The MTBF could be expected to decrease with increased time at high voltages, and to decrease rapidly with increased voltage levels above the voltage where saturation begins. At the other extreme, because the speed of an induction motor varies greatly with changes in frequency and only slightly on voltage, the load speed remains essentially constant with decreasing voltage. Therefore, the load power and electrical volt-ampere requirements remain essentially constant for decreasing motor voltage, and the current increases. Below the limiting values shown in Article 3.2.1.1, the I^2R losses due to this increased current could be expected to produce abnormal heating and again result in reduced MTBF's. Both of these effects are long-term results of high- or low-voltage operation, hence these limiting values apply only to

3.2 CRITERIA (Cont'd)

3.2.1 Allowable Load Voltage Ranges (Cont'd)

3.2.1.3 operating conditions expected to occur for a substantial portion of the forty-year plant lifetime. Since high voltages would occur with most motors stopped, while low voltages would occur with most motors running and therefore more motors would be exposed to the potentially damaging condition. Thus the decrease in reliability due to extended low-voltage operation would be much more severe than that due to extended high-voltage operation.

3.2.1.4 For 4000 volt motor starting cases, the criteria are simpler. At the 4160-volt level, the limitation is maintaining the minimum motor voltages cited in Article 3.2.1.1. Since motors can, without stalling, ride through a transient voltage dip at a voltage sufficient to start them, the limiting condition for the 4160-volt level is to maintain sufficient voltage to start the motors. At the 480-volt level, the limitation is that the starters of motors already running must not drop out when a 4000-volt motor starts. Starters are not guaranteed to hold in at voltages below 70% of their rated coil voltage, or in the case of BSEP, 70% x 480V or 336V. For 460 volt motor starting cases, the criterion is simply that the 460 volt motor must have no less than rated starting voltage (85% of 460V).

3.2 CRITERIA (Cont'd)

3.2.1 Allowable Load Voltage Ranges (Cont'd)

3.2.1.5 For the running LOCA and 2X LOCA cases, the postulated combination of depressed 230KV system voltage and heavy auxiliary load would not be expected to continue indefinitely. Because these are temporary conditions, and because such an accident could affect the operating life of the plant, reduction in motor MTBF becomes a secondary consideration. The important voltage limitation in these accident conditions is imposed by the requirement of 85% x 480V or 408V at the motor control centers to ensure that a starter will pick up.

3.2.1.6 Using the above values, voltage criteria were developed for buses and unit substations. At the 4160-volt level, the voltage drops due to cable impedances are negligible. Hence, the bus voltages are considered to be the same as the motor voltages. At the 480-volt level, the voltage drops between the unit substations and motor control centers, and between the motor control centers and the motor terminals are significant. VOLTS runs were made to determine the exact 480 Volt unit substation voltage required to maintain the required voltages at all motor control centers. It was found that if the voltage at Unit Substation E7 is above .8718, and that at Unit Substation E8 is above .8803, then all MCC voltages will be at least 85%. VOLTS runs were also made

3.2 CRITERIA (Cont'd)

3.2.1 Allowable Load Voltage Ranges (Cont'd)

3.2.1.6 to determine the minimum unit substation voltages to ensure that all MCC's will see not less than 70% voltage when 4000 volt motors start. It was found that if the Unit Substation E8 voltage is .7368 x 480V or more, all MCC's will see not less than 70% voltage. Note that specifying a single unit substation's voltage essentially specifies all unit substations' voltages, because unit substation voltages are determined by the 4KV system voltage.

3.2.1.7 Summary of Voltage Requirements

4160-Volt Buses	Minimum	Maximum
Running Voltage	3600	4400
Starting Voltage (non-Class IE)	3400	4400
Starting Voltage (Class IE Spec. by G.E.)	2800	4400
Starting Voltage (Class IE Spec. by UE&C)	3000	4400
460-Volt Motors		
Starting voltage at motor terminals	391	506

3.2.1.7 SUMMARY OF VOLTAGE REQUIREMENTS

480 VOLT UNIT SUBSTATION VOLTAGES

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

OPERATING VOLTAGE LIMITS

CASE	BUS	BASE VOLTAGE	PER-UNIT VOLTAGE	ACTUAL VOLTAGE
LOCA RUNNING LOADS, UNIT SUBSTATION E7 MOTOR CONTROL CENTERS				
	2CA	480.	0.8500	408.
	E7	480.	0.8718	418.
LOCA RUNNING LOADS, UNIT SUBSTATION E8 MOTOR CONTROL CENTERS				
	2CB	480.	0.8500	408.
	E8	480.	0.8803	423.
LOCA STARTING, UNIT SUBSTATION E7 MOTOR CONTROL CENTERS				
	2CA	480.	0.7000	336.
	E7	480.	0.7265	349.
LOCA STARTING, UNIT SUBSTATION E8 MOTOR CONTROL CENTERS				
	2CB	480.	0.7000	336.
	E8	480.	0.7368	354.
FULL LOAD, UNIT SUBSTATION E7 MOTOR CONTROL CENTERS				
	2CA	460.	0.9000	414.
	E7	480.	0.8797	422.
FULL LOAD, UNIT SUBSTATION E8 MOTOR CONTROL CENTERS				
	2CB	460.	0.9000	414.
	E8	480.	0.8864	425.
FULL LOAD, UNIT SUBSTATION 2E MOTOR CONTROL CENTERS				
	2TK	460.	0.9000	414.
	2E	480.	0.8715	418.
FULL LOAD, UNIT SUBSTATION 2F MOTOR CONTROL CENTERS				
	2TG	460.	0.9000	414.
	2F	480.	0.8730	419.
FULL LOAD, UNIT SUBSTATION COMMON D MOTOR CONTROL CENTERS				
	RWD	460.	0.9000	414.
	COM D	480.	0.8753	420.

Note: First line represents the MCC having the lowest bus voltage for the operating condition. The second line represents the unit substation to which the MCC is connected and the corresponding voltage on its bus.

3.2 CRITERIA (Cont'd)

3.2.2 Loads

4000 Volt motor loads were based on the load brake horsepower, using the motors' actual efficiencies and power factors to determine the electrical loads. The starting admittance values for both 4000 Volt and large 460 Volt motors were derived from the motors' actual inrush currents and power factors. Running loads on the 480 Volt system were taken from the 480 Volt Load Study[5.9]

3.2.3 Postulated Events and Plant Operating Conditions

3.2.3.1 "Normal Operation", as used in this study, includes the entire range of steady-state non-accident conditions from cold shutdown to full power operation. Any of the conditions included in this concept could be expected to continue for weeks or months at a time, and therefore the load voltage range for these conditions is that described in Article 3.2.1.2. The load conditions for normal operation are:

UAT	Full Load
SAT	Full Load
UAT	Light Load
SAT	Shutdown (Light Load)

3.2.3.2 "Motor Starting" cases refer to those motors which would be started at various times during normal plant operation. On each 4160 volt bus and each 480 volt unit substation, the largest motor was selected for study. It was assumed that the motor was starting while all other loads required for full power operation were running. If the largest motors

3.2 CRITERIA (Cont'd)

3.2.3 Postulated Events and Plant Operating Conditions (Cont'd)

3.2.3.2 on each bus can be started under this condition, it is reasonable to assume that all motors can be started under all "Normal Operation" conditions. These motor starting runs were made for both the UAT and SAT.

The following motors were studied:

Motor	HP	Fed From	Via
Reactor Recirculation Pump MG Set	7000	4160V Bus 2B	-
Circulating Water Intake Pump 2B	2250	4160V Bus 2D	-
Screen Wash Pump 2A	200	480V Unit Sub E7	MCC 2PA
Screen Wash Pump 2B	200	480V Unit Sub E8	MCC 2PB
Turbine Building Closed Cooling Water Pump 2A	200	480V Unit Sub 2E	MCC 2TJ
Turbine Building Closed Cooling Water Pump 2B	200	480V Unit Sub 2F	MCC 2TH
Backwash Air Blower 2-CFD-D063	150	480V Unit Sub Common D	MCC RWD
Reactor Building Closed Cooling Water Pumps 2A and 2C	75 + 75	480V Unit Sub E8	MCC 2XE

3.2 CRITERIA (Cont'd)

3.2.3 Postulated Events and Plant Operating Conditions (Cont'd)

3.2.3.3 "LOCA" cases are those initiated by a Loss of Coolant Accident on Unit 2. Both starting cases and running cases were studied. For detailed descriptions of the load conditions, see Article 3.2.4. The voltage criteria for these cases are described in Article 3.2.1.4 (starting) and 3.2.1.5 (running).

3.2.3.4 "2X LOCA" cases are those initiated by a Loss of Coolant Accident on Unit 2 and a false LOCA signal from Unit 1, resulting in the starting and running of both units' ESS loads. Again, both starting and running cases were studied. The voltage criteria for these cases are described in Article 3.2.1.4 (starting) and 3.2.1.5 (running).

3.2.3.5 "LOCA Motor Starting" and "2X LOCA Motor Starting" are the cases which address the problem of starting 460 volt motors after an accident, while the emergency motors are still running. The largest 460 volt motors fed from the emergency power system are the screen wash pumps, and starting and running of the screen wash pumps is blocked under LOCA conditions. The next largest motors on the 480 volt emergency system, which could start under LOCA conditions, are the 75 horsepower Reactor Building Closed Cooling Water Pumps. The worst case is a postulated simultaneous start of Reactor

3.2.3.5 Building Closed Cooling Water Pumps 2A and 2C on loss of closed cooling water header pressure.

3.2.4 Load Conditions

The various load conditions studied are defined below:

3.2.4.1 UAT Full Load: This is the normal plant operating condition, with the generating unit at full power and with auxiliary loads fed as follows:

Source	UAT	SAT
4160V Bus 2B	X	
4160V Bus 2C	X	
4160V Bus 2D	X	
4160V Bus Common B		X
480V Bus 2E	X	
480V Bus 2F	X	
480V Bus E7	X	
480V Bus E8	X	
480V Bus 2SY		X
480V Bus Common D		X
480V Bus 2L		X
480V Bus 4L		X

3.2.4.2 SAT Full Load: This is the normal plant operating condition with the generating unit at full power and auxiliary loads fed from the SAT. The plant is in operation with the UAT out of service.

3.2.4.3 UAT Light Load: This represents the estimated minimum auxiliary load that would exist with the generator connected to the system. Load buses are fed from the same sources as cited under "UAT Full Load".

3.2.4.4 SAT Shutdown: (Light Load) This represents the minimum auxiliary load, with the plant shut down and all auxiliary loads fed from the SAT.

3.2 <u>CRITERIA</u> (Cont'd)

3.2.4 <u>Load Conditions</u> (Cont'd)

3.2.4.5 <u>LOCA Start:</u> This represents the inrush condition at the start of an accident, with 2 RHR pumps and 2 Core Spray pumps simultaneously starting, with all other loads running as in the SAT Full Load condition except that the Turbine Building Air Conditioning Compressors are tripped.

3.2.4.6 <u>LOCA Run:</u> This represents the steady-state condition during an accident, with 2 RHR pumps and 2 Core Spray pumps running in addition to the running loads cited in the LOCA Start case above.

3.2.4.7 <u>2X LOCA Start:</u> This represents the simultaneous starting of all RHR pumps and Core Spray pumps, with all the other loads running as in the SAT Full Load condition except that the Turbine Building Air Conditioning Compressors are tripped.

3.2.4.8 <u>2X LOCA Run:</u> This represents the steady-state condition following 2X LOCA Start with all RHR pumps, all Core Spray pumps and all other loads (except Turbine Building Air Conditioning Compressors) running. It should be noted that this condition applies during a LOCA on Unit 2 and simultaneous shutdown cooling of Unit 1.

3.3 METHOD OF ANALYSIS

3.3.1 Program

The UE&C computer program "VOLTS" was used to calculate bus voltages. This program performs a Gauss-Seidel load flow calculation, with provision for constant MVA loads to model running motors, and constant admittance loads to model starting motors. Up to 25 buses can be modeled. Transformers with tap changers can be represented. Bus voltages are computed by the program to a tolerance of $\pm.0001\pm j.0001$ per unit.

3.3.2 Per Unit Values

Calculations were performed using a per-unit scheme with base values as follows:

System	Base Volts	Base MVA
230-KV	230 KV	100
24-KV	23.5 KV*	100
4160-V	4160-V	100
480-V	480-V	100

*23.5 KV is the base value for computer calculations only. Where generator voltages are expressed in %, the base value is the rated generator voltage, i.e., 24 KV.

3.3 METHOD OF ANALYSIS (Cont'd)

3.3.3. Impedances

The transformer impedances in the study are the actual impedances taken from the test reports.(9.10) Cable impedances were calculated from the manufacturer's data. In order to stay within the computer program's 25-bus limitation, cable impedances were combined with transformer impedances as required.

4.0 ANALYSIS OF ALTERNATES

4.1 ALTERNATIVES

Two alternative operating conditions have been reviewed. One operating condition is with the 4160 Volt Buses Common B and Common A Tie Breaker Open. This is a normal operating condition. The other operating condition is with this Tie Breaker closed. This condition could occur when the Unit No. 1 startup transformer is out of service.

4.2 4160 VOLT BUSES COMMON B & COMMON A TIE BREAKER OPEN

Review of the various VOLTS computer runs (Appendix A) determined six operating voltage limits. These limits are tabulated in 2.1.2. The minimum expected switchyard voltage of 100%[5.1] is above the 97.27% required for normal plant operation and the minimum post turbine generator trip switchyard of 96%[5.1] is above the 95.93% required for operating the ESS equipment. The maximum switchyard voltage of 102%[5.1] would normally occur when the unit was operating and the Startup Auxiliary Transformer was feeding both 4160 Volt Bus Common B and 4160 Volt Bus 2B. The additional load imposed by Bus 2B would allow the Switchyard Voltage to exceed the 101.38% limit. It is expected that with Unit No. 2 shutdown, the switchyard voltage would not exceed the 100.9% limit. In addition, any loads which might be operating during shutdown (i.e. circulating water pumps; service water pumps, etc.) would allow an increase of switchyard voltage beyond the 100.9%.

4.3 4160 VOLT BUSES COMMON B & COMMON A TIE BREAKER CLOSED

Review of the various VOLTS computer runs (Appendix B) determined two operating voltage limits. These limits are tabulated in 2.1.3. The minimum expected switchyard voltage of 100%[5.1] is above the 98.09% required for normal plant operation. The minimum post turbine trip voltage of 96%(5.1) is below the 97.20% required for operation of the ESS equipment. This problem can be resolved in one of two ways:

a. Provide a minimum Switchard Voltage of 101.2% when tie breaker is closed

b. Reduce auxiliary load (UAT and SAT) to 31.5 MW and 18.8 MVAR when tie breaker is closed

The addition of the 4160 Volt Bus Common A loads will permit an increase in Switchyard Voltage above the limits of 100.9% and 101.38% noted in 4.2 and therefore cannot be considered an operating limit. For this reason the VOLTS runs were not performed.

5.0 <u>REFERENCES</u>

5.1 CP&L letter to NRC NO-80-;093 dated July 24, 1980.

5.2 United Engineers and Constructors, <u>Miscellaneous Induction Motors 100 HP and Larger</u>, Specification Number 9527-01-128-2, Revision 6, dated June 4, 1976.

5.3 United Engineers and Constructors, <u>Synchronous Motors 100 HP and Larger</u>, Specification Number 9527-01-128-3, Revision 4, dated July 11, 1975.

5.4 General Electric Company letter GU-894 to United Engineers and Constructors, dated April 21, 1971.

5.5 General Electric Company, <u>Electric Motor List</u>, GE Specification Number 22A827, Revision 1, dated November 23, 1970.

5.6 United Engineers and Constructors, <u>Class I Induction Motors 100 HP and Larger</u>, Specification Number 9527-01-128-4, Revision 4, dated June 9, 1976.

5.7 United Engineers and Constructors, <u>Non-Special Alternating Current Induction Motors less than 100 HP in size</u>, Specification Number 9527-01-128-1, Revision 4, dated December 23, 1974.

5.8 United Engineers and Constructors, <u>480 Volt Motor Control Centers</u>, Specification Number 9527-01-143-1, Revision 4, dated August 9, 1976.

5.9 United Engineers and Constructors, <u>480 Volt Load Study for Carolina Power and Light Company, Brunswick Steam Electric Plant, Unit 2</u>, Revision 1, dated March 31, 1978

5.10 Transformer Test Report

Transformer	Foreign Print Number
Main	F.P. 9527-30131
Unit Auxiliary	F.P. 9527-3873
Start up Auxiliary	F.P. 9527-3821
Unit Substations:	
2E	F.P. 9527-30073
2F	F.P. 9527-30072
E7	F.P. 9527-30069
E8	F.P. 9527-30071
2L	F.P. 9527-30075
4L	F.P. 9527-30075
2SY	F.P. 9527-30076
Common D	F.P. 9527-30073

5.11 Key Single Line Diagrams

9527-F-3043	230KV, 24KV, 4160V Key Single Line Diagram
9527-F-3044	480V System

5.12 Single Line Diagrams

9527-F-3002	4160V System SWGR 2B, 2C, 2D and Common "B"
9527-F-3003	4160V Emergency System Buses E3 and E4
9527-F-3004	4160V Emergency System Buses E1 and E2
9527-F-3005	480V System Unit Substations 2E, 2F, E7, E8 and Common "D"
9527-F-3045	480V Motor Control Centers 2TA, 2TB, 2TC, 2TF, 2TJ
9527-F-3047	480V Motor Control Centers 2TD, 2TE, 2TG, 2TH
9527-F-3048	480V Motor Control Centers 2TK, 2TL, 2TM, 2TN
9527-F-3049	480V Motor Control Centers 2XA, 2XC, 2XE, 2XG, 2XJ, 2XL
9527-F-3050	480 V Motor Control Centers 2XB, 2XD, 2XF, 2XH, 2XK, 2XM
9527-F-3051	480V Motor Control Centers RWA, RWB, RWC, RWD
9527-F-3052	480V Motor Control Centers BHA, SBA, WTA and WHA
9527-F-3053	480V Motor Control Centers 2CA, 2CB, 2PA, 2PB, 2SA
9527-F-3055	480V Motor Control Centers SYA, SYB, SYC and SYD
9527-F-3057	480V Motor Control Centers DGA, DGB, DGC and DGD

6.0 APPENDICIES

APPENDIX A

VOLTAGE DROP STUDY

FOR

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT

UNIT NO. 2

BY

UNITED ENGINEERS & CONSTRUCTORS INC.

VOLTAGES

AND

IMPEDANCE DIAGRAMS

4160 VOLT BUSES COMMON B &

COMMON A TIE BREAKER OPEN

VOLTAGE DROP STUDY

APPENDIX A

GENERAL NOTES

1. The choice of source voltages to be studied was made as follows: An initial VOLTS run was made at the appropriate limiting value determined by the source in question. For the full load, motor starting, and LOCA cases, the initial runs were made at 95% of 24KV for the UAT cases, and 95% of 230KV for the SAT cases. For the light load cases, the initial runs were made at 110% of 24KV for the UAT cases and 105% of 230KV for the SAT cases. If the voltages which resulted from a given initial run were satisfactory for all loads, then no further runs were made for that particular operating case. If the voltages were not satisfactory, then a second run was made at a voltage chosen so that the two voltages would bracket the limiting voltage. After load voltages were available for two source voltages, a linear interpolation calculation was done to determine the limiting voltage. The VOLTS run was then performed using the limiting source voltage, and these are the runs which are presented in those cases where the limiting voltage would be determined by the loads. In the accident cases a minimum voltage limited by the loads was determined in every case, even when this voltage was below the expected minimum 230KV switchyard voltage.

VOLTAGE DROP STUDY

APPENDIX A

UAT

LIGHT LOAD
(Fig. No. A1)

BUS NAMES	MAXIMUM VOLTAGE PER UNIT VOLTAGE	MAXIMUM VOLTAGE ACTUAL VOLTAGE
GENERATOR (24 KV BASE)	1.0365	24,876
4160 VOLT BUS 2B	1.1	4,576
4160 VOLT BUS 2C, 2D, E3 & E4	1.059	4,405
480 VOLT UNIT SUBSTATION E7	1.0648	511
480 VOLT UNIT SUBSTATION 2E	1.0721	515
480 VOLT UNIT SUBSTATION 2F	1.0685	513
480 VOLT UNIT SUBSTATION E8	1.0631	510

NOTE: ALL VOLTAGES, EXCEPT GENERATOR, ARE ON 4000 VOLT OR 460 VOLT BASE AS APPROPRIATE.

VOLTAGE DROP STUDY

APPENDIX A

UAT

FULL LOAD
(Fig. No. A2)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	ACTUAL VOLTAGE
GENERATOR (24 KV BASE)	.95	22,800
4160 VOLT BUS 2B	.9448	3,930
4160 VOLT BUS 2C, 2D, E3 & E4	.9191	3,823
480 VOLT UNIT SUBSTATION E7	.9095	437
480 VOLT UNIT SUBSTATION 2E	.9175	440
480 VOLT UNIT SUBSTATION 2F	.9135	438
480 VOLT UNIT SUBSTATION E8	.9076	436

NOTE: ALL VOLTAGES ARE EXPRESSED IN PER UNIT ON THE BASE VOLTAGE SHOWN IN THE LEFT-HAND COLUMN

VOLTAGE DROP STUDY

APPENDIX A

UAT

REACTOR RECIRC. PUMP MG SET 2B MOTOR STARTING
(Fig. No. A3)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
GENERATOR (24 KV BASE)	.95	22,800
4160 VOLT BUS 2B	.8093	3,367
4160 VOLT BUS 2C, 2D, E3 & E4	.9374	3,900
480 VOLT UNIT SUBSTATION E7	.93	446
480 VOLT UNIT SUBSTATION 2E	.9378	450
480 VOLT UNIT SUBSTATION 2F	.934	448
480 VOLT UNIT SUBSTATION E8	.9282	446
4000V REACTOR RECIRC. MG SET 2B MOTOR	.8307	3,322

NOTE: ALL VOLTAGES ARE ON THE BASE SHOWN IN THE LEFT-HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

UAT

CIRCULATING WATER PUMP STARTING
(Fig. No. A4)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
GENERATOR (24 KV BASE)	.95	22,800
4160 VOLT BUS 2B	.9505	3,954
4160 VOLT BUS 2C, 2D, E3 & E4	.8723	3,629
480 VOLT UNIT SUBSTATION E7	.8563	411
480 VOLT UNIT SUBSTATION 2E	.865	415
480 VOLT UNIT SUBSTATION 2F	.8607	413
480 VOLT UNIT SUBSTATION E8	.8543	410
4000V CIRCULATING WATER PUMP 2B MOTOR	.8803	3,521

NOTE: ALL VOLTAGES ARE ON THE BASE SHOWN IN THE LEFT-HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

UAT

SCREEN WASH PUMP 2A STARTING
(Fig. No. A5)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
GENERATOR (24 KV BASE)	.9665	23,198
4160 VOLT BUS 2B	.9628	4,005
4160 VOLT BUS 2C, 2D, E3 & E4	.9321	3,878
480 VOLT UNIT SUBSTATION E7	.8807	423
480 VOLT UNIT SUBSTATION 2E	.932	447
480 VOLT UNIT SUBSTATION 2F	.9281	445
480 VOLT UNIT SUBSTATION E8	.9222	443
480 VOLT MOTOR CONTROL CENTER 2PA	.8298	398
460 V SCREEN WASH PUMP 2A MOTOR TERMINALS	.8501	391

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

UAT

TURBINE BUILDING CLOSED COOLING WATER PUMP 2A STARTING
(Fig. No. A6)

	MINIMUM VOLTAGE	
BUS NAMES	PER UNIT VOLTAGE	ACTUAL VOLTAGE
GENERATOR (24 KV BASE)	.95	22,800
4160 VOLT BUS 2B	.9455	3,933
4160 VOLT BUS 2C, 2D, E3 & E4	.9135	3,800
480 VOLT UNIT SUBSTATION E7	.9031	433
480 VOLT UNIT SUBSTATION 2E	.8655	415
480 VOLT UNIT SUBSTATION 2F	.9072	435
480 VOLT UNIT SUBSTATION E8	.9012	433
480 VOLT MOTOR CONTROL CENTER 2TJ	.8338	[illegible]
460V TURBINE BUILDING CLOSED COOLING WATER PUMP 2A	.8573	394

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

UAT

TURBINE BUILDING CLOSED COOLING WATER PUMP 2B STARTING
(Fig. No. A7)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
GENERATOR (24 KV BASE)	.956	22,944
4160 VOLT BUS 2B	.9519	3,960
4160 VOLT BUS 2C, 2D, E3 & E4	.9201	3,828
480 VOLT UNIT SUBSTATION E7	.9106	437
480 VOLT UNIT SUBSTATION 2E	.9187	441
480 VOLT UNIT SUBSTATION 2F	.8684	417
480 VOLT UNIT SUBSTATION E8	.9087	436
480 VOLT MOTOR CONTROL CENTER 2TH	.8381	402
460 V TURBINE BUILDING CLOSED COOLING WATER PUMP 2B	.8501	391

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

UAT

SCREEN WASH PUMP 2B STARTING
(Fig. No. A8)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
GENERATOR (24 KV BASE)	.9576	2,298
4160 VOLT BUS 2B	.9535	3,967
4160 VOLT BUS 2C, 2D, E3 & E4	.9223	3,837
480 VOLT UNIT SUBSTATION E7	.913	438
480 VOLT UNIT SUBSTATION 2E	.92J	442
480 VOLT UNIT SUBSTATION 2F	.9171	440
480 VOLT UNIT SUBSTATION E8	.8681	417
480 VOLT MOTOR CONTROL CENTER 2PB	.832	399
460V SCREEN WASH PUMP 2B MOTOR TERMINALS	.8502	391

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

SHUTDOWN
(Fig. No. A9)

BUS NAMES	MAXIMUM VOLTAGE PER UNIT VOLTAGE	 ACTUAL VOLTAGE
230 KV SWITCHYARD	1.0090	232,068
4160 VOLT BUS 2B	1.0751	4,472
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	1.0599	4,409
480 VOLT UNIT SUBSTATION E7	1.0813	519
480 VOLT UNIT SUBSTATION 2E	1.0927	524
480 VOLT UNIT SUBSTATION 2F	1.1001	528
480 VOLT UNIT SUBSTATION E8	1.0765	517
480 VOLT UNIT SUBSTATION 2SY	1.0809	519
480 VOLT UNIT SUBSTATION COMMON D	1.0813	519
480 VOLT UNIT SUBSTATION 2L	1.0549	506
480 VOLT UNIT SUBSTATION 4L	1.0725	515

NOTE: ALL VOLTAGES, EXCEPT SWITCHYARD, ARE ON 4000 VOLT OR 460 VOLT BASE AS APPROPRIATE.

VOLTAGE DROP STUDY

APPENDIX A

SAT

UNIT LOADS FED FROM UAT
(Fig. No. A10)

BUS NAMES	MAXIMUM VOLTAGE PER UNIT VOLTAGE	MAXIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	1.0138	233,185
4160 VOLT BUS COMMON B	1.0787	4,487
480 VOLT UNIT SUBSTATION 2SY	1.0999	528
480 VOLT UNIT SUBSTATION COMMON D	1.0931	525
480 VOLT SUBSTATION 2L	1.0738	515
480 VOLT UNIT SUBSTATION 4L	1.0922	524

NOTE: ALL VOLTAGES, EXCEPT SWITCHYARD, ARE ON 4000 VOLT OR 460 VOLT BASE AS APPROPRIATE.

VOLTAGE DROP STUDY

APPENDIX A

SAT

FULL LOAD
(Fig. No. A11)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	.95	218,500
4160 VOLT BUS 2B	.9384	3,904
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	.9119	3,794
480 VOLT UNIT SUBSTATION E7	.9013	433
480 VOLT UNIT SUBSTATION 2E	.9095	437
480 VOLT UNIT SUBSTATION 2F	.9055	435
480 VOLT UNIT SUBSTATION E8	.8994	432
480 VOLT UNIT SUBSTATION 2SY	.9243	444
480 VOLT UNIT SUBSTATION COMMON D	.9167	440
480 VOLT UNIT SUBSTATION 2L	.9027	433
480 VOLT UNIT SUBSTATION 4L	.9157	440

NOTE: ALL VOLTAGES ARE EXPRESSED IN PER UNIT ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

REACTOR RECIRC. PUMP MG SET 2B MOTOR STARTING
(Fig. No. A12)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	.95	218,500
4160 VOLT BUS 2B	.8019	3,336
4160 VOLT BUS 2C, 2D, COMMON B, E3 & E4	.9004	3,746
480 VOLT UNIT SUBSTATION E7	.8882	426
480 VOLT UNIT SUBSTATION 2E	.8965	430
480 VOLT UNIT SUBSTATION 2F	.8924	428
480 VOLT UNIT SUBSTATION E8	.8863	425
480 VOLT UNIT SUBSTATION 2SY	.9123	438
480 VOLT UNIT SUBSTATION COMMON D	.9046	434
480 VOLT UNIT SUBSTATION 2L	.891	428
480 VOLT UNIT SUBSTATION 4L	.9036	434
4000V REACTOR RECIRC. PUMP MG SET MOTOR TERMINALS	.8231	3,292

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

CIRCULATING WATER PUMP 2B MOTOR STARTING
(Fig. No. A13)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	.95	218,500
4160 VOLT BUS 2B	.9348	3,889
4160 VOLT BUS 2C, 2D, COMMON B, E3 & E4	.8642	3,595
480 VOLT UNIT SUBSTATION E7	.847	407
480 VOLT UNIT SUBSTATION 2E	.8559	411
480 VOLT UNIT SUBSTATION 2F	.8515	409
480 VOLT UNIT SUBSTATION E8	.845	406
480 VOLT UNIT SUBSTATION 2SY	.8747	420
480 VOLT UNIT SUBSTATION COMMON D	.8667	416
480 VOLT UNIT SUBSTATION 2L	.8544	419
480 VOLT UNIT SUBSTATION 4L	.8656	415
4000V CIRCULATING WATER PUMP MOTOR 2B	.8721	3,488

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

SCREEN WASH PUMP 2A STARTING
(Fig. No. A14)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	.9727	223,711
4160 VOLT BUS 2B	.9623	4,003
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	.9319	3,877
480 VOLT UNIT SUBSTATION E7	.8807	423
480 VOLT UNIT SUBSTATION 2E	.8318	399
480 VOLT UNIT SUBSTATION 2F	.9279	445
480 VOLT UNIT SUBSTATION E8	.9221	443
480 VOLT UNIT SUBSTATION 2SY	.9451	454
480 VOLT UNIT SUBSTATION COMMON D	.9377	450
480 VOLT UNIT SUBSTATION 2L	.9229	443
480 VOLT UNIT SUBSTATION 4L	.9367	450
480 VOLT MOTOR CONTROL CENTER 2PA	.8299	398
460V SCREEN WASH PUMP 2A	.8502	391

NOTE: BASE VOLTAGES ARE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

TURBINE BUILDING CLOSED COOLING WATER PUMP 2A MOTOR STARTING
(Fig. No. A15)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	ACTUAL VOLTAGE
230 KV SWITCHYARD	.95	218,500
4160 VOLT BUS 2B	.9379	3,902
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	.9061	3,769
480 VOLT UNIT SUBSTATION E7	.8947	429
480 VOLT UNIT SUBSTATION 2E	.8579	412
480 VOLT UNIT SUBSTATION 2F	.8989	431
480 VOLT UNIT SUBSTATION E8	.8928	429
480 VOLT UNIT SUBSTATION 2SY	.9182	441
480 VOLT UNIT SUBSTATION COMMON D	.9106	437
480 VOLT UNIT SUBSTATION 2L	.8968	430
480 VOLT UNIT SUBSTATION 4L	.9096	437
480 VOLT MOTOR CONTROL CENTER 2TJ	.8265	397
460V TURBINE BUILDING CLOSED COOLING WATER PUMP 2A	.8498	391

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

TURBINE BUILDING CLOSED COOLING WATER PUMP 2B START
(Fig. No. A16)

BUS NAMES	MINIMUM VOLTAGE	
	PER UNIT VOLTAGE	ACTUAL VOLTAGE
230 KV SWITCHYARD	.9623	221,329
4160 VOLT BUS 2B	.9511	3,957
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	.92	3,827
480 VOLT UNIT SUBSTATION E7	.9104	437
480 VOLT UNIT SUBSTATION 2E	.9185	441
480 VOLT UNIT SUBSTATION 2F	.8684	417
480 VOLT UNIT SUBSTATION E8	.9085	436
480 VOLT UNIT SUBSTATION 2SY	.9326	448
480 VOLT UNIT SUBSTATION COMMON D	.9252	440
480 VOLT UNIT SUBSTATION 2L	.9108	437
480 VOLT UNIT SUBSTATION 4L	.9242	444
480 VOLT MOTOR CONTROL CENTER 2TH	.8382	402
460 V TURBINE BUILDING CLOSED COOLING WATER PUMP 2B	.8501	391

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

SCREEN WASH PUMP 2B STARTING
(Fig. No. A17)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	.9638	221,674
4160 VOLT BUS 2B	.9527	3,963
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	.9222	3,836
480 VOLT UNIT SUBSTATION E7	.9126	438
480 VOLT UNIT SUBSTATION 2E	.9207	442
480 VOLT UNIT SUBSTATION 2F	.9167	440
480 VOLT UNIT SUBSTATION 2SY	.8679	417
480 VOLT UNIT SUBSTATION COMMON D	.9347	449
480 VOLT UNIT SUBSTATION 2L	.9273	445
480 VOLT UNIT SUBSTATION 4L	.9263	445
480 VOLT MOTOR CONTROL CENTER 2PB	.8319	399
460 V SCREEN WASH PUMP 2B	.8501	391

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

LOCA START

(Fig. No. A18)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	.9115	209,645
4160 VOLT BUS 2B	.9218	3,835
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	.7577	3,152
480 VOLT UNIT SUBSTATION E7	.7457	358
480 VOLT UNIT SUBSTATION 2E	.7151	343
480 VOLT UNIT SUBSTATION 2F	.7079	340
480 VOLT UNIT SUBSTATION E8	.7366	354
480 VOLT UNIT SUBSTATION 2SY	.7603	365
480 VOLT UNIT SUBSTATION COMMON D	.7485	359
480 VOLT UNIT SUBSTATION 2L	.7419	356
480 VOLT UNIT SUBSTATION 4L	.7468	358
4000 VOLT CORE SPRAY PUMP 2A	.7735	3,094
4000 VOLT RHR PUMP 2A	.7807	3,123
4000 VOLT CORE SPRAY PUMP 2B	.7705	3,082
4000 VOLT RHR PUMP 2B	.7777	3,111

NOTE: BASE VOLTAGES FOR ALL LOADS ARE THE RATED VOLTAGES SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

LOCA RUN
(Fig. No. A19)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	.9291	213,693
4160 VOLT BUS 2B	.9478	3,943
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	.8843	3,679
480 VOLT UNIT SUBSTATION E7	.8876	426
480 VOLT UNIT SUBSTATION 2E	.8637	415
480 VOLT UNIT SUBSTATION 2F	.8582	412
480 VOLT UNIT SUBSTATION E8	.8804	423
480 VOLT UNIT SUBSTATION 2SY	.8927	428
480 VOLT UNIT SUBSTATION COMMON D	.8828	424
480 VOLT UNIT SUBSTATION 2L	.8711	418
480 VOLT UNIT SUBSTATION 4L	.8814	423

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

LOCA

REACTOR BUILDING CLOSED COOLING WATER PUMPS STARTING

(Fig. No. A20)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	.9509	218,707
4160 VOLT BUS 2B	.97	4,035
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	.9049	3,764
480 VOLT UNIT SUBSTATION E7	.8776	421
480 VOLT UNIT SUBSTATION 2E	.8873	426
480 VOLT UNIT SUBSTATION 2F	.882	423
480 VOLT UNIT SUBSTATION E8	.9035	434
480 VOLT UNIT SUBSTATION 2SY	.9142	439
480 VOLT UNIT SUBSTATION COMMON D	.9045	434
480 VOLT UNIT SUBSTATION 2L	.8921	428
480 VOLT UNIT SUBSTATION 4L	.9032	434
480 VOLT MOTOR CONTROL CENTER 2XE	.8267	397
460V REACTOR BUILDING CLOSED COOLING WATER PUMP 2A	.8501	391
460V REACTOR BUILDING CLOSED COOLING WATER PUMP 2C	.8535	393

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

2X LOCA START
(Fig. No. A21)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	.9593	220,639
4160 VOLT BUS 2B	.9673	4,024
4160 VOLT BUS 2C, 2D, E3, E4, & COMMON B	.758	3,153
480 VOLT UNIT SUBSTATION E7	.7459	358
480 VOLT UNIT SUBSTATION 2E	.7154	343
480 VOLT UNIT SUBSTATION 2F	.7082	340
480 VOLT UNIT SUBSTATION E8	.7368	354
480 VOLT UNIT SUBSTATION 2SY	.7605	365
480 VOLT UNIT SUBSTATION COMMON D	.7487	359
480 VOLT UNIT SUBSTATION 2L	.7421	356
480 VOLT UNIT SUBSTATION 4L	.7471	359
4000 VOLT CORE SPRAY PUMP 2A	.7737	3,095
4000 VOLT RHR PUMP 1A	.7798	3,119
4000 VOLT RHR PUMP 2A	.7809	3,124
4000 VOLT CORE SPRAY PUMP 2B	.7708	3,083
4000 VOLT RHR PUMP 1B	.7811	3,124
4000 VOLT RHR PUMP 2B	.7709	3,084

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

2X LOCA RUN
(Fig. No. A22)

	MINIMUM VOLTAGE	
BUS NAMES	PER UNIT VOLTAGE	ACTUAL VOLTAGE
230 KV SWITCHYARD	.9351	215,073
4160 VOLT BUS 2B	.9534	3,966
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	.8843	3,679
480 VOLT UNIT SUBSTATION E7	.8876	426
480 VOLT UNIT SUBSTATION 2E	.8636	415
480 VOLT UNIT SUBSTATION 2F	.8581	412
480 VOLT UNIT SUBSTATION E8	.8803	423
480 VOLT UNIT SUBSTATION 2SY	.8926	428
480 VOLT UNIT SUBSTATION COMMON D	.8827	424
480 VOLT UNIT SUBSTATION 2L	.871	418
480 VOLT UNIT SUBSTATION 4L	.8814	423

NOTE: ALL VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

VOLTAGE DROP STUDY

APPENDIX A

SAT

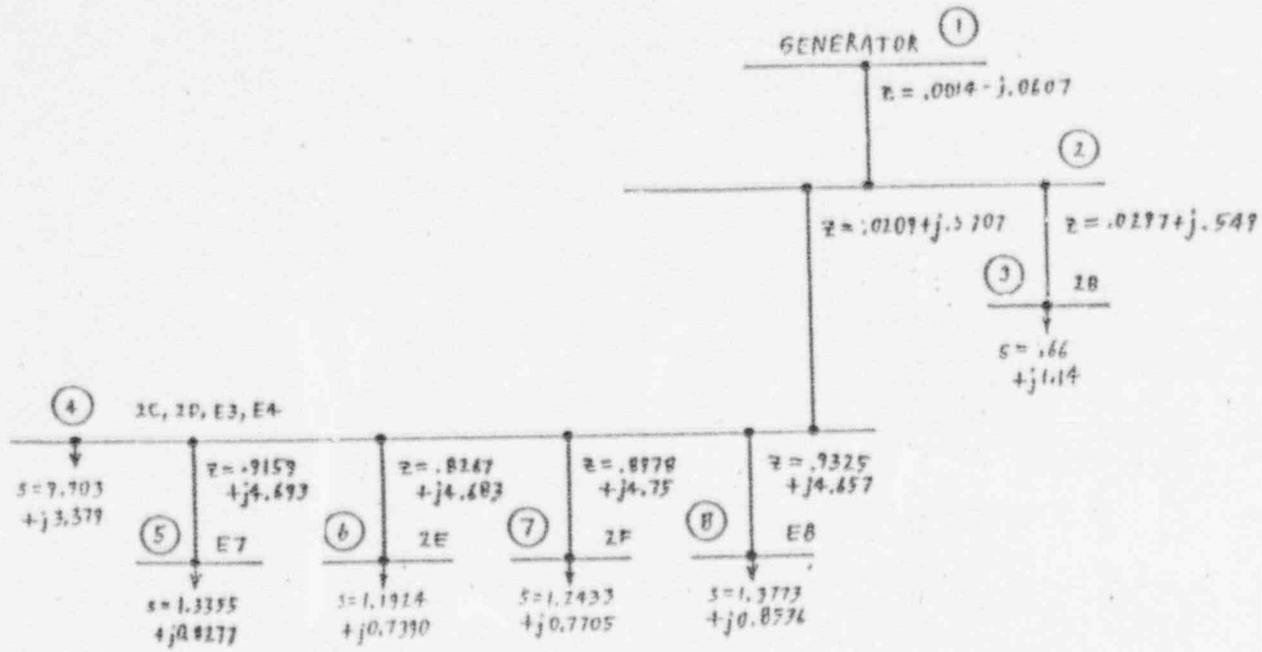
2X LOCA

REACTOR BUILDING CLOSED COOLING WATER PUMPS 2A AND 2C START

(Fig. No. A23)

BUS NAMES	MINIMUM VOLTAGE PER UNIT VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	.955	219,650
4160 VOLT BUS 2B	.9739	4,051
4160 VOLT BUS 2C, 2D, E3, E4 & COMMON B	.9048	3,764
480 VOLT UNIT SUBSTATION E7	.8775	421
480 VOLT UNIT SUBSTATION 2E	.8872	426
480 VOLT UNIT SUBSTATION 2F	.8819	423
480 VOLT UNIT SUBSTATION E8	.9033	434
480 VOLT UNIT SUBSTATION 2SY	.9141	439
480 VOLT UNIT SUBSTATION COMMON D	.9044	434
480 VOLT UNIT SUBSTATION 2L	.892	428
480 VOLT UNIT SUBSTATION 4L	.9031	433
480 VOLT MOTOR CONTROL CENTER 2XE	.8266	397
460V REACTOR BUILDING CLOSED COOLING WATER PUMP 2A	.85	391
460V REACTOR BUILDING CLOSED COOLING WATER PUMP 2C	.8534	393

NOTE: ALL LOAD VOLTAGES ARE ON THE BASE VOLTAGE SHOWN IN THE LEFT HAND COLUMN.

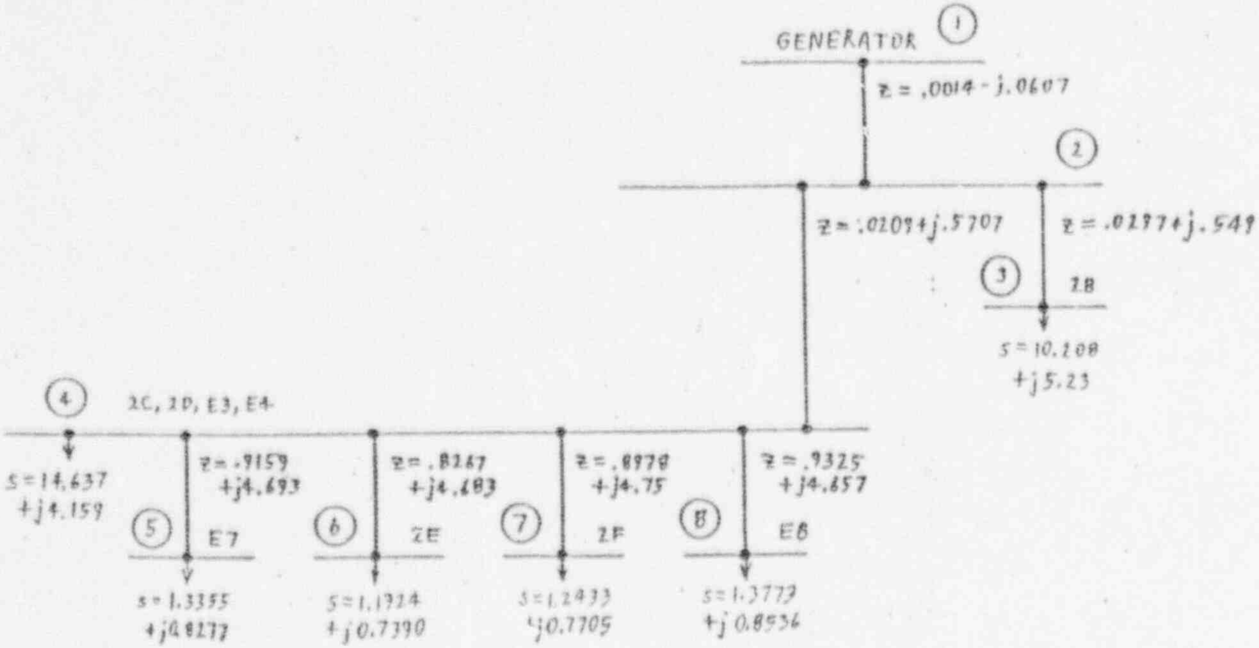


UAT IMPEDANCE DIAGRAM
LIGHT LOAD

FLIGHTU

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

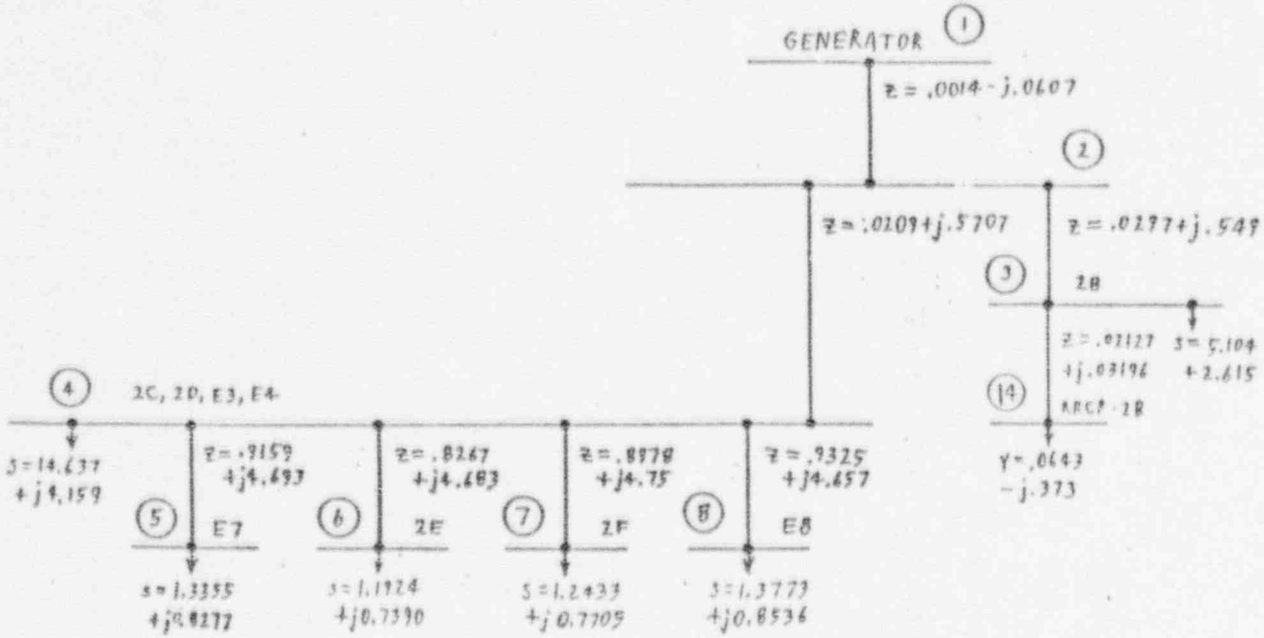
FIG. A1



UAT IMPEDANCE DIAGRAM
FULL LOAD

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

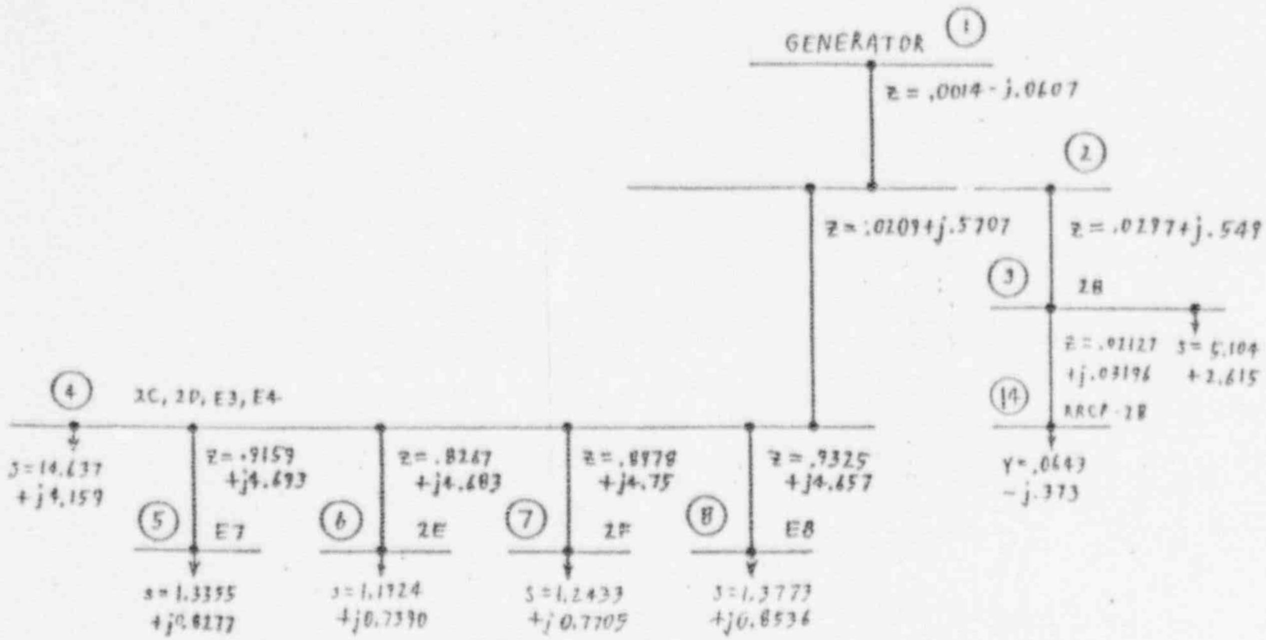
FIG. A2



UAT IMPEDANCE DIAGRAM
REACTOR RECIRC. PUMP MG SET 2B
MOTOR STARTING

DRR PSU9
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

FIG. A3

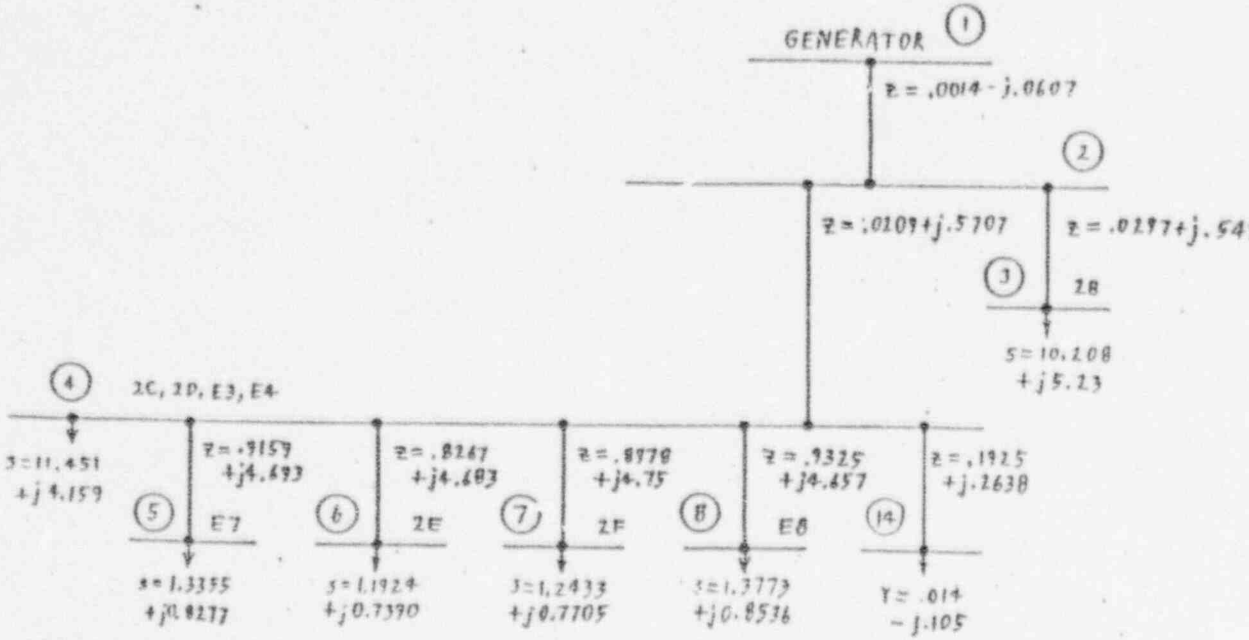


UAT IMPEDANCE DIAGRAM
REACTOR RECIRC. PUMP MG SET 2B
MOTOR STARTING

POOR ORIGINAL

DREPSUC
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

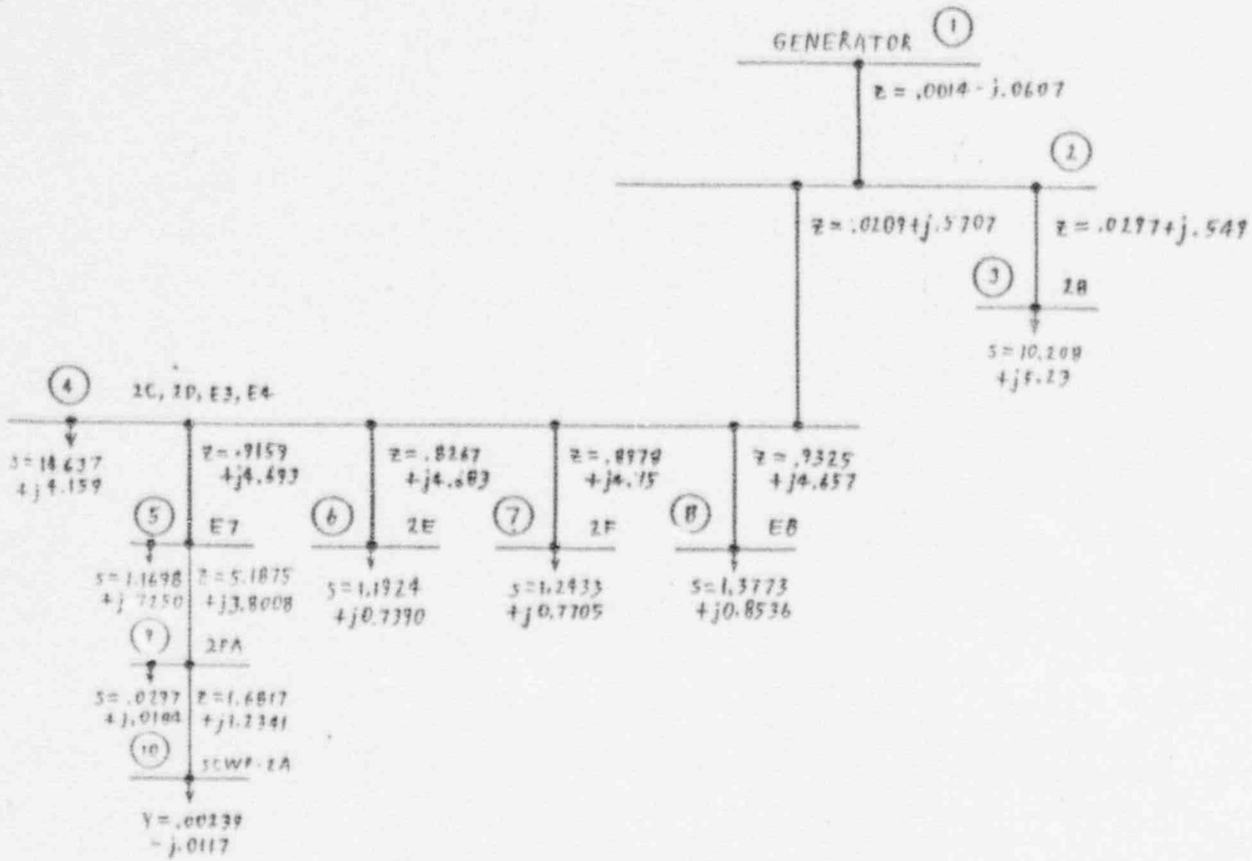
FIG. A3



UAT IMPEDANCE DIAGRAM
CIRCULATING WATER PUMP
STARTING

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

FIG. A4

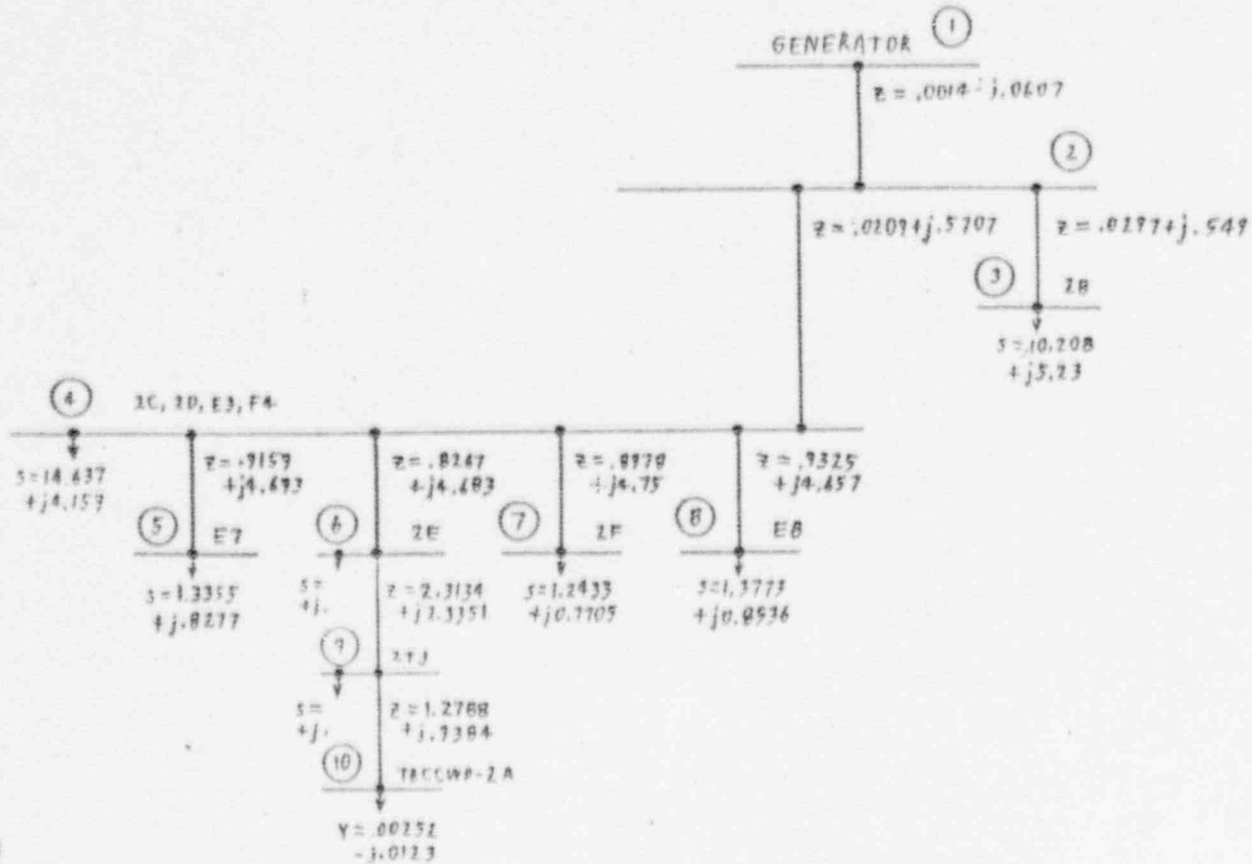


UAT IMPEDANCE DIAGRAM
SCREEN WASH PUMP 2A
STARTING

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

FIG. A5

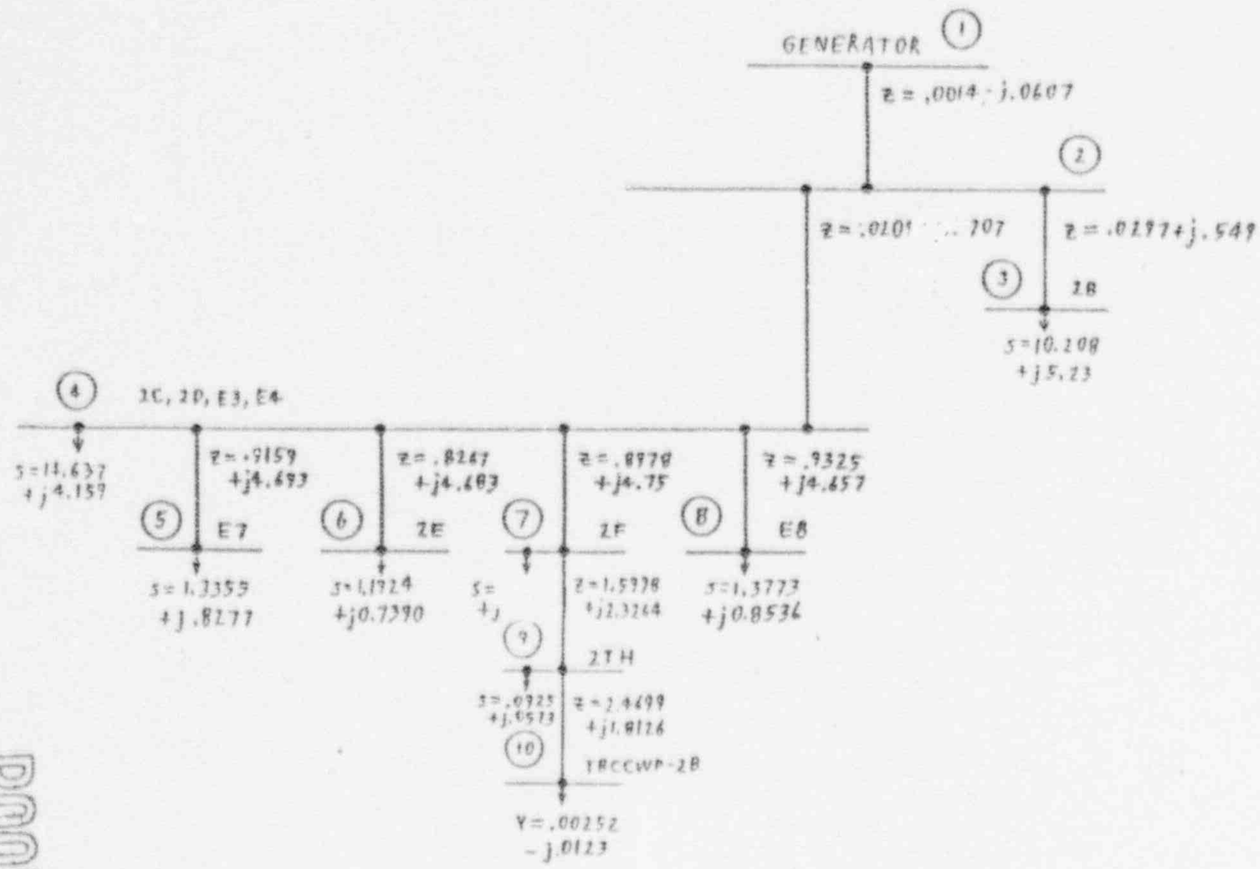
POOR ORIGINAL



UAT IMPEDANCE DIAGRAM
TURBINE BLDG. CLOSED COOLING
WATER PUMP 2A STARTING

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

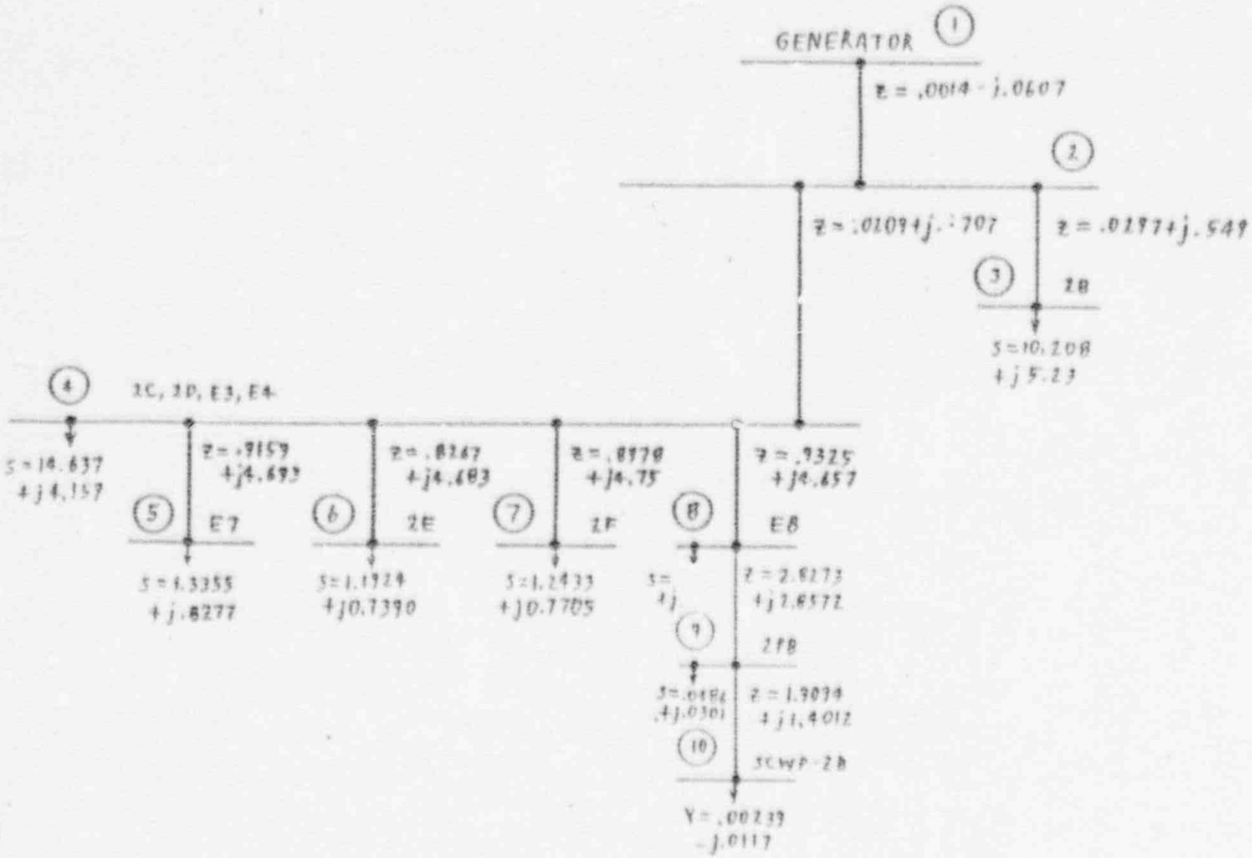
FIG. A6



UAT IMPEDANCE DIAGRAM
TURBINE BLDG. CLOSED COOLING
WATER PUMP 2B STARTING

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

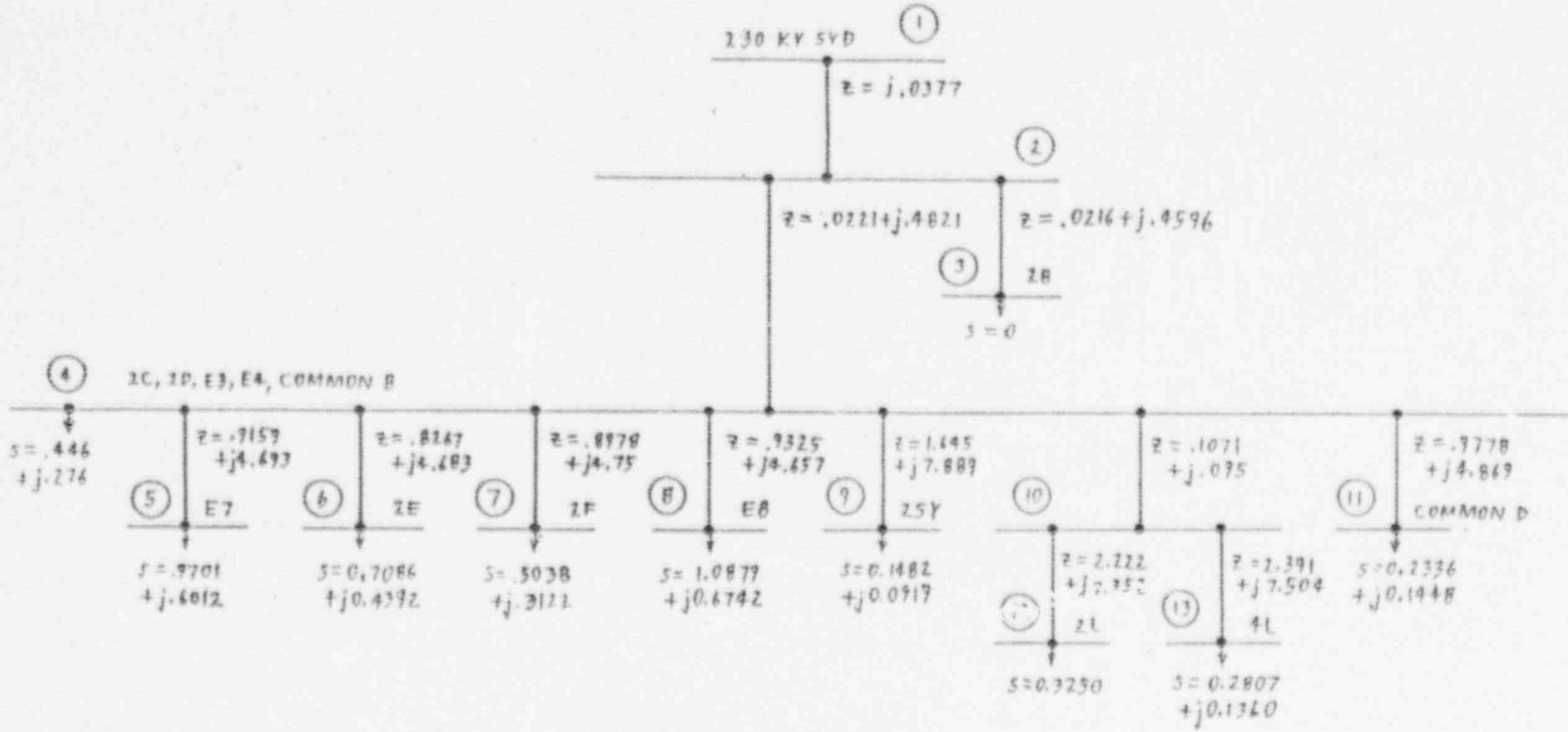
FIG. A7



UAT IMPEDANCE DIAGRAM
SCREEN WASH PUMP 2B
STARTING

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

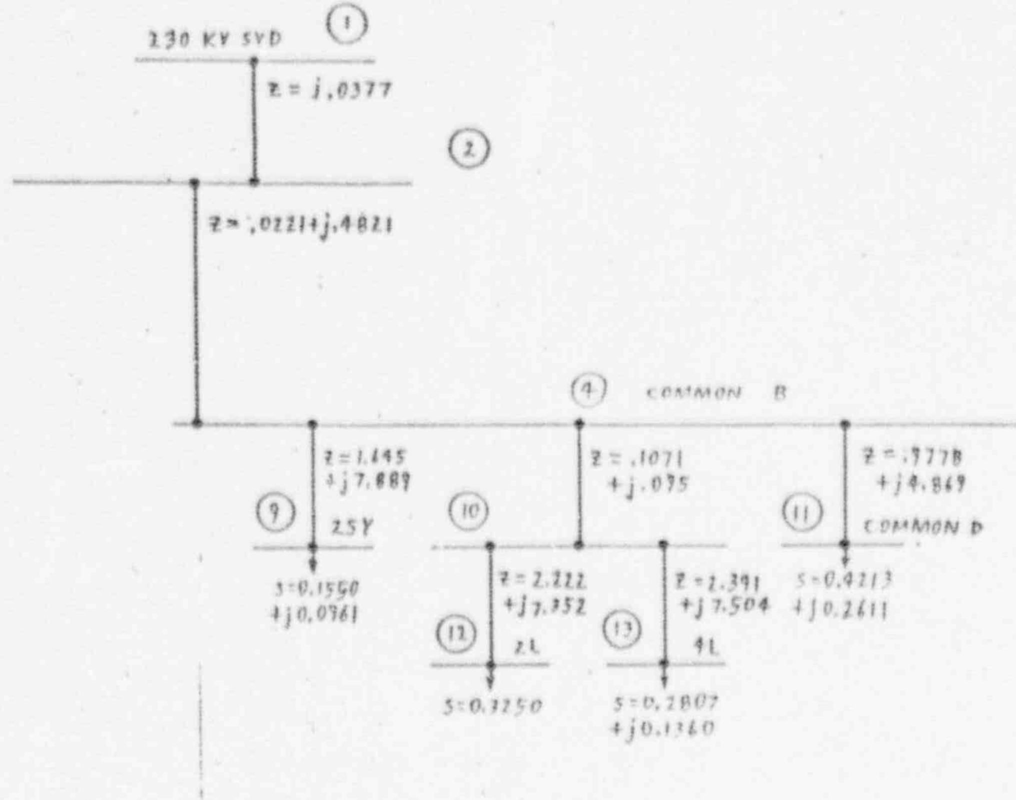
FIG. A8



SAT IMPEDANCE DIAGRAM
SHUTDOWN

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

FIG. A9



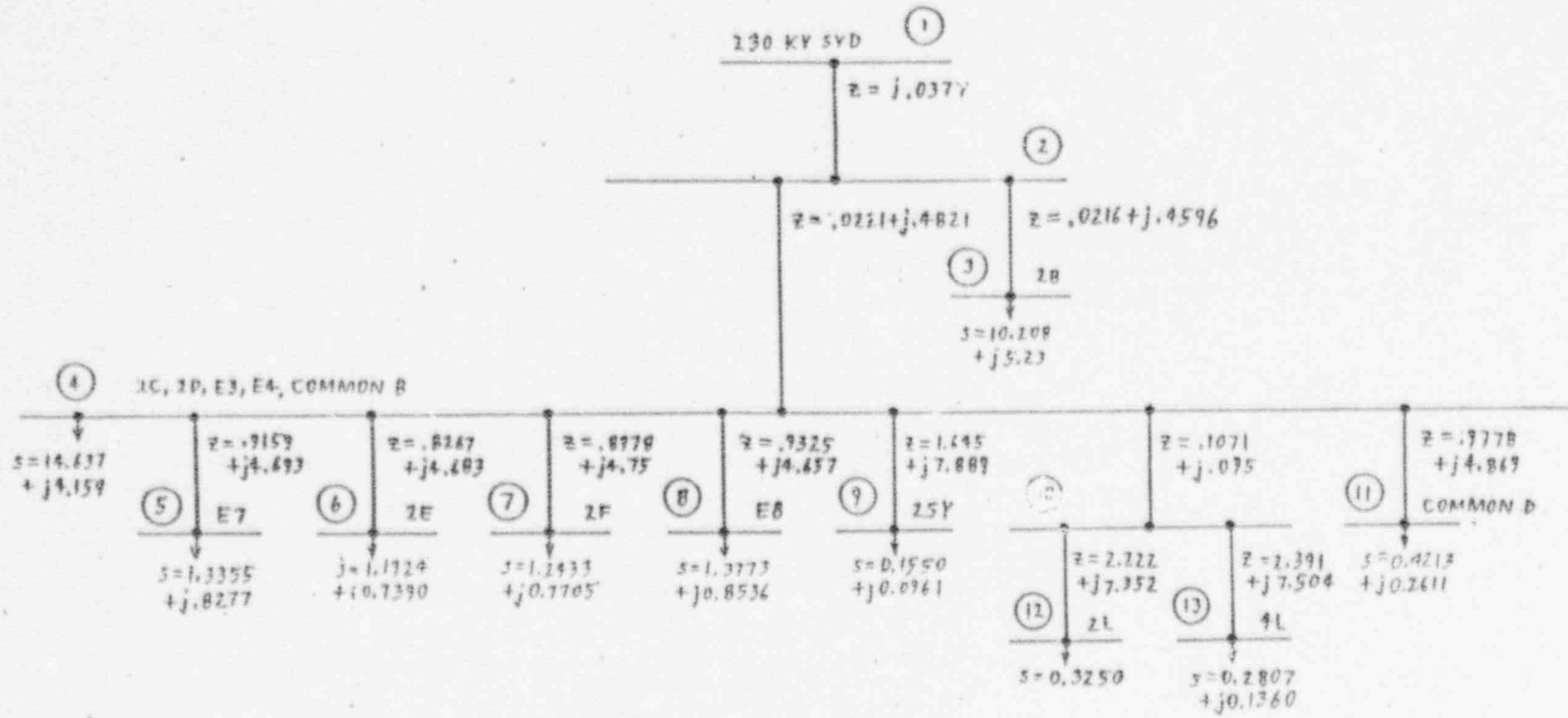
SAT IMPEDANCE DIAGRAM

UNIT LOADS FED FROM UAT

DSATE102
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

FIG. A10

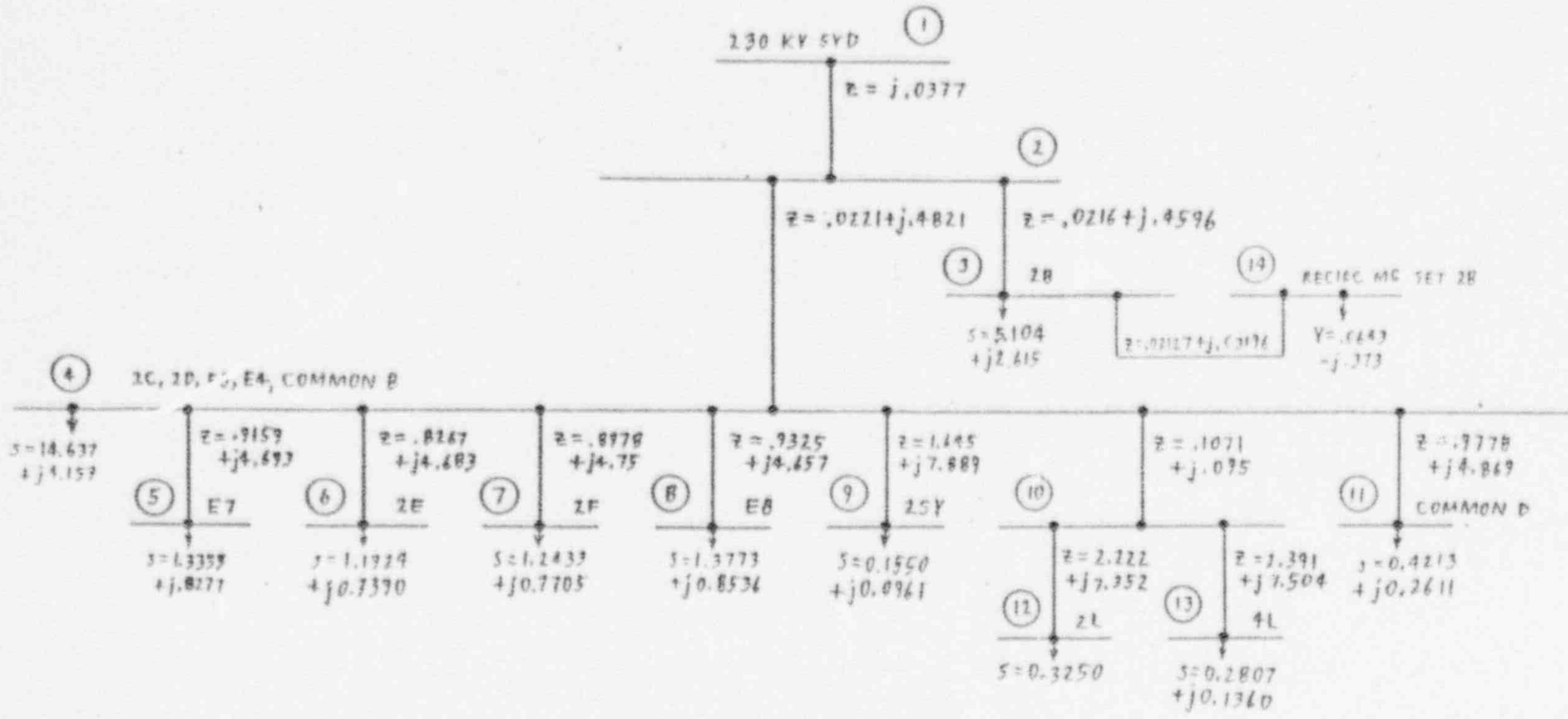
POOR ORIGINAL



SAT IMPEDANCE DIAGRAM
FULL LOAD

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

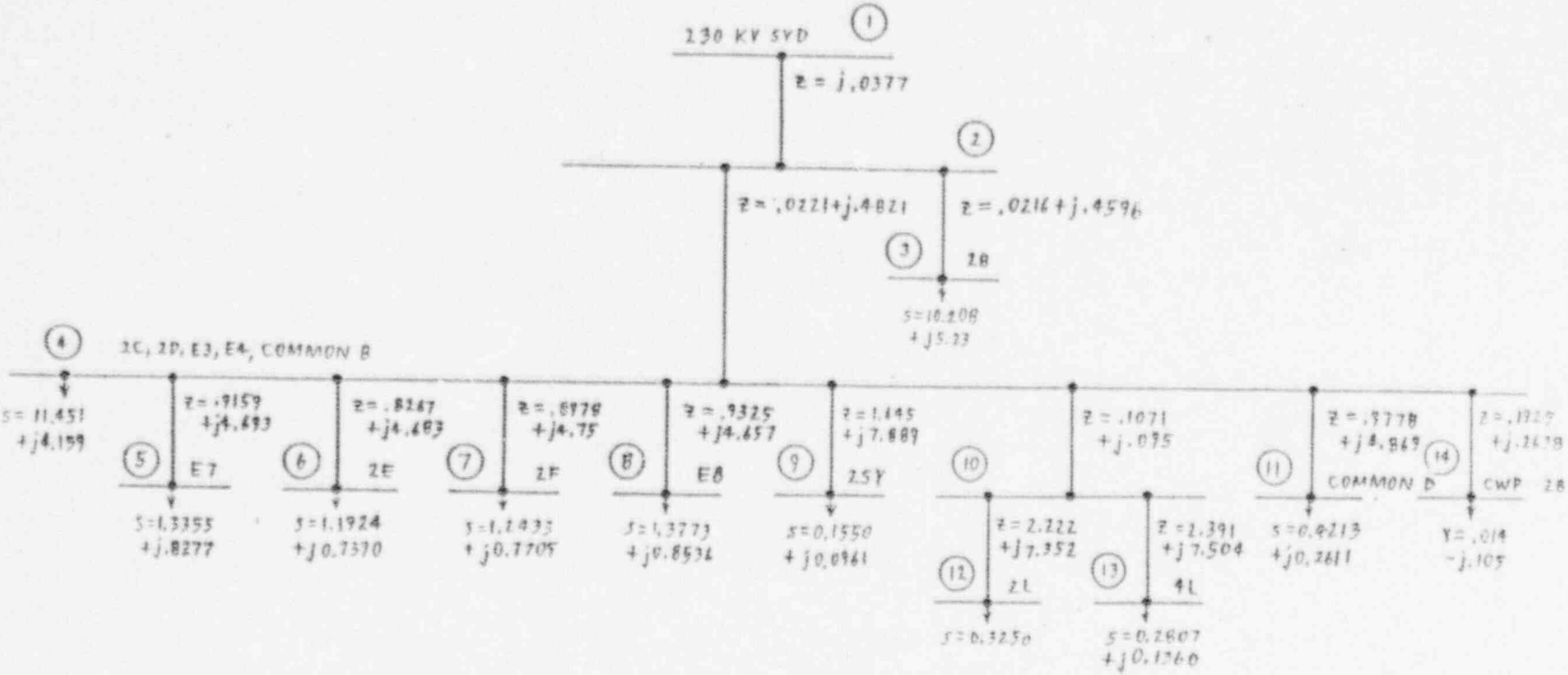
FIG. A11



SAT IMPEDANCE DIAGRAM
REACTOR RECIRC. PUMP MG SET 2B
MOTOR STARTING

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

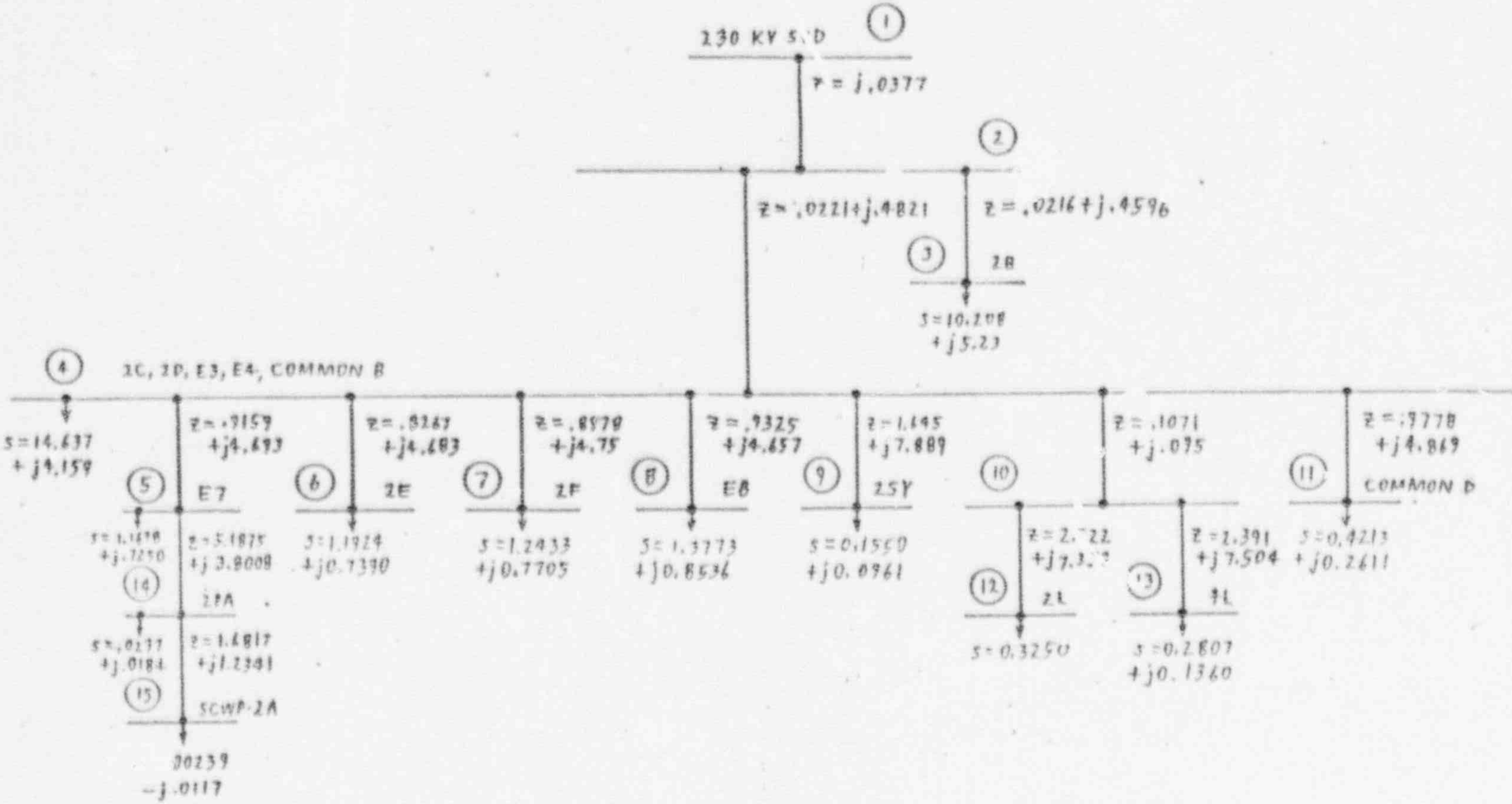
FIG. A12



SAT IMPEDANCE DIAGRAM
CIRCULATING WATER PUMP 2B MOTOR
STARTING

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

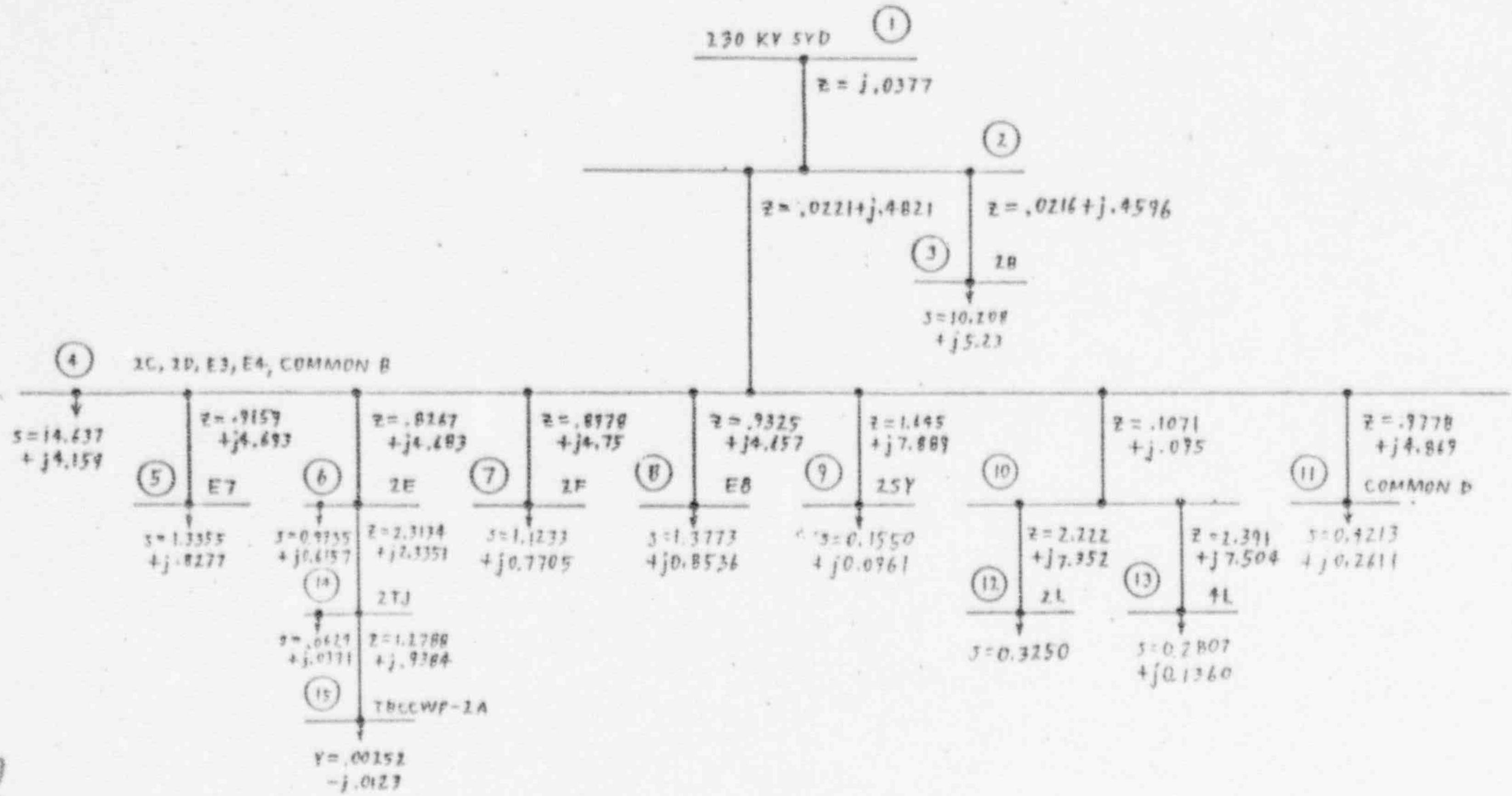
FIG. A13



SAT IMPEDANCE DIAGRAM
SCREEN WASH PUMP 2A
STARTING

DSWPASC2
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

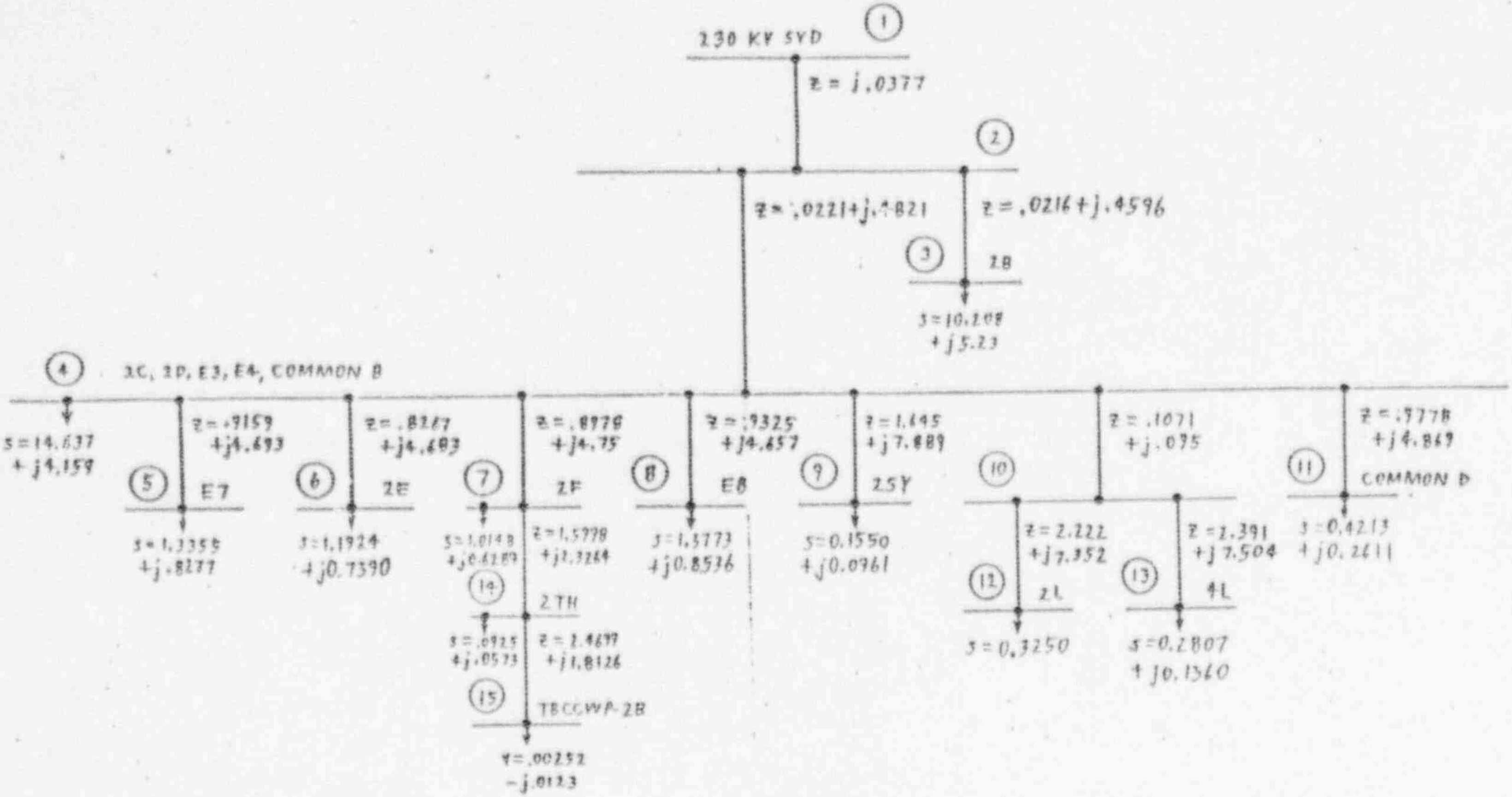
FIG. A14



SAT IMPEDANCE DIAGRAM
TURBINE BLDG. CLOSED COOLING
WATER PUMP 2A MOTOR STARTING

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

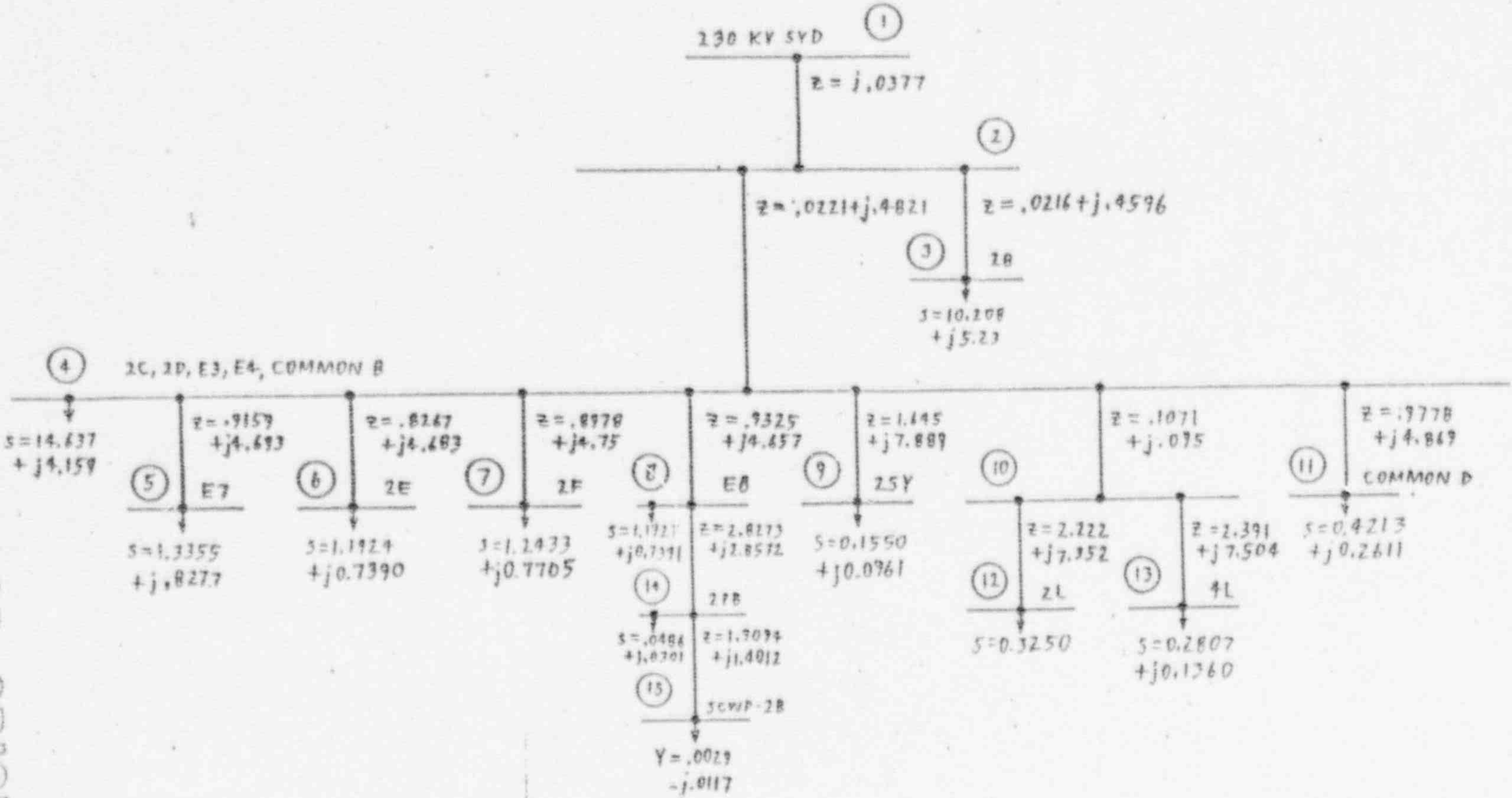
FIG. A15



SAT IMPEDANCE DIAGRAM
TURBINE BLDG. CLOSED COOLING
WATER PUMP 2B STARTING

DTCWB502
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

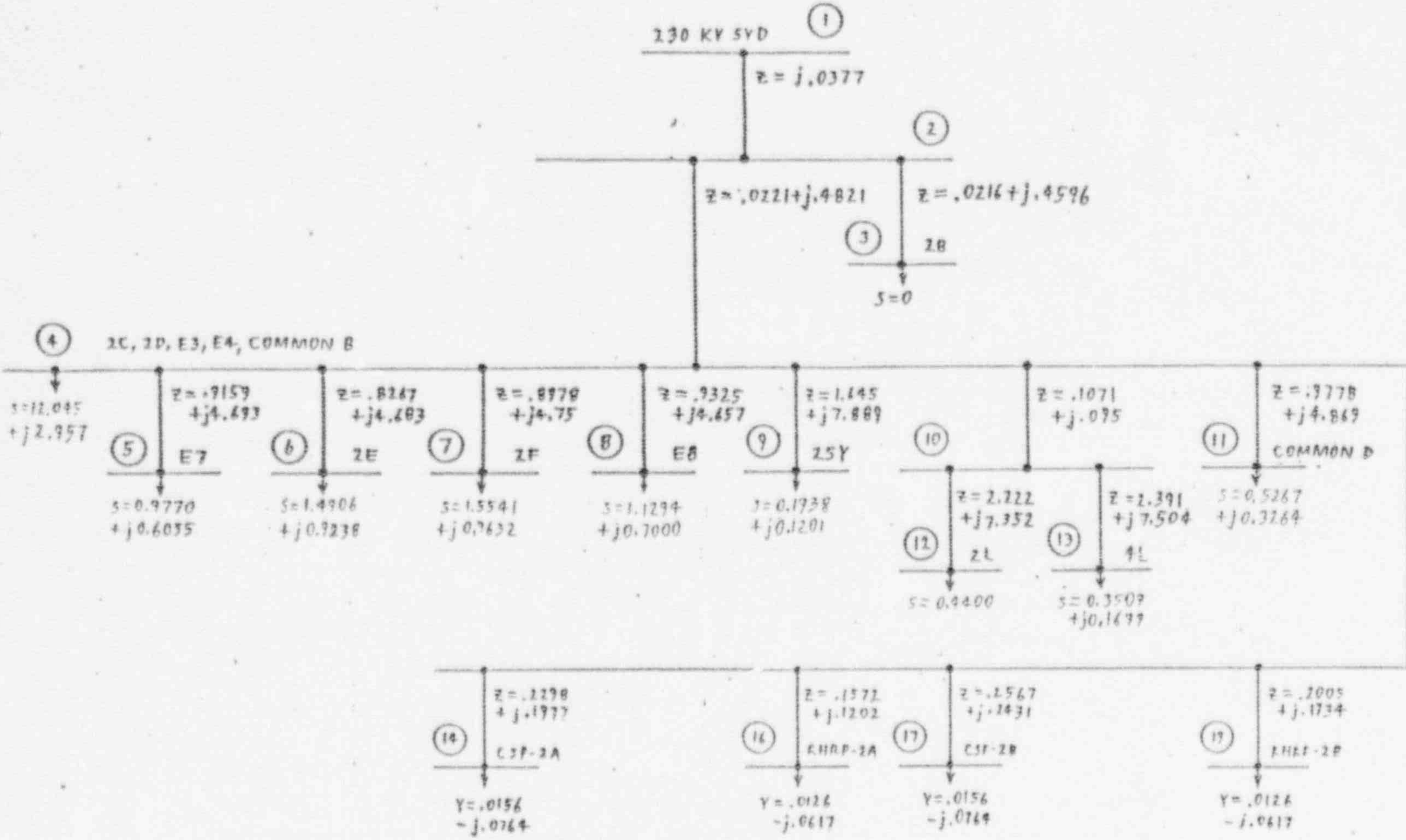
FIG. A16



SAT IMPEDANCE DIAGRAM
SCREEN WASH PUMP 2B
STARTING

DSWEB102
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

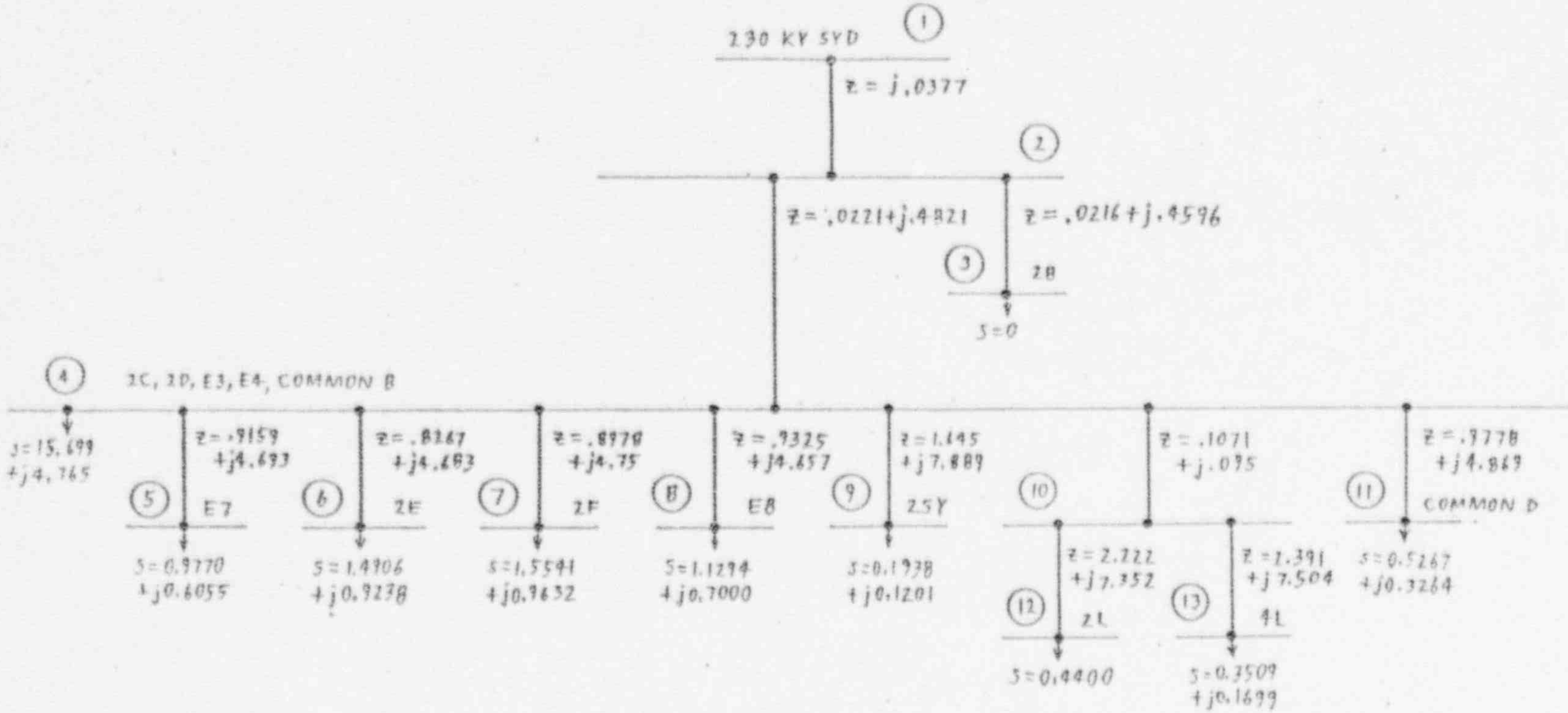
FIG. A17



SAT IMPEDANCE DIAGRAM
LOCA START

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

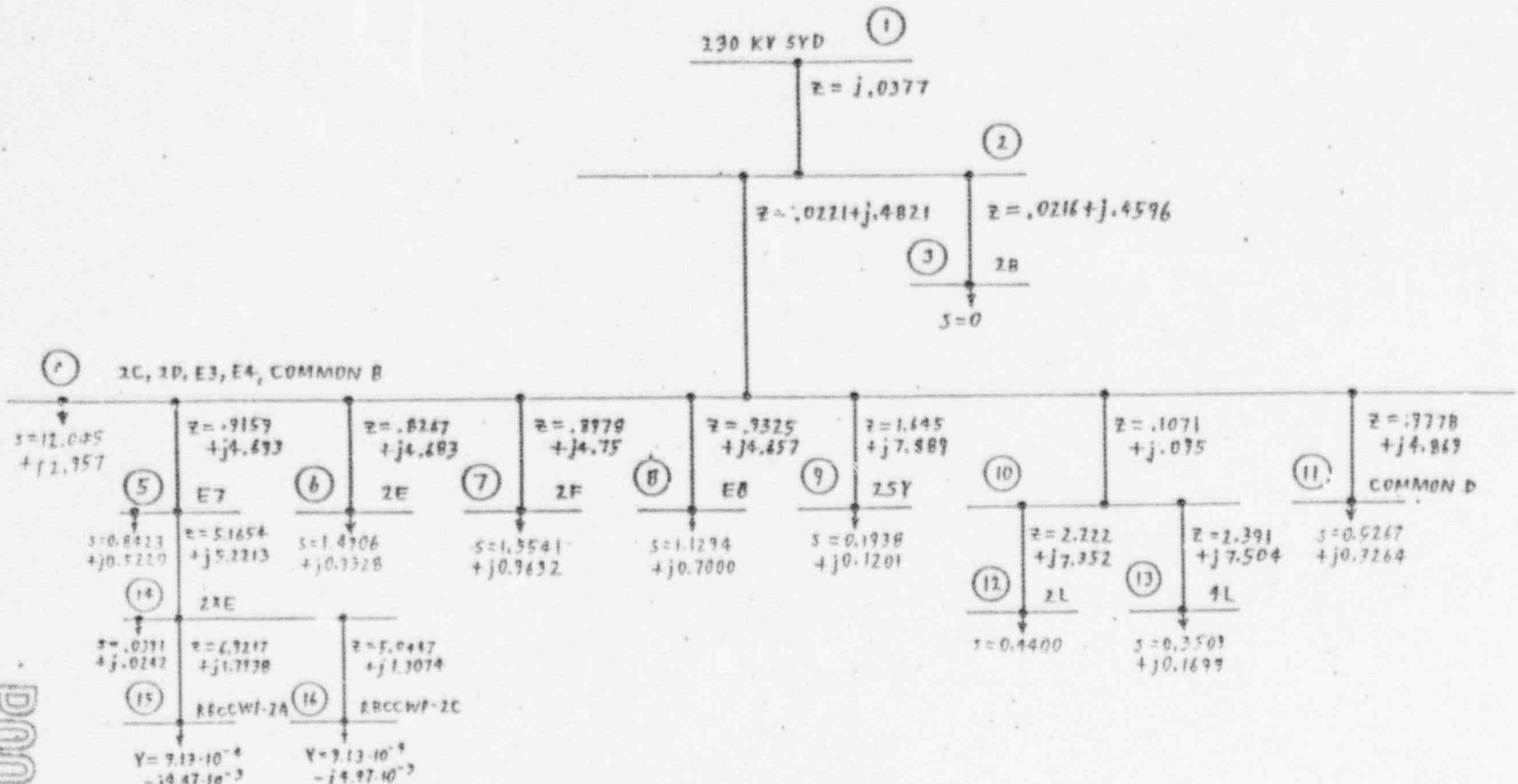
FIG. A18



SAT IMPEDANCE DIAGRAM
LOCA RUN

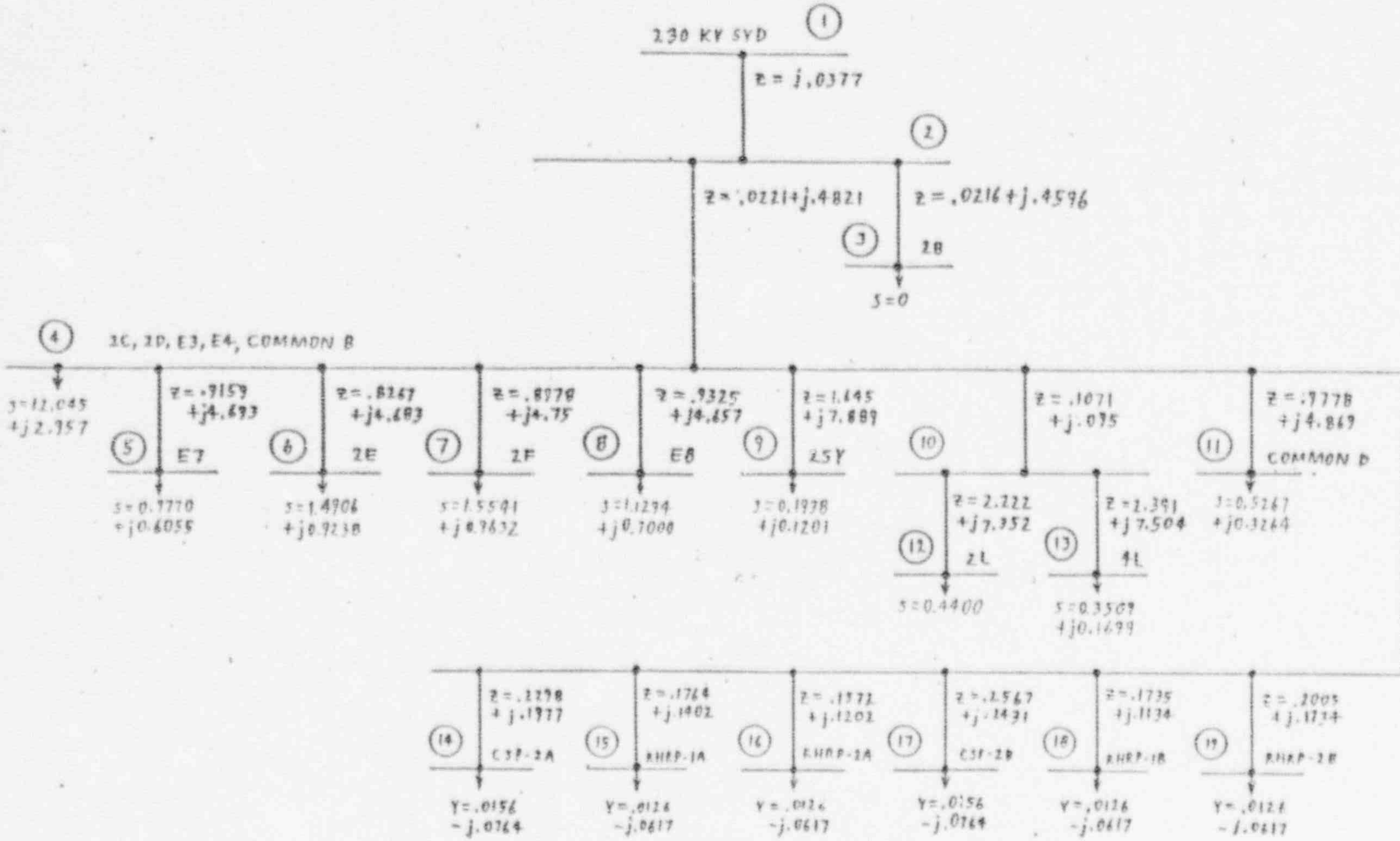
FIOCAL 67
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

FIG. A19



SAT IMPEDANCE DIAGRAM
LOCA
REACTOR BLDG. CLOSED COOLING WATER
PUMPS STARTING

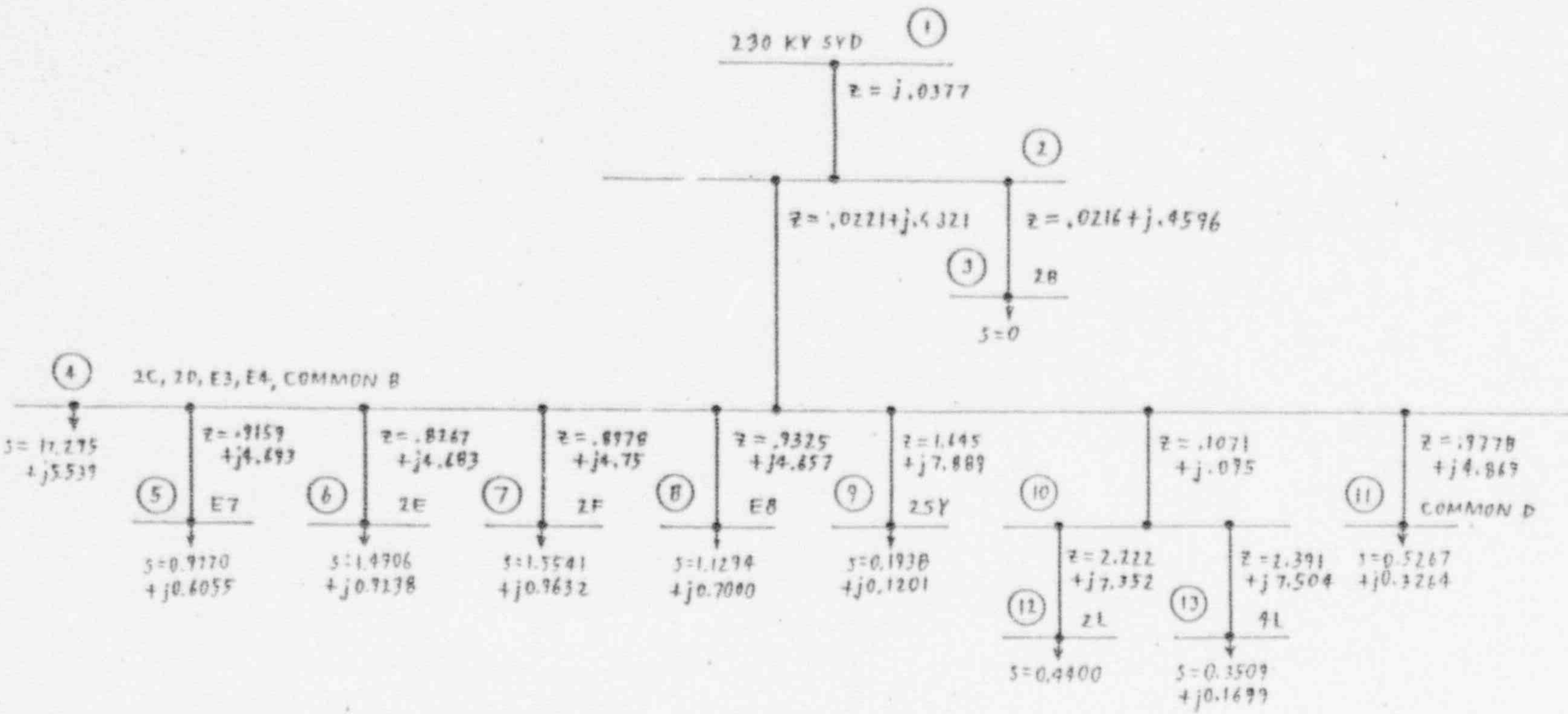
DRBPASM2
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2
FIG. A20



SAT IMPEDANCE DIAGRAM
2X LOCA START

P2LOCA52
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

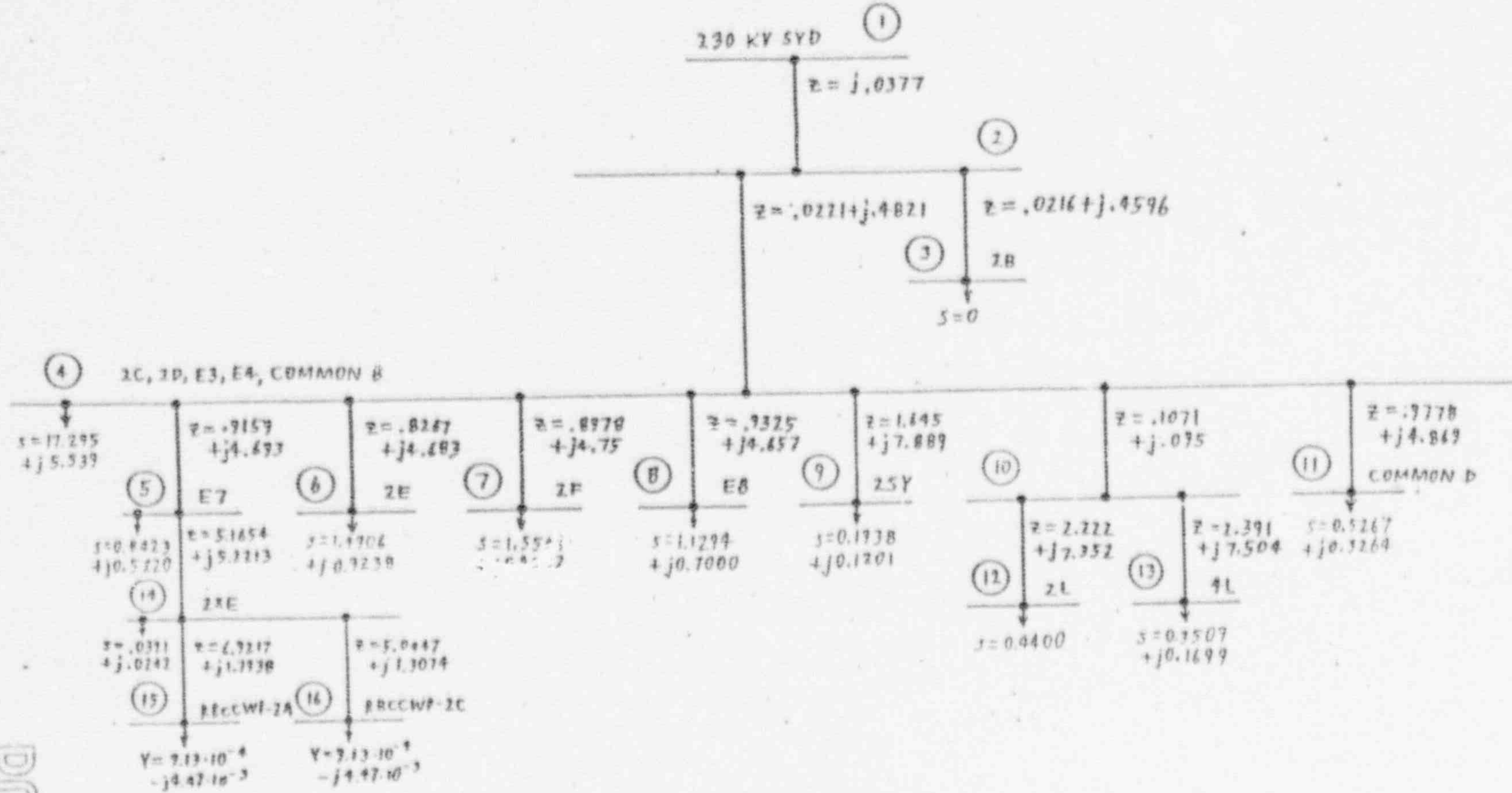
FIG. A21



SAT IMPEDANCE DIAGRAM
2X LOCA RUN

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

FIG. A22



SAT IMPEDANCE DIAGRAM
2X LOCA
REACTOR BLDG CLOSED COOLING WATER
PUMPS 2A & 2C START

CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2
FIG. A23

APPENDIX B

VOLTAGE DROP STUDY

FOR

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT

UNIT NO. 2

BY

UNITED ENGINEERS & CONSTRUCTORS INC.

VOLTAGES

AND

IMPEDANCE DIAGRAMS

4160 VOLT BUSES COMMON B &

COMMON A TIE BREAKER CLOSED

VOLTAGE DROP STUDY

APPENDIX B

GENERAL NOTES

1. The choice of source voltages to be studied was made as follows: The VOLTS runs of 4160V Buses Common A & Common B Tie Breaker Closed were made for the worst cases of minimum Switchyard Voltage based on the previous studies with the tie breaker open (Appendix A). Both the normal operating conditions and accident conditions were considered for the VOLTS runs. The worst case Switchyard Voltage for the normal operating condition is SAT, Screen Wash Pump 2A Starting (Full Load). The worst case Switchyard Voltage for the accident condition is SAT, 2X LOCA Start (Full Load).
2. Impedance input data for the VOLTS runs duplicated the input data utilized in Appendix A VOLTS runs. Load input data for the VOLTS runs was the same as input data in Appendix A with the exception of the 4160 Volt Bus Loads. These loads were increased to reflect the additional loads from 4160 Volt Bus Common A.
3. The Switchyard input voltage to the VOLTS run was then increased to compensate for the additional load. The resulting Switchyard Voltages meet the criteria established in 3.2.

VOLTAGE DROP STUDY

APPENDIX B

SAT

SCREEN WASH PUMP 2A STARTING
(Fig. No. B1)

BUS NAMES	MINIMUM VOLTAGE P. U. VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHARD	0.9809	225,607
4160 VOLT BUS 2B	0.9703	4,037
4160 VOLT BUS 2C, 2D, E3, E4, COMMON B, COMMON A	0.9326	3,880
480 VOLT UNIT SUBSTATION E7	0.8815	423
480 VOLT UNIT SUBSTATION 2E	0.9326	448
480 VOLT UNIT SUBSTATION 2F	0.9288	446
480 VOLT UNIT SUBSTATION E8	0.9228	443
480 VOLT UNIT SUBSTATION 2SY	0.9457	454
480 VOLT UNIT SUBSTATION COMMON D	0.93884	450
480 VOLT UNIT SUBSTATION 2L	0.9236	443
480 VOLT UNIT SUBSTATION 4L	0.9374	450
480 VOLT MOTOR CONTROL CENTER 2PA	0.8307	399
460 VOLT SCREEN WASH PUMP 2A	0.8510	391

NOTE: P. U. VOLTAGES ARE BASED ON BASE VOLTAGE SHOWN IN LEFT-HAND COLUMN

VOLTAGE DROP STUDY

APPENDIX B

SAT

2X LOCA START
(Fig. No. B2)

BUS NAMES	MINIMUM VOLTAGE P. U. VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHARD	0.9720	223,560
4160 VOLT BUS 2B	0.9793	4,074
4160 VOLT BUS 2C, 2D, E3, E4, COMMON B, COMMON A	0.7582	3,154
480 VOLT UNIT SUBSTATION E7	0.7462	358
480 VOLT UNIT SUBSTATION 2E	0.7157	344
480 VOLT UNIT SUBSTATION 2F	0.7086	340
480 VOLT UNIT SUBSTATION E8	0.7372	354
480 VOLT UNIT SUBSTATION 2SY	0.7608	365
480 VOLT UNIT SUBSTATION COMMON D	0.7490	360
480 VOLT UNIT SUBSTATION 2L	0.7424	356
480 VOLT UNIT SUBSTATION 4L	0.7474	359
4000 VOLT CORE SPRAY PUMP 2A	0.7740	3,096
4000 VOLT RHR PUMP 1A	0.7801	3,120
4000 VOLT RHR PUMP 2A	0.7812	3,125
4000 VOLT CORE SPRAY PUMP 2B	0.7711	3,084
4000 VOLT RHR PUMP 1B	0.7814	3,125
4000 VOLT RHR PUMP 2B	0.7782	3,113

NOTE: P. U. VOLTAGES ARE BASED ON BASE VOLTAGES SHOWN IN LEFT-HAND COLUMN

VOLTAGE DROP STUDY

APPENDIX B

SAT

2X LOCA RUN
(Fig No. B3)

BUS NAMES	MINIMUM VOLTAGE P. U. VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	0.9460	217,580
4160 VOLT BUS 2B	0.9637	4,009
4160 VOLT BUS 2C, 2D, E3, E4, COMMON B, COMMON A	0.8848	3,681
480 VOLT UNIT SUBSTATION E7	0.8881	426
480 VOLT UNIT SUBSTATION 2E	0.8642	415
480 VOLT UNIT SUBSTATION 2F	0.8587	412
480 VOLT UNIT SUBSTATION E8	0.8809	423
480 VOLT UNIT SUBSTATION 2SY	0.8931	429
480 VOLT UNIT SUBSTATION COMMON D	0.8833	424
480 VOLT UNIT SUBSTATION 2L	0.8716	418
480 VOLT UNIT SUBSTATION 4L	0.8819	423

NOTE: P. U. VOLTAGES ARE BASED ON BASE VOLTAGES SHOWN IN LEFT-HAND COLUMN

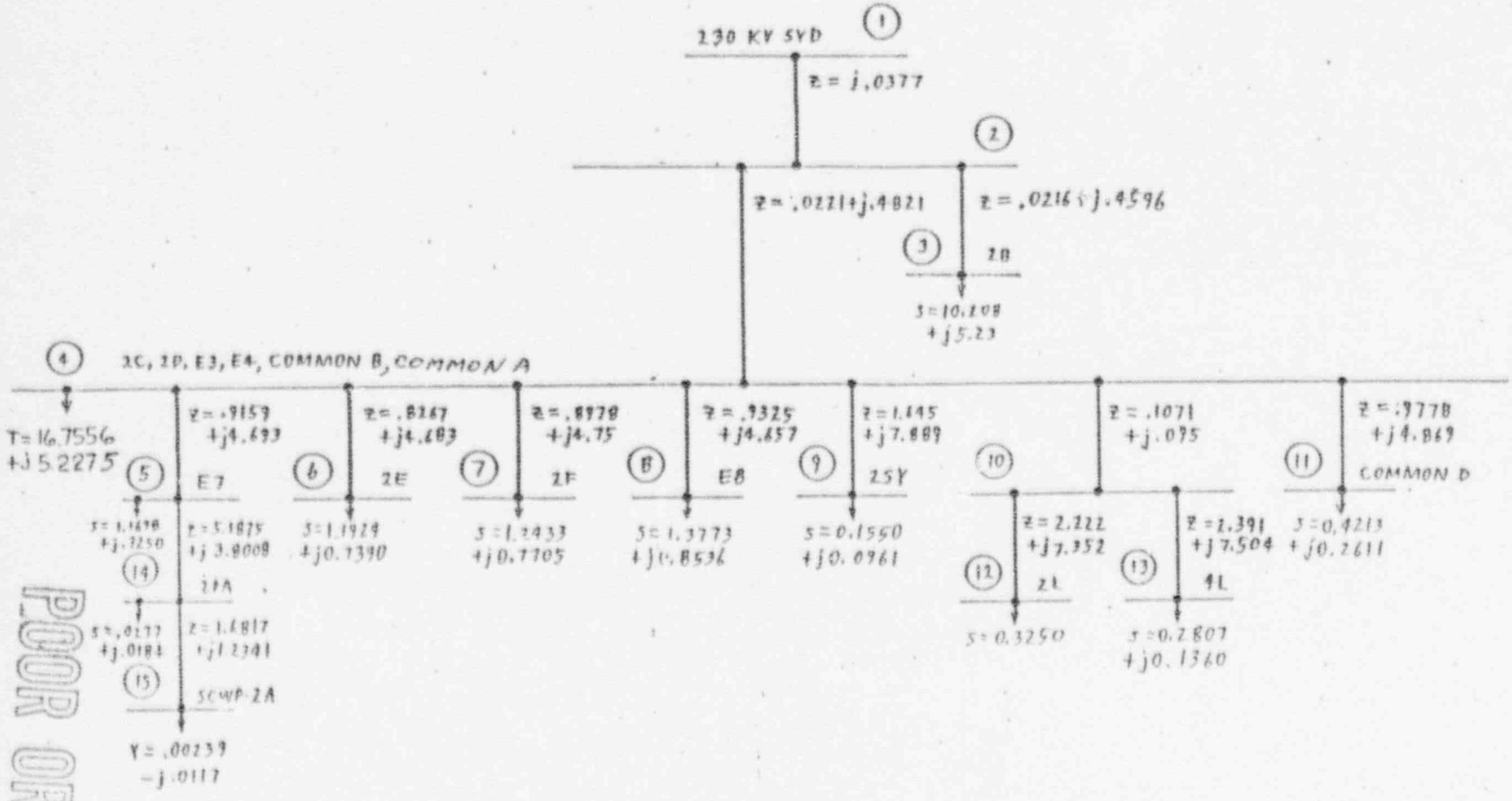
VOLTAGE DROP STUDY

APPENDIX B
SAT
2X LOCA
(Fig. No. B4)

REACTOR BUILDING CLOSED COOLING WATER PUMPS 2A AND 2C START

BUS NAMES	MINIMUM VOLTAGE P. U. VOLTAGE	MINIMUM VOLTAGE ACTUAL VOLTAGE
230 KV SWITCHYARD	0.9670	222,410
4160 VOLT BUS 2B	0.9852	4,099
4160 VOLT BUS 2C, 2D, E3, E4, COMMON B, COMMON A	0.9050	3,765
480 VOLT UNIT SUBSTATION E7	0.8775	421
480 VOLT UNIT SUBSTATION 2E	0.8875	426
480 VOLT UNIT SUBSTATION 2F	0.8821	423
480 VOLT UNIT SUBSTATION E8	0.9036	434
480 VOLT UNIT SUBSTATION 2SY	0.9143	439
480 VOLT UNIT SUBSTATION COMMON D	0.9047	434
480 VOLT UNIT SUBSTATION 2L	0.8922	428
480 VOLT UNIT SUBSTATION 4L	0.9033	434
480 VOLT MOTOR CONTROL CENTER 2XE	0.8265	397
460 VOLT REACTOR BUILDING CLOSED COOLING WATER PUMP 2A	0.8499	391
460 VOLT REACTOR BUILDING CLOSED COOLING WATER PUMP 2C	0.8533	393

NOTE: P. U. VOLTAGES ARE BASED ON BASE VOLTAGES SHOWN IN LEFT-HAND COLUMN

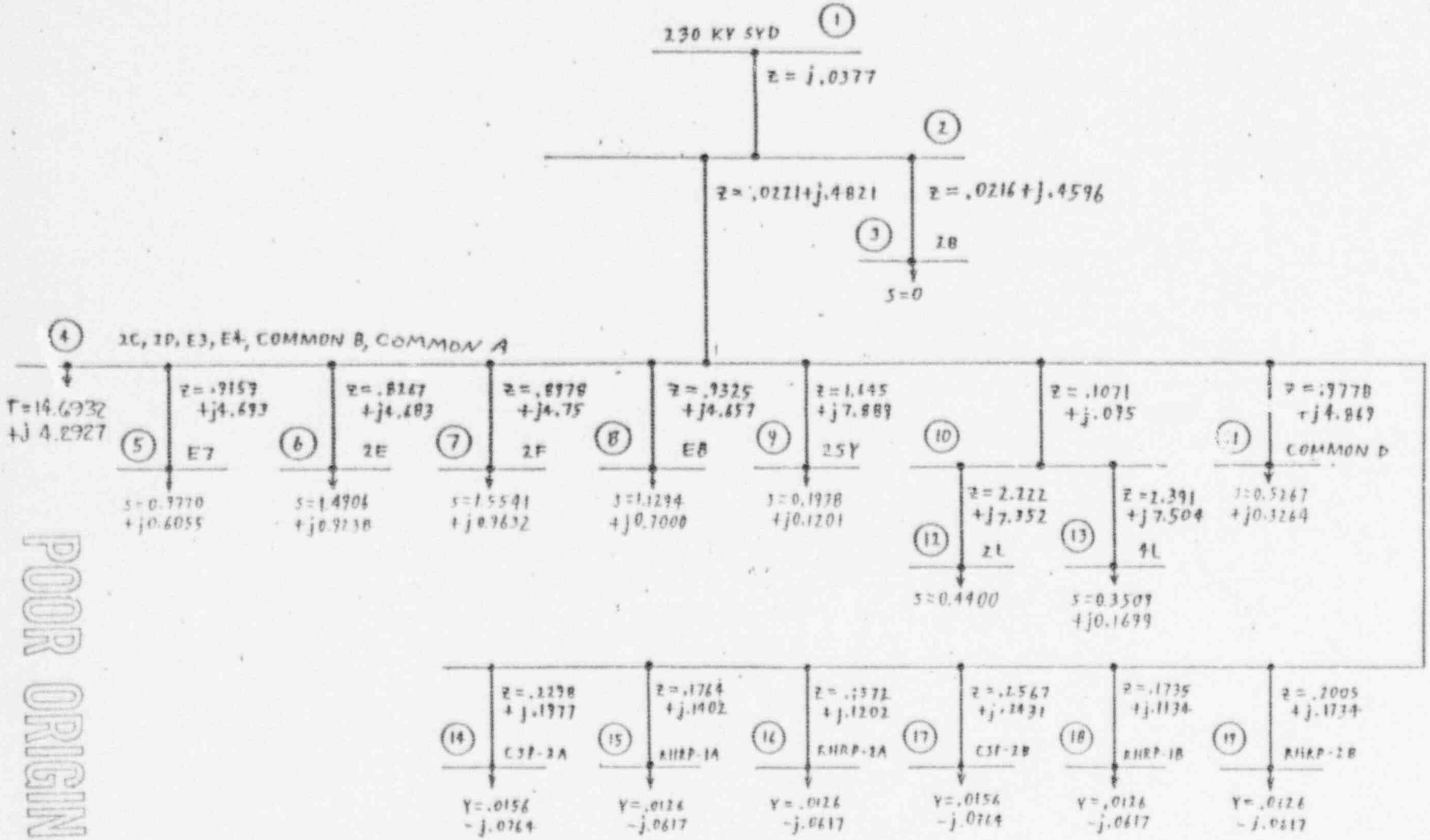


POOR ORIGINAL

SAT IMPEDANCE DIAGRAM
SCREEN WASH PUMP 2A
STARTING

DSOU1
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

FIG. B1

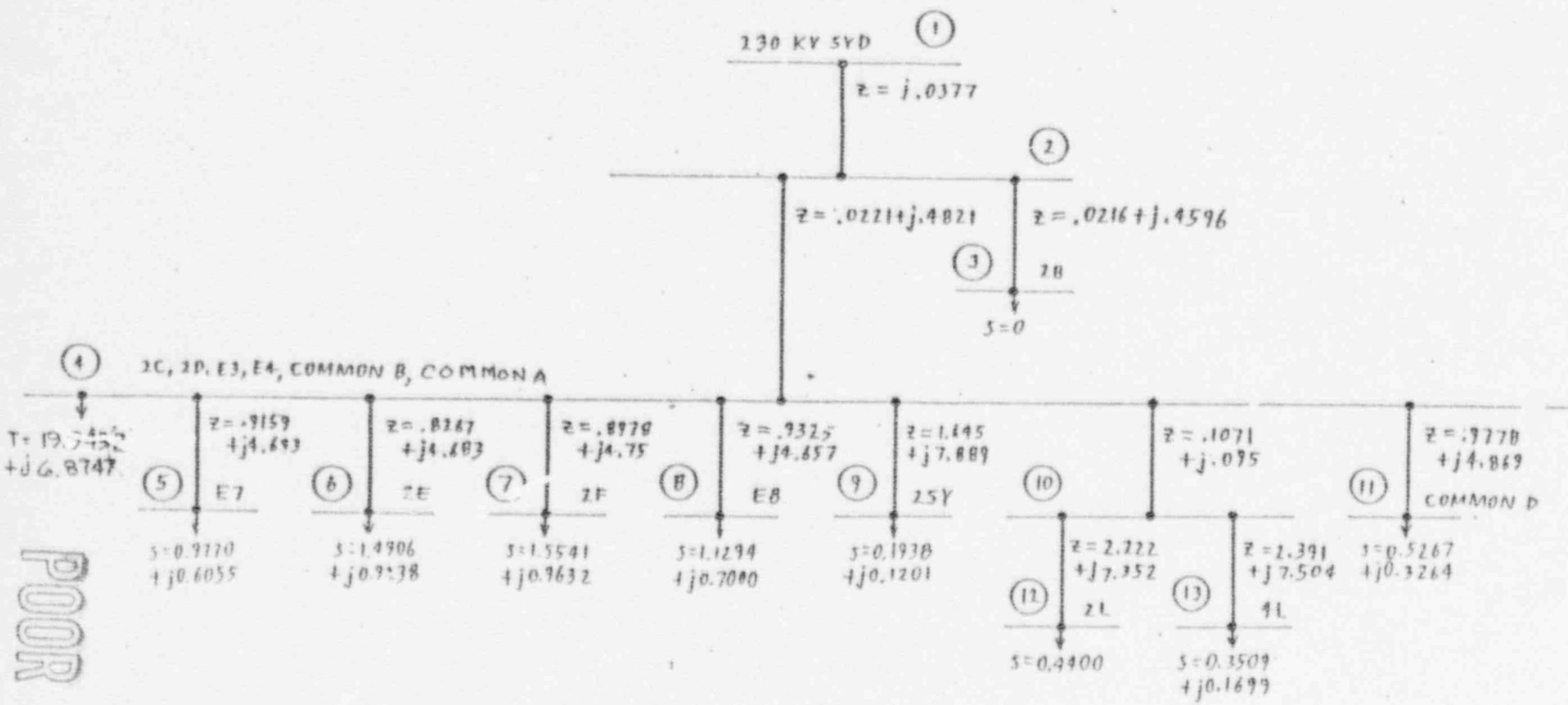


SAT IMPEDANCE DIAGRAM
2X LOCA START

DSC02
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

FIG. B 2

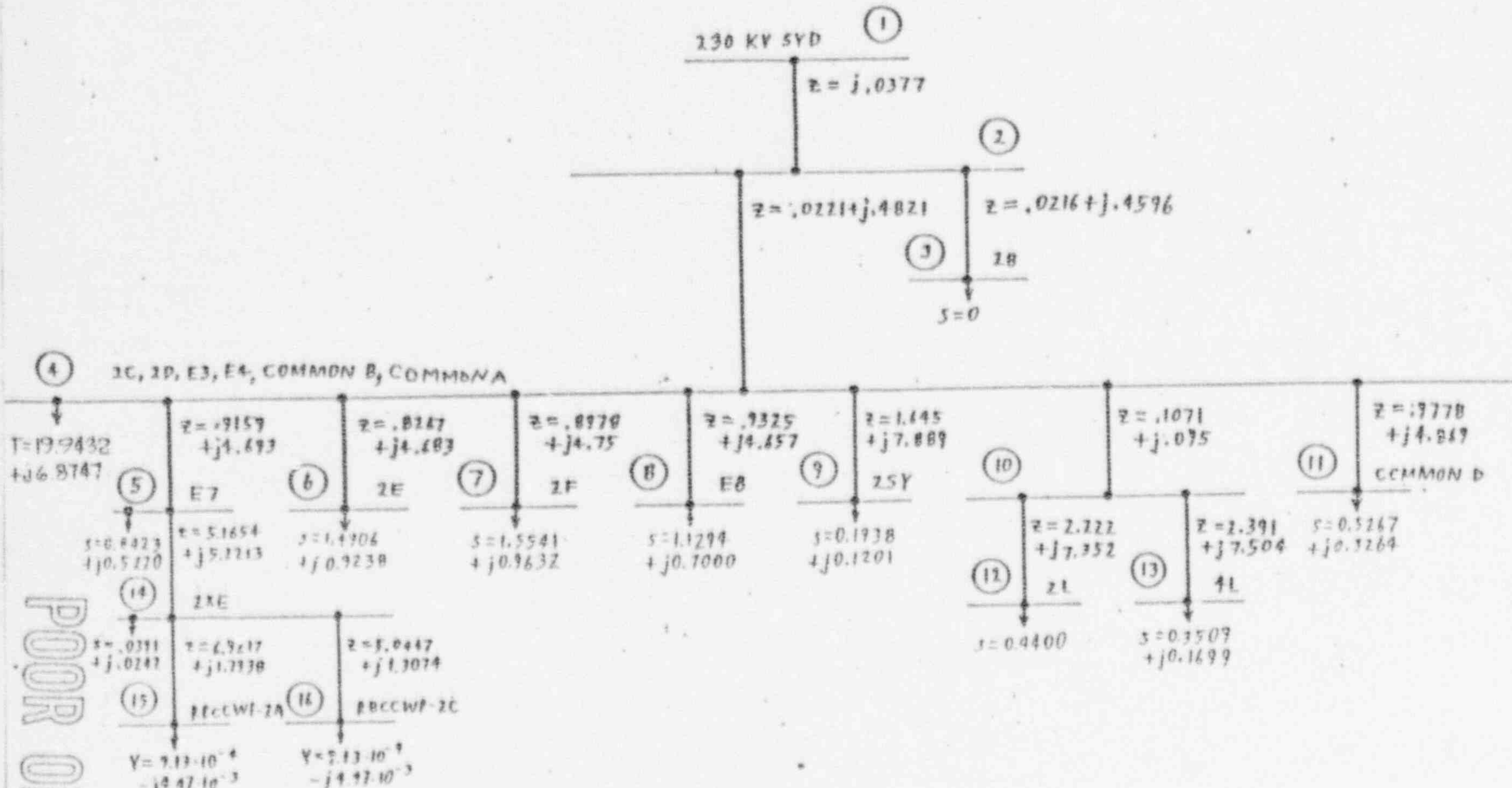
POOR ORIGINAL



SAT IMPEDANCE DIAGRAM
2X LOCA RUN

DSOU3
CAROLINA POWER
& LIGHT COMPANY
BRUNSWICK STEAM
ELECTRIC PLANT
UNIT NO. 2

FIG. B3.



POOR ORIGINAL

SAT IMPEDANCE DIAGRAM
2X LOCA
REACTOR BLDG CLOSED COOLING WATER
PUMPS 2A & 2C START

D5004
CAROLINA POWER & LIGHT COMPANY
BRUNSWICK STEAM ELECTRIC PLANT
UNIT NO. 2
FIG. B4

APPENDIX C

VOLTAGE DROP STUDY

FOR

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT

UNIT NO. 2

BY

UNITED ENGINEERS & CONSTRUCTORS INC.

LOADS

Form 5015 Rev. 11/74

GENERAL COMPUTATION SHEET

(DISCIPLINE)

united engineers & constructors inc

CALC. SET NO.	
PRELIM.	9527-032-5-E-1
FINAL	
VOID	
SHEET C2 OF	
J.O. 9527-032	

REV	COMP. BY	CHK'D BY
0	DATE	DATE
	DATE	DATE

NAME OF COMPANY CP&L BRUNSWICK UNIT/S 1 & 2

SUBJECT VOLTAGE DROP STUDY

4160V RUNNING LOADS

NOTE: UNIT SUBSTATION LOADS ARE NOT INCLUDED IN THE BUS LOADS

LOAD CONDITION		BUS 2B	2C	2D	E3	E4	COMMON B	TOTAL (2C+2D+E3+E4+CB)
LIGHT (SAT)	MW	0	0	0	0	.446	0	.446
	MVAR	0	0	0	0	.276	0	.276
LIGHT (UAT)	MW	.66	2.889	5.815	.599	.6	0	9.903
	MVAR	1.14	.601	2.067	.356	.355	0	3.379
FULL	MW	10.208	5.462	7.976	.599	.6	0	14.637
	MVAR	5.23	1.075	2.373	.356	.355	0	4.159
LOCAS	MW	0	4.166	6.68	.599	.6	0	12.045
	MVAR	0	.474	1.772	.356	.355	0	2.957
LOCAR	MW	0	4.166	6.68	2.238	2.615	0	15.699
	MVAR	0	.474	1.772	1.151	1.368	0	4.765
2LOCAS	MW	0	4.166	6.68	.599	.6	0	12.045
	MVAR	0	.474	1.772	.356	.355	0	2.957
2LOCAR	MW	0	4.166	6.68	3.036	3.413	0	17.295
	MVAR	0	.474	1.772	1.538	1.755	0	5.539

Form 5015 Rev. 11/74

GENERAL COMPUTATION SHEET

(DISCIPLINE)

united engineers & constructors inc

NAME OF COMPANY CP&L BRUNSWICK UNIT/S 2

SUBJECT VOLTAGE DROP STUDY

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J.O. 9527-032	

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	DATE	DATE

BOP MOTOR STARTING CASES
4160V RUNNING LOADS

STARTING MOTOR		2B	2C	2D	E3	E4	COMMON B	2C+2D+E3+E4 +CD TOTAL
CIRC	MW	10.208	5.462	4.790	.599	.600	0	11.451
WATER	MVAR	5.230	1.075	2.373	.356	.355	0	4.159
PUMP	FED FROM			X				
2B	CABLE R			.1925				
	X			.2638				
	MOTOR G			.014				
	B			.105				
REACTOR	MW	5.104	5.462	7.976	.599	.600	0	14.637
RECIRC	MVAR	2.615	1.075	2.373	.356	.355	0	4.159
PUMP	FED FROM	X						
2B	CABLE R	.02127						
	X	.03196						
	MOTOR G	.0643						
	B	.373						

POOR ORIGINAL

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GENERAL COMPUTATION SHEET

united engineers & constructors inc

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J.O. 9527-032	

REV	COMP. BY	CHK'D BY
0	DATE	DATE
	DATE	DATE

NAME OF COMPANY C P & L BRUNSWICK UNIT/S 1 & 2

SUBJECT VOLTAGE DROP STUDY

MOTOR	RATED VOLTAGE V	HORSEPOWER	LOCKED-ROTOR CURRENT A	LOCKED-ROTOR POWER FACTOR	PER-UNIT ADMITTANCE COND.	SUSC.
REACTOR RECIRC MG SET	4000	7000	$5.65 \cdot 10^{3}$	.17	$6.43 \cdot 10^{-2}$	$3.73 \cdot 10^{-1}$
FP-5353 CIRC. WATER PUMP ☆	4000	2250	$1.408 \cdot 10^{3}$	.133	$1.40 \cdot 10^{-2}$	$1.05 \cdot 10^{-1}$
CORE SPRAY PUMP	4000	1250	$1.04 \cdot 10^{3}$	.2	$1.56 \cdot 10^{-2}$	$7.64 \cdot 10^{-2}$
FP-5687 RHR PUMP	4000	1000	$8.40 \cdot 10^{2}$	.2	$1.26 \cdot 10^{-2}$	$6.17 \cdot 10^{-2}$
FP-5727 NUCLEAR S.W. PUMP	4000	300	$2.42 \cdot 10^{2}$	.3	$5.43 \cdot 10^{-3}$	$1.73 \cdot 10^{-2}$
FP-3102 FIRE PUMP	4000	250	$1.82 \cdot 10^{2}$	.3*	$4.09 \cdot 10^{-3}$	$1.30 \cdot 10^{-2}$
FP-4164 SCREEN WASH PUMP	460	200	$1.38 \cdot 10^{3}$	.2*	$2.[illegible]9 \cdot 10^{-3}$	$1.17 \cdot 10^{-2}$
FP-3647 TURB. BLDG. CCW PUMP	460	200	$1.45 \cdot 10^{3}$	.2*	$2.52 \cdot 10^{-3}$	$1.23 \cdot 10^{-2}$
FP-3552 BACKWASH AIR BLOWER	460	150	$1.23 \cdot 10^{3}$†	.2*	$2.12 \cdot 10^{-3}$	$1.04 \cdot 10^{-2}$
REACT. BLDG. CCW PUMP	460	75	$5.26 \cdot 10^{2}$‡	.2*	$9.13 \cdot 10^{-4}$	$4.47 \cdot 10^{-3}$

☆ CHARACTERISTICS FROM PORTEC DATA SHEET - 89% REVERSE ROTATION

* ESTIMATED

† ESTIMATED BASED ON 1KVA PER HORSEPOWER RUNNING, STARTING CURRENT = 6.5 x RUNNING CURRENT.

‡ SEE SH. B 10.1

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GENERAL COMPUTATION SHEET

(DISCIPLINE)

united engineers & constructors inc

CALC. SET NO.	
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SHEET C5 OF	
J.O. 9527-032	

REV	COMP. BY	CHK'D BY
0	DATE	DATE
	DATE	DATE

NAME OF COMPANY C P & L BRUNSWICK UNIT/S 1 & 2

SUBJECT VOLTAGE DROP STUDY

REACTOR BUILDING CLOSED COOLING WATER PUMP STARTING

LOCKED ROTOR CODE LETTER
F : 5.0 - 5.59 KVA/HP

USING 5.59 KVA/HP,

$$I_{LR} = \frac{5.59 \cdot 75 \cdot 1000}{\sqrt{3} \cdot 460} = 526 \text{ A}$$

Form 5015 Rev. 11/74

GENERAL COMPUTATION SHEET

(DISCIPLINE)

united engineers & constructors inc.

CALC. SET NO.	
PRELIM.	9527-032-5-E-1
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SHEET C 6 OF	
J.O. 9527-032	

REV	COMP. BY	CHK'D BY
0	DATE	DATE
	DATE	DATE

NAME OF COMPANY CP&L BRUNSWICK UNIT/S 2

SUBJECT VOLTAGE DROP STUDY

460V MOTOR STARTING DATA

UNIT SUBSTATION	MCC	LARGEST MOTOR	HP	CABLE NO.	LENGTH	TYPE
2E	2TJ	TCC-2A	200	MF1-NGØ	73	3/C 350 MCM
2F	2TH	TCC-2C	200	D17-NG2	141	3/C 350 MCM
E7	2PA	SCW-2A	200	EØ2-NK6	96	3/C 350 MCM
E8	2PB	SCW-2B	200	E42-NK7	109	3/C 350 MCM
COMMON D	RWB	2-CFD-D063	150	BG5-P42	77	3/C #4/0

UNIT SUBSTATION	MCC	MOTOR G	MOTOR B	CABLE R	CABLE X	MOTOR FP
2E	2TJ	.00252	.0123	1.2788	.9384	3552
2F	2TH	.00252	.0123	2.4699	1.8126	3552
E7	2PA	.00239	.0117	1.6817	1.2341	3647
E8	2PB	.00239	.0117	1.9094	1.4012	3647
COMMON D	RWB	.00212	.0104	2.2020	.9929	DATA ESTIMATED

POOR ORIGINAL

Form 5015 Rev. 11/74

GENERAL COMPUTATION SHEET

(DISCIPLINE)

united engineers & constructors inc.

CALC. SET NO.	
PRELIM.	9527-032-S-E-1
FINAL	
VOID	
SHEET C7 OF	
J.O. 9527-032	

REV	COMP. BY	CHK'D BY
0	DATE	DATE
	DATE	DATE

NAME OF COMPANY CP&L BRUNSWICK UNIT/S 2

SUBJECT VOLTAGE DROP STUDY

UNIT SUBSTATION	MCC	MOTOR	HP	CABLE NO.	LENGTH	TYPE
E7	2XE	RBCCWP-2A	75	EA1-NF6	118	4/C #1/0
E7	2XE	RBCCWP-2C	75	EA7-NF8	86	4/C #1/0
E8	2XF	RBCCWP-2B	75	ED7-NF7	356	4/C #1/0

UNIT SUBSTATION		MCC	MOTOR G	MOTOR B	CABLE R	CABLE X
E7	(2A)	2XE	$9.13 \cdot 10^{-4}$	$4.47 \cdot 10^{-3}$	6.9217	1.7938
E7	(2C)	2XE	$9.13 \cdot 10^{-4}$	$4.47 \cdot 10^{-3}$	5.0447	1.3074
E8	(2B)	2XF	$9.13 \cdot 10^{-4}$	$4.47 \cdot 10^{-3}$	20.8826	5.4119

CAROLINA POWER AND LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

UNIT SUBSTATION E7 MOTOR CONTROL CENTERS

FROM BUS	TO BUS	CABLE IMPEDANCES RESISTANCE	REACTANCE
E7	2XA	3.3854	2.4783
E7	2XC	3.3854	2.4783
E7	2XE	5.1654	5.2213
E7	2XG	2.0178	2.1753
E7	2XL	4.9349	4.3954
E7	1XA-2	6.7665	7.0312
E7	1XJ	7.5868	7.6693
E7	2CA	3.2882	3.3229
E7	2PA	5.1875	3.8008
E7	DGC	0.9792	0.5347
E7	2A	7.8950	7.6345

CAROLINA POWER AND LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

UNIT SUBSTATION 2E MOTOR CONTROL CENTERS

FROM	TO	CABLE IMPEDANCES	
BUS	BUS	RESISTANCE	REACTANCE
2E	2TA	3.7934	3.8235
2E	2TB	2.6432	2.6736
2E	2TC	2.6432	2.6736
2E	2TF	2.7908	2.8212
2E	2TJ	2.3134	2.3351
2E	2TK	1.6580	2.4088
2E	2TL	1.8403	2.6736
2E	2ETB	6.9314	2.2135

CAROLINA POWER AND LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

UNIT SUBSTATION 2F MOTOR CONTROL CENTERS

FROM BUS	TO BUS	CABLE IMPEDANCES RESISTANCE	REACTANCE
2F	2TD	1.8663	1.3672
2F	2TE	1.8663	1.3672
2F	2TG	1.6823	1.2335
2F	2TH	1.5998	2.3264
2F	2TM	1.1892	1.7318
2F	2TN	3.0859	2.2613
2F	2FTB	0.5925	1.9140

CAROLINA POWER AND LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

UNIT SUBSTATION E8 MOTOR CONTROL CENTERS

FROM BUS	TO BUS	CABLE IMPEDANCES RESISTANCE	REACTANCE
E8	2XB	1.6580	1.2153
E8	2XD	2.6345	2.6649
E8	2XF	8.2031	7.5521
E8	2XH	3.4770	3.9770
E8	2XM	5.8594	4.4835
E8	1XB-2	6.1198	5.9939
E8	1XK	7.0356	7.113[illegible]
E8	2PB	2.8273	2.85[illegible]
E8	2CB	4.6875	4.7396
E8	DGD	0.6120	0.6163
E8	E11,E12	0.3906	0.1754
E8	2B	13.0599	12.3220

CAROLINA POWER AND LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

UNIT SUBSTATION COMMON D MOTOR CONTROL CENTERS

FROM BUS	TO BUS	CABLE IMPEDANCES RESISTANCE	REACTANCE
COMMON D	RWB	1.7990	1.8181
COMMON D	RWD	4.7613	4.8090
COMMON D	2SA	9.1797	9.2752
COMMON D	CRANE	14.7352	8.0469

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

4160 VOLT BUS 2B, FULL LOAD AND ACCIDENT CONDITIONS

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
REACTOR RECIRC PUMP 2A	6520.	6520.	0.8900	0.9530	5.1038	2.6148
REACTOR RECIRC PUMP 2B	6520.	6520.	0.8900	0.9530	5.1038	2.6148
TOTAL					10.2076	5.2295

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

4160 VOLT BUS 2B, RECIRC PUMP 2B MOTOR STARTING CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
REACTOR RECIRC PUMP 2A	6520.	6520.	0.8900	0.9530	5.1038	2.6148
REACTOR RECIRC PUMP 2B	0.	6520.	0.8900	0.9530	0.	0.
TOTAL					5.1038	2.6148

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

BUS 2C LOADS, FULL LOAD CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CIRCULATING WATER PUMP 2A	2060.	2250.	1.0000	0.9645	1.5933	0.
CIRCULATING WATER PUMP 2C	2060.	2250.	1.0000	0.9645	1.5933	0.
CONDENSATE BOOSTER PUMP 2A	1243.	1250.	0.9000	0.9460	0.9804	0.4749
CONDENSATE BOOSTER PUMP 2C	0.	1250.	0.9000	0.9460	0.	0.
HEATER DRAIN PUMP 2B	0.	1000.	0.8950	0.9260	0.	0.
CONDENSATE PUMP 2B	0.	1000.	0.8800	0.9260	0.	0.
CHILLER 2B-RM-TB	1650.	1650.	0.9070	0.9500	1.2957	0.6016
TOTAL					5.4628	1.0765

<u>MOTOR LIST</u>

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

BUS 2C LOADS, UAT LIGHT LOAD CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CIRCULATING WATER PUMP 2A	0.	2250.	1.0000	0.9645	0.	0.
CIRCULATING WATER PUMP 2C	2060.	2250.	1.0000	0.9645	1.5933	0.
CONDENSATE BOOSTER PUMP 2A	0.	1250.	0.9000	0.9460	0.	0.
CONDENSATE BOOSTER PUMP 2C	0.	1250.	0.9000	0.9460	0.	0.
HEATER DRAIN PUMP 2B	0.	1000.	0.8950	0.9260	0.	0.
CONDENSATE PUMP 2B	0.	1000.	0.8800	0.9260	0.	0.
CHILLER 2B-RM-TB	1650.	1650.	0.9070	0.9500	1.2957	0.6016
TOTAL					2.8890	0.6016

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

BUS 2C LOADS, ACCIDENT (LOCA AND 2XLOCA) CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CIRCULATING WATER PUMP 2A	2060.	2250.	1.0000	0.9645	1.5933	0.
CIRCULATING WATER PUMP 2C	2060.	2250.	1.0000	0.9645	1.5933	0.
CONDENSATE BOOSTER PUMP 2A	1243.	1250.	0.9000	0.9460	0.9804	0.4749
CONDENSATE BOOSTER PUMP 2C	0.	1250.	0.9000	0.9460	0.	0.
HEATER DRAIN PUMP 2B	0.	1000.	0.8950	0.9260	0.	0.
CONDENSATE PUMP 2B	0.	1000.	0.8800	0.9260	0.	0.
CHILLER 2B-RM-TB	0.	1650.	0.9070	0.9500	0.	0.
TOTAL					4.1671	0.4749

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

BUS 2D LOADS, FULL LOAD CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CIRCULATING WATER PUMP 2B	2060.	2250.	1.0000	0.9645	1.5933	0.
CIRCULATING WATER PUMP 2D	2060.	2250.	1.0000	0.9645	1.5933	0.
CONDENSATE BOOSTER PUMP 2B	1243.	1250.	0.9000	0.9460	0.9804	0.4749
HEATER DRAIN PUMP 2A	855.	1000.	0.8950	0.9260	0.6888	0.3433
HEATER DRAIN PUMP 2C	855.	1000.	0.8950	0.9260	0.6888	0.3433
CONDENSATE PUMP 2A	705.	1000.	0.8800	0.9260	0.5680	0.3066
CONDENSATE PUMP 2C	705.	1000.	0.8800	0.9260	0.5680	0.3066
CHILLER 2A-RM-TB	1650.	1650.	0.9070	0.9500	1.2957	0.6016
TOTAL					7.9763	2.3762

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

BUS 2D LOADS, CIRC WATER PUMP 2B START, FULL LOAD

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CIRCULATING WATER PUMP 2B	0.	2250.	1.0000	0.9645	0.	0.
CIRCULATING WATER PUMP 2D	2060.	2250.	1.0000	0.9645	1.5933	0.
CONDENSATE BOOSTER PUMP 2B	1243.	1250.	0.9000	0.9460	0.9804	0.4749
HEATER DRAIN PUMP 2A	855.	1000.	0.8950	0.9260	0.6888	0.3433
HEATER DRAIN PUMP 2C	855.	1000.	0.8950	0.9260	0.6888	0.3433
CONDENSATE PUMP 2A	705.	1000.	0.8800	0.9260	0.5680	0.3066
CONDENSATE PUMP 2C	705.	1000.	0.8800	0.9260	0.5680	0.3066
CHILLER 2A-RM-TB	1650.	1650.	0.9070	0.9500	1.2957	0.6016
TOTAL					6.3830	2.3762

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

BUS 2D LOADS, UAT LIGHT LOAD CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CIRCULATING WATER PUMP 2B	0.	2250.	1.0000	0.9645	0.	0.
CIRCULATING WATER PUMP 2D	2060.	2250.	1.0000	0.9645	1.5933	0.
CONDENSATE BOOSTER PUMP 2B	1243.	1250.	0.9000	0.9460	0.9804	0.4749
HEATER DRAIN PUMP 2A	855.	1000.	0.8950	0.9260	0.6888	0.3433
HEATER DRAIN PUMP 2C	855.	1000.	0.8950	0.9260	0.6880	0.3433
CONDENSATE PUMP 2A	0.	1000.	0.8800	0.9260	0.	0.
CONDENSATE PUMP 2C	705.	1000.	0.8800	0.9260	0.5680	0.3066
CHILLER 2A-RM-TB	1650.	1650.	0.9070	0.9500	1.2957	0.6016
TOTAL					5.8150	2.0696

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

BUS 2D LOADS, ACCIDENT (LOCA AND 2XLOCA) CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CIRCULATING WATER PUMP 2B	2060.	2250.	1.0000	0.9645	1.5933	0.
CIRCULATING WATER PUMP 2D	2060.	2250.	1.0000	0.9645	1.5933	0.
CONDENSATE BOOSTER PUMP 2B	1243.	1250.	0.9000	0.9460	0.9804	0.4749
HEATER DRAIN PUMP 2A	855.	1000.	0.8950	0.9260	0.6888	0.3433
HEATER DRAIN PUMP 2C	855.	1000.	0.8950	0.9260	0.6888	0.3433
CONDENSATE PUMP 2A	705.	1000.	0.8800	0.9260	0.5680	0.3066
CONDENSATE PUMP 2C	705.	1000.	0.8800	0.9260	0.5680	0.3066
CHILLER 2A-RM-TB	0.	1650.	0.9070	0.9500	0.	0.
TOTAL					6.6806	1.7745

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

4160 VOLT BUS E3 LOADS, NORMAL OPERATING CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CORE SPRAY PUMP 2A	0.	1250.	0.9000	0.9400	0.	0.
RHR SERVICE WATER PUMP 2A	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 1A	0.	800.	0.9000	0.9350	0.	0.
RHR SERVICE WATER PUMP 1A	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 2A	0.	800.	0.9000	0.9350	0.	0.
CONTROL ROD DRIVE HYD. PUMP	190.	250.	0.8860	0.9270	0.1529	0.0800
NUCLEAR SERVICE PUMP 2A	275.	300.	0.8500	0.9200	0.2230	0.1382
CONVENTIONAL SERVICE PUMP 2A	275.	300.	0.8500	0.9200	0.2230	0.1382
TOTAL					0.5989	0.3564

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

4160 VOLT BUS E3 LOADS, SHUTDOWN CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CORE SPRAY PUMP 2A	0.	1250.	0.9000	0.9400	0.	0.
RHR SERVICE WATER PUMP 2A	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 1A	0.	800.	0.9000	0.9350	0.	0.
RHR SERVICE WATER PUMP 1A	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 2A	0.	800.	0.9000	0.9350	0.	0.
CONTROL ROD DRIVE HYD. PUMP	0.	250.	0.8860	0.9270	0.	0.
NUCLEAR SERVICE PUMP 2A	275.	300.	0.8500	0.9200	0.2230	0.1382
CONVENTIONAL SERVICE PUMP 2A	275.	300.	0.8500	0.9200	0.2230	0.1382
TOTAL					0.4460	0.2764

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

4160 VOLT BUS E3 LOADS, LOCA CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CORE SPRAY PUMP 2A	1060.	1250.	0.9000	0.9400	0.8412	0.4074
RHR SERVICE WATER PUMP 2A	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 1A	0.	1000.	0.9000	0.9350	0.	0.
RHR SERVICE WATER PUMP 1A	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 2A	1000.	1000.	0.9000	0.9350	0.7979	0.3864
CONTROL ROD DRIVE HYD. PUMP	190.	250.	0.8860	0.9270	0.1529	0.0800
NUCLEAR SERVICE PUMP 2A	275.	300.	0.8500	0.9200	0.2230	0.1382
CONVENTIONAL SERVICE PUMP 2A	275.	300.	0.8500	0.9200	0.2230	0.1382
TOTAL					2.2380	1.1503

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

4160 VOLT BUS E3 LOADS, 2XLOCA CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CORE SPRAY PUMP 2A	1060.	1250.	0.9000	0.9400	0.8412	0.4074
RHR SERVICE WATER PUMP 2A	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 1A	1000.	1000.	0.9000	0.9350	0.7979	0.3864
RHR SERVICE WATER PUMP 1A	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 2A	1000.	1000.	0.9000	0.9350	0.7979	0.3864
CONTROL ROD DRIVE HYD. PUMP	190.	250.	0.8860	0.9270	0.1529	0.0800
NUCLEAR SERVICE PUMP 2A	275.	300.	0.8500	0.9200	0.2230	0.1382
CONVENTIONAL SERVICE PUMP 2A	275.	300.	0.8500	0.9200	0.2230	0.1382
TOTAL					3.0358	1.5367

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

4160 VOLT BUS E4 LOADS, FULL LOAD CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CORE SPRAY PUMP 2B	0.	1250.	0.9000	0.9400	0.	0.
RHR SERVICE WATER PUMP 2B	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 1B	0.	1000.	0.9000	0.9350	0.	0.
RHR SERVICE WATER PUMP 1B	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 2B	0.	1000.	0.9000	0.9350	0.	0.
CONTROL ROD DRIVE HYD. PUMP	0.	250.	0.8860	0.9270	0.	0.
NUCLEAR SERVICE PUMP 2B	0.	300.	0.8500	0.9200	0.	0.
CONVENTIONAL SERVICE PUMP 2B	275.	300.	0.8500	0.9200	0.2230	0.1382
CONVENTIONAL SERVICE PUMP 1A	275.	300.	0.8500	0.9200	0.2230	0.1382
FIRE PUMP	190.	250.	0.8890	0.9200	0.1541	0.0794
TOTAL					0.6000	0.3557

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

4160 VOLT BUS E4 LOADS, UAT LIGHT LOAD CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CORE SPRAY PUMP 2B	0.	1250.	0.9000	0.9400	0.	0.
RHR SERVICE WATER PUMP 2B	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 1B	0.	1000.	0.9000	0.9350	0.	0.
RHR SERVICE WATER PUMP 1B	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 2B	0.	1000.	0.9000	0.9350	0.	0.
CONTROL ROD DRIVE HYD. PUMP	0.	250.	0.8860	0.9270	0.	0.
NUCLEAR SERVICE PUMP 2B	0.	300.	0.8500	0.9200	0.	0.
CONVENTIONAL SERVICE PUMP 2B	275.	300.	0.8500	0.9200	0.2230	0.1382
CONVENTIONAL SERVICE PUMP 1A	275.	300.	0.8500	0.9200	0.2230	0.1382
FIRE PUMP	0.	250.	0.8890	0.9200	0.	0.
TOTAL					0.4460	0.2764

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

4160 VOLT BUS E4 LOADS, LOCA CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CORE SPRAY PUMP 2B	1060.	1250.	0.9000	0.9400	0.8412	0.4074
RHR SERVICE WATER PUMP 2B	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 1B	0.	1000.	0.9000	0.9350	0.	0.
RHR SERVICE WATER PUMP 1B	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 2B	1000.	1000.	0.9000	0.9350	0.7979	0.3864
CONTROL ROD DRIVE HYD. PUMP	190.	250.	0.8860	0.9270	0.1529	0.0800
NUCLEAR SERVICE PUMP 2B	275.	300.	0.8500	0.9200	0.2230	0.1382
CONVENTIONAL SERVICE PUMP 2B	275.	300.	0.8500	0.9200	0.2230	0.1382
CONVENTIONAL SERVICE PUMP 1A	275.	300.	0.8500	0.9200	0.2230	0.1382
FIRE PUMP	190.	250.	0.8890	0.9200	0.1541	0.0794
TOTAL					2.6150	1.3678

MOTOR LIST

CP&L BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 2

VOLTAGE DROP STUDY

4160 VOLT BUS E4 LOADS, 2XLOCA CONDITION

MOTOR	BRAKE HP	RATED HP	POWER FACTOR	EFF	MW	MVAR
CORE SPRAY PUMP 2B	1060.	1250.	0.9000	0.9400	0.8412	0.4074
RHR SERVICE WATER PUMP 2B	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 1B	1000.	1000.	0.9000	0.9350	0.7979	0.3864
RHR SERVICE WATER PUMP 1B	0.	800.	0.9000	0.9350	0.	0.
RHR PUMP 2B	1000.	1000.	0.9000	0.9350	0.7979	0.3864
CONTROL ROD DRIVE HYD. PUMP	190.	250.	0.8860	0.9270	0.1529	0.0800
NUCLEAR SERVICE PUMP 2B	275.	300.	0.8500	0.9200	0.2230	0.1382
CONVENTIONAL SERVICE PUMP 2B	275.	300.	0.8500	0.9200	0.2230	0.1382
CONVENTIONAL SERVICE PUMP 1A	275.	300.	0.8500	0.9200	0.2230	0.1382
FIRE PUMP	190.	250.	0.8890	0.9200	0.1541	0.0794
TOTAL					3.4129	1.7542

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION E7, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2XA	36.19	0.0290	0.0246	0.0153
2XC	85.63	0.0685	0.0582	0.0361
2XE	193.45	0.1548	0.1315	0.0815
2XG	503.67	0.4029	0.3425	0.2123
2XL	159.42	0.1275	0.1084	0.0672
1XA-2	25.63	0.0205	0.0174	0.0108
1XJ	81.67	0.0653	0.0555	0.0344
2CA	408.70	0.3270	0.2779	0.1722
2PA	243.65	0.19[illegible]9	0.1657	0.1027
DGC	150.92	0.1207	0.1026	0.0636
2A	75.00	0.0600	0.0510	0.0316
TOTAL	1964.	1.5711	1.3355	0.8277

Note:

Load MVA is given based on horsepower times load factor expressed in P. U. on 100 MVA base.

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION E7, SCWP 2A START, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2XA	36.19	0.0290	0.0246	0.0153
2XC	85.63	0.0685	0.0582	0.0361
2XE	193.45	0.1548	0.1315	0.0815
2XG	503.67	0.4029	0.3425	0.2123
2XL	159.42	0.1275	0.1084	0.0672
1XA-2	25.63	0.0205	0.0174	0.0108
1XJ	61.67	0.0653	0.0555	0.0344
2CA	408.70	0.3270	0.2779	0.1722
DGC	150.92	0.1207	0.1026	0.0636
2A	75.00	0.0600	0.0510	0.0316
TOTAL	1720.	1.3762	1.1698	0.7250

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION E7, SHUTDOWN CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2XA	14.50	0.0116	0.0099	0.0061
2XC	81.55	0.0652	0.0555	0.0344
2XE	155.50	0.1244	0.1057	0.0655
2XG	503.50	0.4028	0.3424	0.2122
2XL	153.55	0.1228	0.1044	0.0647
1XA-2	0.	0.	0.	0.
1XJ	41.50	0.0332	0.0282	0.0175
2CA	264.45	0.2116	0.1798	0.1114
2PA	43.00	0.0344	0.0292	0.0181
DGC	94.00	0.0752	0.0639	0.0396
2A	75.00	0.0600	0.0510	0.0316
TOTAL	1427.	1.1412	0.9701	0.6012

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION E7, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2XA	36.19	0.0362	0.0308	0.0191
2XC	36.78	0.0368	0.0313	0.0194
2XE	158.45	0.1585	0.1347	0.0835
2XG	122.17	0.1222	0.1038	0.0644
2XL	23.97	0.0240	0.0204	0.0126
1XA-2	25.63	0.0256	0.0218	0.0135
1XJ	1.67	0.0017	0.0014	0.0009
2CA	408.70	0.4087	0.3474	0.2153
2PA	43.40	0.0434	0.0369	0.0229
DGC	217.42	0.2174	0.1848	0.1145
2A	75.00	0.0750	0.0638	0.0395
TOTAL	1149.	1.1494	0.9770	0.6055

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION E7, RBCCWP 2A AND 2C START, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2XA	36.19	0.0362	0.0308	0.0191
2XC	36.78	0.0368	0.0313	0.0194
2XG	122.17	0.1222	0.1038	0.0644
2XL	23.97	0.0240	0.0204	0.0126
1XA-2	25.63	0.0256	0.0218	0.0135
1XJ	1.67	0.0017	0.0014	0.0009
2CA	408.70	0.4087	0.3474	0.2153
2PA	43.40	0.0434	0.0369	0.0229
DGC	217.42	0.2174	0.1848	0.1145
2A	75.00	0.0750	0.0638	0.0395
TOTAL	991.	0.9909	0.8423	0.5220

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2E, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2TA	116.41	0.0931	0.0792	0.0491
2TB	149.75	0.1198	0.1018	0.0631
2TC	225.67	0.1805	0.1535	0.0951
2TF	250.69	0.2006	0.1705	0.1056
2TJ	292.49	0.2340	0.1989	0.1233
2TK	362.69	0.2902	0.2466	0.1528
2TL	280.89	0.2247	0.1910	0.1184
2ETB	75.00	0.0600	0.0510	0.0316
TOTAL	1754.	1.4029	1.1924	0.7390

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2E, TBCCWP 2A START, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2TA	116.41	0.0931	0.0792	0.0491
2TB	149.75	0.1198	0.1018	0.0631
2TC	225.67	0.1805	0.1535	0.0951
2TF	250.69	0.2006	0.1705	0.1056
2TK	362.69	0.2902	0.2466	0.1528
2TL	280.89	0.2247	0.1910	0.1184
2ETB	75.00	0.0600	0.0510	0.0316
TOTAL	1461.	1.1689	0.9935	0.6157

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2E, SHUTDOWN CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2TA	57.63	0.0461	0.0392	0.0243
2TB	69.50	0.0556	0.0473	0.0293
2TC	179.50	0.1436	0.1221	0.0756
2TF	72.00	0.0576	0.0490	0.0303
2TJ	29.50	0.0236	0.0201	0.0124
2TK	284.50	0.2276	0.1935	0.1199
2TL	274.50	0.2196	0.1867	0.1157
2ETB	75.00	0.0600	0.0510	0.0316
TOTAL	1042.	0.8337	0.7086	0.4392

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2E, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2TA	116.41	0.1164	0.0989	0.0613
2TB	149.75	0.1498	0.1273	0.0789
2TC	225.67	0.2257	0.1918	0.1189
2TF	250.69	0.2507	0.2131	0.1321
2TJ	292.49	0.2925	0.2486	0.1541
2TK	362.69	0.3627	0.3083	0.1911
2TL	280.89	0.2809	0.2388	0.1480
2ETB	75.00	0.0750	0.0638	0.0395
TOTAL	1754.	1.7536	1.4906	0.9238

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2F, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2TD	256.51	0.2052	0.1744	0.1081
2TE	325.94	0.2608	0.2216	0.1374
2TG	546.94	0.4376	0.3719	0.2305
2TH	335.98	0.2688	0.2285	0.1416
2TM	228.32	0.1827	0.1553	0.0962
2TN	59.70	0.0478	0.0406	0.0252
2FTB	75.00	0.0600	0.0510	0.0316
TOTAL	1828.	1.4627	1.2433	0.7705

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2F, TBCCWP 2B START, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2TD	256.51	0.2052	0.1744	0.1081
2TE	325.94	0.2608	0.2216	0.1374
2TG	546.94	0.4376	0.3719	0.2305
2TM	228.32	0.1827	0.1553	0.0962
2TN	59.70	0.0478	0.0406	0.0252
2FTB	75.00	0.0600	0.0510	0.0316
TOTAL	1492.	1.1939	1.0148	0.6289

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2F, SHUTDOWN CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2TD	90.50	0.0724	0.0615	0.0381
2TE	29.88	0.0239	0.0203	0.0126
2TG	344.50	0.2756	0.2343	0.1452
2TH	129.50	0.1036	0.0881	0.0546
2TM	4.50	0.0036	0.0031	0.0019
2TN	67.00	0.0536	0.0456	0.0282
2FTB	75.00	0.0600	0.0510	0.0316
TOTAL	741.	0.5927	0.5038	0.3122

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2F, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2TD	256.51	0.2565	0.2180	0.1351
2TE	325.94	0.3259	0.2770	0.1717
2TG	546.94	0.5469	0.4649	0.2881
2TH	335.98	0.3360	0.2856	0.1770
2TM	228.32	0.2283	0.1941	0.1203
2TN	59.70	0.0597	0.0507	0.0314
2FTB	75.00	0.0750	0.0638	0.0395
TOTAL	1828.	1.8284	1.5541	0.9632

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION E8, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2XB	45.54	0.0364	0.0310	0.0192
2XD	81.13	0.0649	0.0552	0.0342
2XF	164.33	0.1315	0.1117	0.0693
2XH	508.50	0.4068	0.3458	0.2143
2XM	120.97	0.0968	0.0823	0.0510
1XB-2	25.63	0.0205	0.0174	0.0108
1XK	81.67	0.0653	0.0555	0.0344
2PB	271.50	0.2172	0.1846	0.1144
2CB	396.90	0.3175	0.2699	0.1673
DGD	151.92	0.1215	0.1033	0.0640
E11	70.67	0.0565	0.0481	0.0298
E12	31.64	0.0253	0.0215	0.0133
2B	75.00	0.0600	0.0510	0.0316
TOTAL	2025.	1.6203	1.3773	0.8536

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION E8, SCWP 2B START, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2XB	45.54	0.0364	0.0310	0.0192
2XD	81.13	0.0649	0.0552	0.0342
2XF	164.33	0.1315	0.1117	0.0693
2XH	508.50	0.4068	0.3458	0.2143
2XM	120.97	0.0968	0.0823	0.0510
1XB-2	25.63	0.0205	0.0174	0.0108
1XK	81.67	0.0653	0.0555	0.0344
2CB	396.90	0.3175	0.2699	0.1673
DGD	151.92	0.1215	0.1033	0.0640
E11	70.67	0.0565	0.0481	0.0298
E12	31.64	0.0253	0.0215	0.0133
2B	75.00	0.0600	0.0510	0.0316
TOTAL	1754.	1.4031	1.1927	0.7[illegible]91

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION E8, SHUTDOWN CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2XB	24.50	0.0196	0.0167	0.0103
2XD	75.30	0.0602	0.0512	0.0317
2XF	163.00	0.1304	0.1108	0.0687
2XH	522.50	0.4180	0.3553	0.2202
2XM	125.65	0.1005	0.0854	0.0530
1XB-2	0.	0.	0.	0.
1XK	81.50	0.0652	0.0554	0.0343
2PB	71.00	0.0568	0.0483	0.0299
2CB	265.40	0.2123	0.1805	0.1118
DGD	93.67	0.0749	0.0637	0.0395
E11	70.67	0.0565	0.0481	0.0298
E12	31.64	0.0253	0.0215	0.0133
2B	75.00	0.0600	0.0510	0.0316
TOTAL	1600.	1.2799	1.0879	0.6742

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION EB, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2XB	45.54	0.0455	0.0387	0.0240
2XD	37.73	0.0377	0.0321	0.0199
2XF	179.33	0.1793	0.1524	0.0945
2XH	138.50	0.1385	0.1177	0.0730
2XM	15.97	0.0160	0.0136	0.0084
1XB-2	25.63	0.0256	0.0218	0.0135
1XK	1.67	0.0017	0.0014	0.0009
2PB	71.25	0.0713	0.0606	0.0375
2CB	396.90	0.3969	0.3374	0.2091
DGD	238.92	0.2389	0.2031	0.1259
E11	70.67	0.0707	0.0601	0.0372
E12	31.64	0.0316	0.0269	0.0167
2B	75.00	0.0750	0.0638	0.0395
TOTAL	1329.	1.3288	1.1294	0.7000

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION E8, RBCCWP 2B START, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
2XB	45.54	0.0455	0.0387	0.0240
2XD	37.73	0.0377	0.0321	0.0199
2XH	138.50	0.1385	0.1177	0.0730
2XM	15.97	0.0160	0.0136	0.0084
1XB-2	25.63	0.0256	0.0218	0.0135
1XK	1.67	0.0017	0.0014	0.0009
2PB	71.25	0.0713	0.0606	0.0375
2CB	396.90	0.3969	0.3374	0.2091
DGD	238.92	0.2389	0.2031	0.1259
E11	70.67	0.0707	0.0601	0.0372
E12	31.64	0.0316	0.0269	0.0167
2B	75.00	0.0750	0.0638	0.0395
TOTAL	1149.	1.1494	0.9770	0.6055

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2SY, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
SYB	227.96	0.1824	0.1550	0.0961
TOTAL	228.	0.1824	0.1550	0.0961

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2SY, SHUTDOWN CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
SYB	217.96	0.1744	0.1482	0.0919
TOTAL	218.	0.1744	0.1482	0.0919

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 25Y, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
SYB	227.96	0.2280	0.1938	0.1201
TOTAL	228.	0.2280	0.1938	0.1201

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION COMMON D, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
RWB	267.36	0.2139	0.1818	0.1127
RWD	209.33	0.1675	0.1423	0.0882
2SA	77.90	0.0623	0.0530	0.0328
CRANE	65.00	0.0520	0.0442	0.0274
TOTAL	620.	0.4957	0.4213	0.2611

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION COMMON D, BACKWASH AIR BLR START, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
RWD	209.33	0.1675	0.1423	0.0882
2SA	77.90	0.0623	0.0530	0.0328
CRANE	65.00	0.0520	0.0442	0.0274
TOTAL	352.	0.2818	0.2395	0.1484

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION COMMON D, SHUTDOWN CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
RWB	80.28	0.0642	0.0546	0.0338
RWD	132.80	0.1062	0.0903	0.0560
2SA	65.50	0.0524	0.0445	0.0276
CRANE	65.00	0.0520	0.0442	0.0274
TOTAL	344.	0.2749	0.2336	0.1448

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION COMMON D, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.85.

MCC	HORSEPOWER	MVA	MW	MVAR
RWB	267.36	0.2674	0.2273	0.1408
RWD	209.33	0.2093	0.1779	0.1103
2SA	77.90	0.0779	0.0662	0.0410
CRANE	65.00	0.0650	0.0553	0.0342
TOTAL	620.	0.6196	0.5267	0.3264

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2L, FULL LOAD AND SHUTDOWN CONDITIONS

LOAD FACTOR = 0.80 POWER FACTOR = 1.00.

MCC	HORSEPOWER	MVA	MW	MVAR
2A	138.62	0.1109	0.1109	0.
2B	169.08	0.1353	0.1353	0.
2D	132.25	0.1058	0.1058	0.
TOTAL	440.	0.3520	0.3520	0.

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 2L, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 1.00.

MCC	HORSEPOWER	MVA	MW	MVAR
2A	138.62	0.1386	0.1386	0.
2B	169.08	0.1691	0.1691	0.
2D	132.25	0.1323	0.1323	0.
TOTAL	440.	0.4400	0.4400	0.

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 4L, FULL LOAD AND SHUTDOWN CONDITIONS

LOAD FACTOR = 0.80 POWER FACTOR = 0.90.

MCC	HORSEPOWER	MVA	MW	MVAR
HR8	89.00	0.0712	0.0641	0.0310
201	35.29	0.0282	0.0254	0.0123
202	18.95	0.0152	0.0136	0.0066
203	2.71	0.0022	0.0020	0.0009
204	7.50	0.0060	0.0054	0.0026
252	16.02	0.0128	0.0115	0.0056
SBA	220.42	0.1763	0.1587	0.0769
TOTAL	390.	0.3119	0.2807	0.1360

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 4L, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.90.

MCC	HORSEPOWER	MVA	MW	MVAR
HR8	89.00	0.0890	0.0801	0.0388
201	35.29	0.0353	0.0318	0.0154
202	18.95	0.0190	0.0171	0.0083
203	2.71	0.0027	0.0024	0.0012
204	7.50	0.0075	0.0068	0.0033
2S2	16.02	0.0160	0.0144	0.0070
SBA	220.42	0.2204	0.1984	0.0961
TOTAL	390.	0.3899	0.3509	0.1699

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION COMMON C, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR = 0.85

MCC	HORSEPOWER	MVA	MW	MVAR
RWA	283.54	0.2268	0.1928	0.1195
RWC	251.73	0.2014	0.1712	0.1061
BHA	615.65	0.4925	0.4186	0.2595
WTA	621.77	0.4974	0.4228	0.2620
1SA	77.90	0.0623	0.0530	0.0328
TOTAL	1851.	1.4805	1.2584	0.7799

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION COMMON C, LOCA CONDITION

LOAD FACTOR - 1.00 POWER FACTOR - 0.85

MCC	HORSEPOWER	MVA	MW	MVAR
RWA	283.54	0.2835	0.2410	0.1494
RWC	251.73	0.2517	0.2140	0.1326
BHA	615.65	0.6157	0.5233	0.3243
WTA	621.77	0.6218	0.5285	0.3275
1SA	77.90	0.0779	0.0662	0.0410
TOTAL	1851.	1.8506	1.5730	0.9749

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 1SY, FULL LOAD CONDITION

LOAD FACTOR = 0.80 POWER FACTOR - 0.85

MCC	HORSEPOWER	MVA	MW	MVAR
SYA	295.89	0.2367	0.2012	0.1247
TOTAL	296.	0.2367	0.2012	0.1247

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 1SY, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.85

MCC	HORSEPOWER	MVA	MW	MVAR
SYA	295.89	0.2959	0.2515	0.1559
TOTAL	296.	0.2959	0.2515	0.1559

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 1L, FULL LOAD AND SHUTDOWN CONDITIONS

LOAD FACTOR = 0.80 POWER FACTOR = 1.00

MCC	HORSEPOWER	MVA	MW	MVAR
1A	112.48	0.0900	0.0900	0
1B	161.64	0.1293	0.1293	0
1D	126.51	0.1012	0.1012	0
TOTAL	401.	0.3205	0.3205	0

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 1L, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 1.00

MCC	HORSEPOWER	MVA	MW	MVAR
1A	112.48	0.1125	0.1125	0
1B	161.64	0.1616	0.1616	0
1D	126.51	0.1265	0.1265	0
TOTAL	401.	0.4006	0.4006	0

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 3L, FULL LOAD AND SHUTDOWN CONDITIONS

LOAD FACTOR = 0.80 POWER FACTOR - 0.90

MCC	HORSEPOWER	MVA	MW	MVAR
WHA	222.00	0.1776	0.1598	0.0774
1W1	24.38	0.0195	0.0176	0.0085
1W2	28.77	0.0230	0.0207	0.0100
1W2-1	5.60	0.0045	0.0040	0.0020
1W3	30.00	0.0240	0.0216	0.0105
PNLC	159.34	0.1275	0.1147	0.0556
TOTAL	470.	0.3761	0.3385	0.1639

CAROLINA POWER AND LIGHT COMPANY, BRUNSWICK STEAM ELECTRIC PLANT

UNITS NOS. 1 AND 2, 480 VOLT LOAD STUDY

UNIT SUBSTATION 3L, LOCA CONDITION

LOAD FACTOR = 1.00 POWER FACTOR = 0.90

MCC	HORSEPOWER	MVA	MW	MVAR
WHA	222.00	0.2220	0.1998	0.0968
1W1	24.38	0.0244	0.0219	0.0106
1W2	28.77	0.0288	0.0259	0.0125
1W2-1	5.60	0.0056	0.0050	0.0024
1W3	30.00	0.0300	0.0270	0.0131
PNLC	159.34	0.1593	0.1434	0.0695
TOTAL	470.	0.4701	0.4231	0.2049

CALLAWAY PLANT
UNITS 1 and 2

ENVIRONMENTAL BASELINE INVENTORY

ANNUAL SUMMARY

UNION ELECTRIC COMPANY

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1. INTRODUCTION

This report summarizes results of a 1-year ecological baseline survey of the site of the Union Electric Company Callaway Plant, Units 1 and 2, Callaway County, Missouri.

Part of the data contained in this report was used to prepare chapters of the Union Electric Company's Environmental Report. The remainder is reported here for the first time. These data give a quantitative and qualitative overview of plant site biotic and abiotic seasonal variation; the data have been extensively summarized for the convenience of the reader.

The report consists of two major parts, Aquatic Ecology and Terrestrial Ecology. Each is an entity, with its own introduction, arrangement, supplemental data, summary, and conclusion. The subsections are the standard divisions found in most environmental reports, with the possible exception of the last. In this subsection, Conclusion and Recommendation, an attempt is made to relate survey data to potential environmental impact from plant construction and operation. Tables and figures are placed in the text following the three-digit subsection in which they are mentioned. There are appendices to both the aquatic and terrestrial parts of this report.

2. AQUATIC ECOLOGY

2.1 INTRODUCTION

This report presents results of the aquatic baseline survey of the proposed Callaway Nuclear Power Plant Site near Fulton, Missouri, for Union Electric Company. The study consisted of five sampling periods between April, 1973, and February, 1974. The purpose of our study was to establish the baseline characteristics of the aquatic ecosystems present in the study area. This baseline information will provide the basis for validating predictions regarding environmental impact anticipated to result from the construction and operation of the proposed nuclear project.

As outlined in the proposal dated 6 March 1973, the scope of this study is the description and delineation of the major components of the aquatic ecosystems within the immediate areas of the proposed plant. The specific components of each aquatic system considered in this investigation are:

- Phytoplankton
- Zooplankton
- Benthic Macroinvertebrates
- Vascular Hydrophytes
- Fish
- Water Quality.

Aquatic sampling stations were established on the Missouri River and on Logan Creek, a small tributary to the Missouri River. Locations and descriptions of the stations are discussed in Section 2.2.1 and are shown in Figure 2.2-1. Originally, six locations were sampled in the Missouri and one in Logan Creek. Following Sverdrup & Parcel's feasibility study evaluating alternate intake and discharge locations, five additional stations were established to accommodate potential alternatives. Samples from these stations were collected during September and December, 1973, and February, 1974. To minimize total project costs, however, laboratory analyses of the February samples were not performed for four of the extra stations (F-1, F-2, G-1, and G-2). Since only September and December samples were analyzed, the data from these extra stations are presented in the Appendix instead of the text. Information obtained from these stations are included in the fisheries section, however, because the limited numbers of fish collected from all stations would have made data interpretation extremely speculative.

The report is divided into four major subsections. Subsection 2.1 outlines the purpose and scope of the study and discusses format. Subsection 2.2 describes the sampling stations and the methods and materials utilized to analyze the various aquatic parameters. Subsection 2.3 contains the results and discussion of the sampling and a literature review, and Subsection 2.4 presents conclusions and recommendations. The Missouri River and Logan Creek data are treated and discussed separately. An ecological summary presented in Subsection 2.3.7 provides a description of the physical, chemical, and biological interrelationships of the two project area aquatic systems.

2.2 METHODS AND MATERIALS

2.2.1 DESCRIPTION OF SAMPLING LOCATIONS

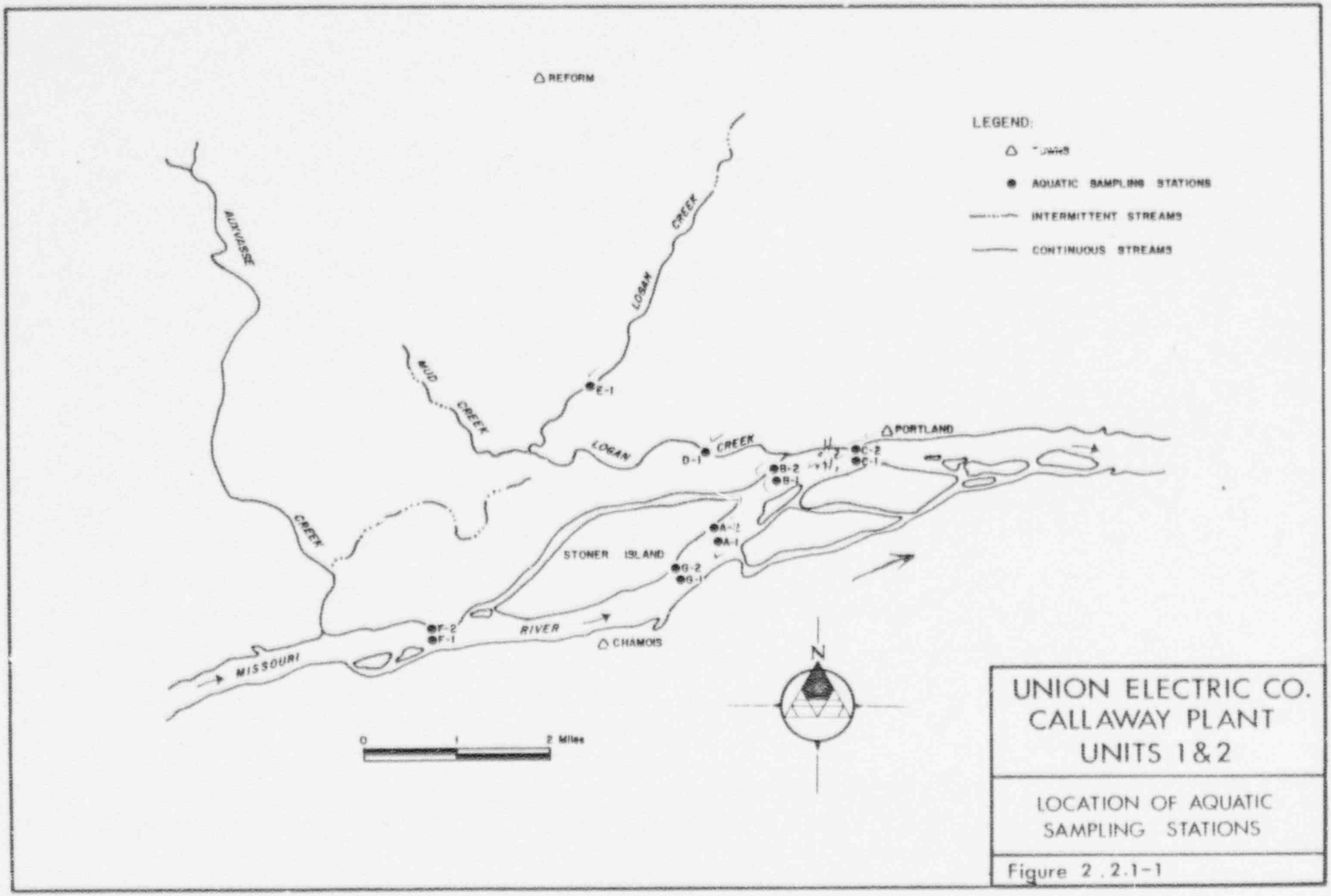
Two primary areas were selected for aquatic sampling: the Missouri River and Logan Creek, a tributary to the Missouri River. The stations were chosen to define the baseline conditions in the site vicinity; they are representative of the area that may be affected by the operation of the plant. The locations of the aquatic sampling stations are shown by Figure 2.2.1-1.

Five stations located in the main channel of the Missouri River (A-1, B-1, C-1, F-1, and G-1) were sampled for water quality, benthos, and plankton. Five stations located approximately 10 meters from the north bank of the Missouri River (A-2, B-2, C-2, F-2, and G-2) were sampled for larval fish, as well as for the parameters listed for the mid-channel stations. Two stations (A-1 and A-2) constituted a transect. Fish collection locations were largely determined by water level and flow rate; therefore, individual sampling stations were not delineated. Instead, fish were collected from each general transect area.

Transect A was located at River Mile 116. Transect B was located 0.4 miles east of Transect A at Mile 115.6. Transect C was immediately downstream from the confluence of Logan Creek and the Missouri River. It was marked by the opening between two groins adjacent to the mouth of Logan Creek. Transect G was approximately 0.5 miles west of Transect A on a line due north of the first groin east of the power plant at Chamois, Missouri. Transect F was the uppermost sampling area on the river and was marked by the confluence of a small, unnamed stream on the south side of the river, approximately 2.0 miles west of Transect G.

The substrate texture along Transects A, B, C, F, and G was characterized as sandy at the main channel stations. The shoreline stations along Transects A, B, and C were silty, while Stations F-2 and G-2 were sandy, with some small gravel.

Two aquatic sampling stations were established on Logan Creek (Figure 2.2.1-1). Station D-1 was marked by the Missouri Highway 94 bridge crossing. Station E-1 was located 0.9 miles upstream from the confluence of Mud Creek. The substrate of Logan Creek varied from rubble and coarse sand at Station E-1 to fine sand and silt at D-1. The banks along Logan Creek were well vegetated by willow, poplar, sycamore, and various shrubs. Near D-1, the creek had a wide bed and was typically slow moving. Fallen logs were numerous in the area and blocked the stream during periods of low flow. In the upper reaches, near E-1, the stream was typically free flowing, with many riffle areas and pools up to 5 feet in depth during normal flow.



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LOCATION OF AQUATIC SAMPLING STATIONS

Figure 2.2.1-1

2.2.2 WATER QUALITY

Water quality samples were collected from each station during April, July, September, and December, 1973, and February, 1974. Samples were collected 1 meter below the surface with a Van Dorn PVC water sampler and placed in polyethylene bottles containing a premeasured amount of preservative, as appropriate. Preservatives used were those recommended by the U.S. Environmental Protection Agency (1971). Samples for fecal and total coliform analyses were collected in sterilized glass bottles. Following collection, all samples were packed in ice for immediate transport to the laboratory. Field determinations were made for dissolved oxygen (YSI Model 54), conductivity (YSI Model 33), temperature (YSI Model 54), turbidity (Hach Model 2100A), and pH (Fisher Acumet).

At the laboratory, gas chromatography was used for pesticide analyses. Analytical techniques for all other physical and chemical parameters were taken from Standard Methods (A.P.H.A., 1971). Coliform bacteria were enumerated by the membrane filter technique.

2.2.3 PHYTOPLANKTON

Phytoplankton samples were collected at all river and creek stations during September and December, 1973, and February, 1974. All stations were sampled during July, 1973, except for river Stations F-1, F-2, G-1, and G-2. Duplicate quantitative plankton samples were collected from all river stations with a Clarke-Bumpus plankton sampler with a No. 20 mesh nylon net (aperture size 76 μ). Subsurface tows (≤0.25 meters deep) were made for 30 seconds against the direction of streamflow at each station parallel to the shoreline. Meter readings for calculating sample volumes were taken before and after each tow. Duplicate quantitative samples were obtained at Logan Creek stations by passing 40 liters of water through a Wisconsin plankton net (No. 20 mesh nylon). Sample concentrates from all stations were preserved in 5-percent buffered formalin solution for transport to the laboratory.

In the laboratory, phytoplankters were identified to the lowest possible taxon from wet mount slide preparations viewed at 1000X. Taxonomic source authorities for phytoplankton identifications were Palmer (1962), Prescott (1962, 1970), Smith (1950), Whitford and Schumacher (1969), and U.S. Department of the Interior (1966). Algal enumerations made from Sedgwick-Rafter preparations were scanned at 200X with a Whipple grid. Counts were extrapolated to organisms per liter.

Chlorophyll a, b, and c measurements were made by filtering whole water samples through membrane filters (0.45 μ porosity) and extracting the pigments in $MgCO_3$ saturated 90-percent aqueous acetone solution in the dark at 4°C. Determinations were made colorimetrically following procedures outlined in Standard Methods (A.P.H.A., 1971).

2.2.4 ZOOPLANKTON

Zooplankton composition and densities were determined for July, September, and December, 1973, and February, 1974. Population estimates for Missouri River stations were made from samples collected with a Clarke-Bumpus plankton sampler, as described in Section 2.2.3. Similarly, population estimates for Logan Creek stations were made from samples concentrated through a Wisconsin plankton net, as previously described.

In the laboratory, a 1-ml subsample from each sample was pipetted into a Sedgwick-Rafter counting chamber for analysis at 200X. Zooplankters were identified to the lowest possible taxon, following Ahlstrom (1940, 1943), Edmondson (1959), Pennak (1953), and Brooks (1957). Counts were extrapolated to organisms per liter.

2.2.5 VASCULAR HYDROPHYTES

Qualitative sampling of rooted aquatic vegetation included visual observations and identification to genus of all hydrophytes encountered in the field. Taxonomic sources consulted were Fassett (1972) and Prescott (1969).

2.2.6 BENTHIC MACROINVERTEBRATES

Triplicate grab samples were taken at each Missouri River station with a 520-cm^2 Ponar bottom sampler. Samples were screened in the field with a U.S. No. 30 standard sieve (0.59 mm). All material not passing through the sieve was washed into plastic bags and preserved in 10-percent buffered formalin solution containing a small amount of rose bengal to stain the biota.

In the laboratory, each sample was washed in a No. 30 sieve and placed in a white tray for sorting invertebrates from detritus. Worm and midge larvae were permanently mounted on glass slides for identification and enumeration. Other macroinvertebrates were preserved in 90-percent ethyl alcohol after analysis. Wet-weight biomass was determined for all species except chironomids and oligochaetes, which were weighed in their respective groups. Each species or group was blotted dry and immediately weighed to the nearest 0.1 mg in a tared dish. All samples were retained as legal voucher specimens. The following taxonomic references were used: Beck (1968), Brinkhurst (1964, 1965), Brown (1972), Burks (1953), Curry (1958), Eddy and Hodson (1961), Edmondson (1959), Hamilton, Saether and Oliver (1969), Hilsenhoff and Narf (1968), Hiltunen (1973), Holsinger (1972), Kennedy (1969), Mason (1973), Roback (1957), Ross (1944), Usinger and Day (1968), and Williams (1972).

Field and laboratory techniques for the Logan Creek macrobenthos were identical to those described for the Missouri River benthos, with the exception of the type of bottom sampler used. A standard 230-cm^2 Ekman dredge was employed at Stations D-1 and E-1 for benthos samples.

Species diversity was calculated according to the Shannon-Wiener Diversity Index. The general form for this index is:

$$D = -\Sigma p_i \log_2 p_i$$; where p_i is a decimal fraction of total individuals belonging to the i^{th} species.

This function describes the average degree of uncertainty of predicting the species of a given individual picked at random from a community. A high species diversity index is indicative of a quality environment while a low index indicates eutrophic or polluted conditions.

The following guide for interpreting species diversity indices was adopted from Wilhm and Dorris (1968):

1 = grossly polluted
2 = moderately polluted
3 = unpolluted

2.2.7 FISH

The fish community of the Missouri River was sampled in July, September, and December, 1973, by netting and electroshocking. Because the placement of nets and locations of shocking areas were largely determined by the water level and flow rate of the Missouri River, individual sampling stations were not established for fisheries studies. General transect areas were sampled instead. High water levels prevented sampling fish in the Missouri River during February, 1974.

Experimental gill nets, utilized along all transects, were rigged for bottom sets and checked every 12 hours for a maximum of 48 hours. These nets were 80 feet long and 6 feet deep with 10-foot long panels of graduated mesh sizes ranging from 0.5 to 40 inches. In September, standard wingless fyke nets (with 0.5-inch mesh and 3 x 6-foot openings) were utilized along some transects in conjunction with the gill nets.

The electroshocker was a Solid State Electro-Fisher manufactured by Power Control Corporation in Pittsburgh, Pennsylvania. The electrical specifications were as follows:

Input Power
240 volts AC, 50 cycle, single phase
Output Voltage
Adjustable 0 to 350 volts, DC, or 0 to 280 volts, AC
Pulse Frequency and Shape
Adjustable 18 CPS to 205 CPS
Rectangular Shape
Output Power
3 KW maximum
Pulse Width (Duty Cycle)
Adjustable 0 to 50 percent
Current Types
Selective for DC pulsing, DC direct, or AC 60 Cycle
Step-up Transformer
3-7 amps

The shocker was a portable unit, constructed of aluminum, and had an all solid state design. It was mounted on a 16-foot flat-bottomed boat powered by a 20-hp outboard motor.

In the field, captured fish were weighed to the nearest gram and measured to the nearest mm (total length: measured from tip of snout to end of compressed caudal fin). Scale samples were taken from all fish for age and growth studies. Stomachs were dissected from a representative sample of shocked fish for food habit analyses and preserved in 10-percent formalin. Specimens comprising the subsamples represented an age gradient of the most abundant species collected. In the laboratory, stomachs were opened and the contents washed into a dish for sorting and identification to the lowest taxon possible, following Edmondson (1959), Pennak (1953), and Usinger and Day (1968). Taxonomic references consulted for fish identification included Eddy (1969), Hubbs and Lagler (1967), Cross (1967), and Pflieger (1971).

Condition factor (K_{TL}) was computed for gizzard shad collected during the September and December Missouri River samplings. Condition factor describes the relative plumpness or well-being of a fish and is defined as:

$$K_{TL} = \frac{W \times 10^5}{L^3}$$

where:

K_{TL} = condition factor

W = weight (grams)

L = total length (mm).

Larval fish were sampled at all Missouri River stations during July, September, and December, 1973. A conical larval fish net, with a 2-foot diameter hoop and an 1/32-inch mesh size, was used.

The net was equipped with an interocean flow meter; this allows the quantity of water passing through the net to be measured. Duplicate 1-minute tows were made against the current at all river stations.

The fish community of Logan Creek was sampled in July, September, and December, 1973, and February, 1974. A battery-powered back-pack electroshocker delivering pulsed AC current was used during all sampling periods. A 50-foot minnow seine was also utilized during the July and September surveys. Field and laboratory techniques were similar to those described for Missouri River fish. Scale samples did not include the cyprinids.

No attempt was made to sample larval fish in Logan Creek; rather, observations of newly hatched fish were made at several locations along the stream bank.

2.2.8 STATISTICAL METHODS

2.2.8.1 Wilcoxan's Test

A statistical analysis of the water quality data was conducted utilizing Wilcoxan's test. Wilcoxan's test is utilized to evaluate two independent samples on the basis of the null hypothesis (Conover, 1971, Hollander and Wolfe, 1973, and Siegel, 1956). The null hypothesis is employed in instances where it is important to ascertain whether or not two independent samples are identical. Wilcoxan's test is used to rank the independent samples from smallest to largest, regardless of the population from which the samples originated. Statistical evaluation is then used to sum the assigned ranks for both samples. If the summation reveals no difference in the rank sums between the two independent samples, the null hypothesis (identical nature of the two independent samples) is proven. However, if there is a difference in the ranked sums, the null hypothesis must be rejected and the independent samples are proven to be significantly distinct. The statistical procedures follow:

1. If T is between $W\ \alpha/_2$ and $W_1\ \alpha/_2$ accept H_ϕ
2. Reject H_ϕ at the level of significance α, if T exceeds $W_1 - \alpha/_2$ or if T is less than $W\ \alpha/_2$ (after Conover, 1971)

H_ϕ = Null hypothesis

W_1 = Individual rank sum

T = Total rank sum

α = Level of significance

Statistically, Wilcoxan's test is a very powerful test, having a power efficiency of $3/\pi$ = 95.5 percent as the population increases

(Mood, 1954). The power efficiency remains close to 95 percent for moderate sample sizes (Conover, 1971).

2.2.8.1.1 Application to Water Quality Data

The water quality data was taken during five seasonal sampling periods from 6 distinct sampling transects, for 28 distinct chemical parameters. To test the null hypothesis applied to these samples, it was necessary to analyze the seasonal differences in the data. This was accomplished by comparing all samples for each individual water quality parameter taken during each sampling period with all samples taken during each other sampling period and comparing these data monthly by employing the following groups:

April - July	July - September	September - December
April - September	July - December	September - February
April - December	July - February	December - February
April - February		

The analysis was continued for the water quality parameters including: pH, turbidity, dissolved oxygen, chemical oxygen demand, total suspended solids, total dissolved solids, temperature, and conductivity. Two levels of significance were utilized: p=.005 indicated significant differences in the two sets of data compared and p=.025 indicated that the difference was insignificant. Using this method, 90 data set comparisons were conducted.

Wilcoxan's test was also used to test the null hypothesis for sample station variance. Data collected for each of 6 distinct sampling locations were analyzed for each water quality parameter previously mentioned. Specifically, the comparisons which were made included:

A_1 A_2	A_2 B_1	B_1 B_2	B_2 C_1	C_1 C_2
A_1 B_1	A_2 B_2	B_1 C_1	B_2 C_2	
A_1 B_2	A_2 C_1	B_1 C_2		
A_1 C_1	A_2 C_2			
A_1 C_2				

This analysis involved 135 separate subsets of the data base. The levels of significance used were p=.025 (insignificant difference). The power efficiency of Wilcoxan's test remains close to 95 percent for this analysis (Conover, 1971).

2.2.8.1.2 Application to Plankton Data

Phytoplankton and zooplankton populations were sampled at six Missouri River stations during July, September, and December, 1973, and February, 1974. Seasonal differences in the data were statistically analyzed to test the null hypothesis. Wilcoxan's two-sample test was used to test for differences between sampling dates in frequency of green algae, blue-green algae, diatoms, and total phytoplankton per liter and in frequency of rotifers, copepods, and total zooplankton per liter. Comparisons were made between the following sets of data:

July and September
July and December
July and February
September and December
September and February
December and February

Significant differences in two sets of data compared were indicated by $p \leq 0.025$, while $p > 0.025$ indicated differences were not significant.

2.2.8.2 Kruskal-Wallis Test

The Kruskal-Wallis one-way analysis of variance by ranks (Siegel, 1956) was employed to determine the overall station and seasonal variance in water quality data. The Kruskal-Wallis test is an analysis of variance which is employed in determining the ranking of the data from the lowest to the highest data point. This test ascertains whether the sums of the assigned ranks are sufficiently distinct to have come from samples drawn from separate populations. The Kruskal-Wallis test employs the null hypothesis as outlined in Wilcoxan's test covered previously.

The probability limits were extended and are listed along with the degrees of freedom (df) for the individual analysis. The null hypothesis was utilized to indicate whether there was a significant or insignificant variance within the subset of data analyzed. Nine different water quality parameters were tested using the Kruskal-Wallis analysis of variance. The power efficiency of this test approaches 95 percent for moderate population sizes; therefore, it is one of the most powerful of the nonparametric tests (Siegel, 1956).

2.3 RESULTS AND DISCUSSION

2.3.1 WATER QUALITY

2.3.1.1 Missouri River

Missouri River discharge data were obtained from the U.S.G.S. at Hermann, Missouri, approximately 20 river miles (R.M.) downstream from the project area. The following discharges were recorded on each sampling date: 18 April 1973 - 280,000 cfs; 12 July 1973 - 67,000 cfs; 7 September 1973 - 58,500 cfs; 18 December 1973 - 86,300 cfs; and 22 February 1974 - 136,000 cfs. The discharge in this section of the Missouri River is partly regulated by numerous upstream reservoirs. The 75-year average discharge at Hermann is 78,370 cfs. The maximum discharge of 676,000 cfs occurred in 1903, and the minimum of about 4,200 cfs was recorded in 1940 before flow control was initiated by the Corps of Engineers (U.S. Geological Survey, 1972).

The physical characteristics of the Missouri River near the project vicinity have been drastically altered by channelization (Figure 2.3.1-1). The Federal River and Harbor Act of March 2, 1945, authorized the River and Harbor Project to improve the Missouri River's navigation and channel stabilization from Sioux City, Iowa, to its mouth. The project provides for development of one mixed navigable channel, 300 feet wide and 9 feet deep, from the numerous, small, shallow channels of the natural river. The refinement and control of this channel were obtained by shaping the flow into smooth, easy bends through a system of stone and/or wood pile clump dikes (University of Missouri-Rolla, 1972).

Rapid changes in its erosional and depositional properties may vary the river's morphological characteristics. Substrate texture in particular areas may also be changed by alternating erosional and depositional effects. Generally, the texture of the main channel sediments near the site area varies from gravel to sand. Shorelines, where currents are much reduced, usually have a silt-clay (mud) bottom. Shifting sand bars are quite common to the area.

Depth profiles of sampling transects are shown by Figure 2.3.1-1. Soundings were taken by the Crops of Engineers during October 17 and 18, 1972, when the gage reading at Hermann was 9.2, with a discharge of 62,000 cubic feet per second (cfs) (U.S. Dept. of the Army, Corps of Engineers, 1972a). At this river stage, the maximum river channel depth is approximately 30 feet.

Water quality data from Transects A, B, and C for five sampling periods are presented in Table 2.3.1-1. These recent data from near the site generally correspond to historical records from Hermann (Table 2.3.1-2).

The April, 1973, water quality data significantly exceed the recorded maximum historical values for chemical oxygen demand (COD), turbidity, total dissolved solids (TDS), and total iron. These data were collected and analyzed during a near-record flood, when runoff was extremely high, which would account for their unusually high values. Normally, TDS values would be expected to decrease during flood conditions. But whenever, as during the April survey, the discharge suddenly increases, the first water is usually more highly mineralized than the dilute runoff water. Also, increased concentrations of TDS occur when this first water picks up salt left by evaporation in the channel (Hem, 1959).

The pH values did fall below the state water quality standard of 6.5 (Missouri Clean Water Commission, 1973) at Station A-1 during April, 1973. All stations exhibited low pH readings during this time. These low pH values were probably the result of acid mine runoff above the site area. Extended periods of low pH could be detrimental to aquatic biota.

The only other parameter found to exceed the state water quality standards was fecal coliform bacteria. The standard of 2,000/100 ml (Missouri Clean Water Commission, 1973) was exceeded at Stations A-1, B-1, B-2, and C-1 during the April survey, all six stations during the July collections, Station C-2 during the September survey, and all six stations during the December survey. Fecal coliform bacteria are indicators of relatively recent fecal pollution.

Of all the heavy metals analyzed (historically and during the present survey), only copper and cadmium were found in concentrations that may be toxic to aquatic organisms. The usual range for copper toxicity is from several hundred to a thousand parts-per-billion (ppb); toxic effects have, however, been noted as low as 20 ppb and cadmium has been found to be toxic at 10 ppb (Battelle's Columbus Laboratories, 1971). The effect on the Missouri River biota depends on the duration of recorded high concentrations, as well as the presence of other stresses (toxic metals, temperature, dissolved oxygen, etc.).

Presumptive pesticide tests for total chlorinated hydrocarbons were run on the April water samples. Chlorinated pesticides were present, but only in low concentrations (19-31 μg/l). Analysis for specific pesticides were conducted on the July, September, and December samples, and all concentrations were below detectable limits. Acute biocide toxicity to aquatic organisms, therefore, does not appear to be a problem; chronic effects cannot presently be ruled out, however.

Nutrients such as phosphorus and nitrogen appear to be in sufficient concentrations to support dense populations of algae (see Section 2.3.2). The heavy silt load and associated reduced river system transparency appear to be a major factor limiting phytoplankton populations.

Discharge appears to be the major influence on Missouri River water quality. Turbidity and suspended solids were directly related to river discharge, while total dissolved solids and conductivity were inversely related (Figure 2.3.1-2). An exception to this relationship was noted during July, when laboratory analyses indicated that suspended solids increased and TDS decreased as discharge decreased. A comparison of these data with related turbidity and conductivity data indicated the laboratory analyses to be off by a factor of 2 (low for TDS and high for suspended solids). Therefore, these new projected values were utilized for comparative purposes.

From these discharge-related data, general water quality trends can be predicted. Soluble chemicals will normally vary inversely with the flow, while suspended materials will usually vary directly. Fluctuations in this trend depend on municipal and industrial effluent discharges, as well as the precipitation in the particular area from which runoff occurs. These conditions also determine the existing concentration of the chemical constituent at any particular point in time.

Dissolved oxygen and temperature are two related water quality parameters affecting aquatic organisms. Dissolved oxygen concentration was inversely proportional to temperature (Figure 2.3.1-3) but was also affected by biological activity and oxygen demanding materials. Compared to oxygen demanding materials and biota, percentage oxygen saturation (Figure 2.3.1-3) indicate low primary production. The figure shows an inverse relationship between oxygen saturation and chemical oxygen demand; lowest oxygen saturation occurred during April, when flooded conditions caused the highest oxygen demand.

Statistical analyses of major water quality parameters were conducted to determine seasonal or inter-station variations. As anticipated, the Kruskal-Wallis one-way analysis of variance indicated significant seasonal differences but not significant inter-station differences (Table 2.3.1-3).

Water quality values were then compared by Wilcoxan's two sample test to determine differences between specific stations (Table 2.3.1-4). The majority of the water quality parameters did not vary significantly at the .025 level; the following differences, however, were noted at the .005 level:

a) Total suspended solids from Station C-1 were significantly different from those at Stations A-1 and B-1.

b) Chemical Oxygen Demand values at C-2 differed from A-1.

c) Dissolved oxygen at C-2 differed from A-1.

d) Conductivity values at B-2 were different from values at C-1 and C-2.

It should be noted that all differences involved either Stations C-1 or C-2. These differences could be real, and water quality values at Transect C could be influenced somewhat by Logan Creek, or they may be the result of high variability and small sample size.

The direct and indirect activities of man have modified the Missouri River water quality. Strip-mining, poor soil conservation practices, and dredging contribute to excessive turbidities. Acid mine drainage lowers the river's pH and increases trace metal concentrations, while agricultural runoff and municipal and industrial effluents increase the concentration of oxygen-demanding materials, nutrients and other dissolved chemicals, including heavy metals and pesticides. Accidental spills of hazardous materials from pipeline breaks, truck accidents, and railway wrecks have been occurring with increased frequency within the Missouri River drainage system. Thus, numerous human activities have resulted in a highly stressed aquatic ecosystem. A more complete treatment of pre-existing environmental stresses can be found in Section 2.7 of the Environmental Report.

2.3.1.2 Logan Creek

Logan Creek is a small, perennial tributary stream of the Missouri River (see Figure 2.2.1-1). The upper portion drains most of the site area and flows in a southerly direction until it reaches the flood plain. From its confluence with Mud Creek, it proceeds eastward until it empties into the Missouri River at River Mile 115.2.

No gaging station is located on Logan Creek and, therefore, discharges have not been recorded. Flows are generally very low to non-existent, except for periods of local precipitation.

The banks along Logan Creek are well vegetated with willow, poplar, sycamore, and various shrubs. Fallen logs are numerous and serve to block the stream during periods of low flow.

The upper section has a normal width of approximately 18 feet, while the depth varies from 1-5 feet in pools. The bottom substrate consists of rocks and gravel. The lower portion is about 35 feet wide, with an average depth of 3-4 feet; however, depths of 20-25 feet were observed during the April survey. The bottom consists of fine mud and organic debris.

Historical water quality data for Logan Creek are lacking. Data from the present survey (Table 2.3.1-5) indicate that the general water quality is higher than that of the Missouri River; during local precipitation, however, various concentrations approach or exceed those of the Missouri.

Chemical concentrations in Logan Creek can be expected to follow the same general trends established for the Missouri River. They would be influenced to a much greater extent, however, during local precipitation. Chemical concentrations were less in the upper reaches of the creek (E-1) than in the lower section (D-1). The lower section is subjected to more runoff, which increases chemical concentrations. Coliform bacteria counts, however, are greater in the upper section, reflecting man's influence.

Low pH and dissolved oxygen values recorded for the lower section of the creek could adversely affect certain aquatic biota (see following sections). Pesticides and trace metals were not present in concentrations considered harmful to aquatic organisms.

TABLE 2.3.1-1

MISSOURI RIVER WATER QUALITY DATA

Parameter	Sample Date	Transect A A-1	A-2	Transect B B-1	B-2	Transect C C-1	C-2	Average
Temperature °C	April '73	13.0	13.0	12.0	12.0	11.0	11.0	12.0
	July '73	30.0	29.0	29.0	29.0	29.0	28.5	29.1
	Sept. '73	24.8	24.8	24.5	24.9	24.5	24.9	24.7
	Dec. '73	2.8	2.9	2.9	2.8	2.9	2.9	2.9
	Feb. '74	4.0	4.0	4.0	4.0	4.0	4.0	4.0
pH Standard Units	April '73	6.4	6.8	6.5	6.7	6.7	6.6	6.6
	July '73	8.3	8.3	8.2	8.3	8.3	8.3	8.3
	Sept. '73	7.9	8.0	8.0	8.0	8.1	8.0	8.0
	Dec. '73	7.9	7.9	7.9	7.9	7.9	7.9	7.9
	Feb. '74	7.5	7.4	7.3	7.5	7.3	7.2	7.4
Conductivity µmhos/cm	April '73	220	300	250	300	260	300	272
	July '73	575	575	500	550	500	575	546
	Sept. '73	700	700	625	700	600	700	671
	Dec. '73	490	490	480	500	400	440	467
	Feb. '74	330	360	260	370	260	345	321
Turbidity FTU	April '73	550	600	575	575	525	600	571
	July '73	210	215	215	210	215	100	194
	Sept. '73	22	16	18	19	17	19	19
	Dec. '73	43	42	41	42	40	40	41
	Feb. '74	125	160	120	140	50	130	121
Chloride mg/l	April '73	19	20	20	20	17	20	19
	July '73	21	22	19	22	17	30	22
	Sept. '73	27	26	21	26	22	26	25
	Dec. '73	26	29	24	28	28	28	27
	Feb. '74	19	24	15	25	14	22	20

TABLE 2.3.1-1 (Continued)

Parameter	Sample Date	Transect A A-1	A-2	Transect B B-1	B-2	Transect C C-1	C-2	Average
Nitrate mg/l N	April '73	3.0	4.5	4.3	3.3	2.5	3.8	3.6
	July '73	2.9	3.0	2.5	3.2	2.5	2.2	2.7
	Sept. '73	0.3	0.4	0.6	0.7	0.4	0.4	0.5
	Dec. '73	1.3	1.3	1.3	1.2	1.3	1.3	1.3
	Feb. '74	1.5	1.9	1.3	1.7	1.4	2.0	1.6
Organic Nitrogen mg/l	April '73	-	-	-	-	-	-	-
	July '73	3.6	3.2	3.2	3.9	2.5	1.4	3.0
	Sept. '73	0.7	0.7	0.6	0.6	0.6	0.6	0.6
	Dec. '73	0.9	0.9	1.0	1.1	0.9	0.8	0.9
	Feb. '74	1.2	1.4	1.3	1.4	1.3	1.8	1.4
Total Organic Carbon mg/l	April '73	44	62	39	44	48	113	58
	July '73	-	-	-	-	-	-	-
	Sept. '73	-	-	-	-	-	-	-
	Dec. '73	-	-	-	-	-	-	-
	Feb. '74	-	-	-	-	-	-	-
Orthophosphate mg/l P	April '73	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	July '73	0.01	0.06	0.01	0.01	0.01	0.01	<0.02
	Sept. '73	0.19	0.19	0.18	0.16	0.13	0.16	0.17
	Dec. '73	0.18	0.18	0.16	0.17	0.17	0.14	0.17
	Feb. '74	0.11	0.13	0.09	0.13	0.07	0.12	0.11
Total Phosphorus mg/l P	April '73	0.53	0.57	0.56	0.57	0.41	0.50	0.52
	July '73	0.69	0.66	0.66	0.69	0.65	0.33	0.61
	Sept. '73	0.24	0.22	0.21	0.19	0.17	0.18	0.20
	Dec. '73	0.27	0.28	0.26	0.25	0.25	0.21	0.25
	Feb. '74	0.19	0.23	0.15	0.23	0.15	0.23	0.20

TABLE 2.3.1-1 (Continued)

Parameter	Sample Date	Transect A A-1	A-2	Transect B B-1	B-2	Transect C C-1	C-2	Average
Dissolved Oxygen mg/l	April '73	8.2	8.0	7.5	7.2	7.1	7.7	7.6
	July '73	6.4	5.8	5.7	6.8	6.2	5.7	6.1
	Sept. '73	7.5	7.3	7.5	7.5	7.5	6.9	7.4
	Dec. '73	12.9	12.9	12.7	12.6	12.9	13.0	12.8
	Feb. '74	12.0	12.0	11.8	11.6	11.6	12.0	11.8
Chemical Oxygen Demand mg/l	April '73	102	82	94	123	94	82	96
	July '73	66	56	57	62	48	22	52
	Sept. '73	20	14	16	12	12	8	14
	Dec. '73	14	14	17	19	24	17	18
	Feb. '74	25	32	23	32	14	17	24
Total Suspended Solids mg/l	April '73	659	772	624	652	412	664	631
	July '73	912	760	860	850	776	238	733
	Sept. '73	128	124	118	107	92	32	100
	Dec. '73	133	125	140	101	128	91	120
	Feb. '74	196	234	144	208	90	204	179
Total Dissolved Solids mg/l	April '73	525	444	530	473	605	472	508
	July '73	306	232	288	280	248	292	274
	Sept. '73	506	530	540	519	450	518	511
	Dec. '73	414	482	528	538	484	544	498
	Feb. '74	472	530	414	514	384	458	462
Total Solids mg/l	April '73	1184	1216	1154	1125	1017	1136	1139
	July '73	1218	992	1148	1130	1024	530	1007
	Sept. '73	634	654	658	626	542	550	611
	Dec. '73	547	607	668	639	612	635	618
	Feb. '74	668	764	558	722	474	662	641

TABLE 2.3.1-1 (Continued)

Parameter	Sample Date	Transect A A-1	A-2	Transect B B-1	B-2	Transect C C-1	C-2	Average
Hardness mg/l $CaCO_3$	April '73	-	-	-	-	-	-	-
	July '73	-	-	-	-	-	-	-
	Sept. '73	235	228	217	229	200	226	223
	Dec. '73	246	246	234	240	232	237	239
	Feb. '74	186	208	160	214	162	198	188
Arsenic mg/l	April '73	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	July '73	0.012	0.009	0.014	0.008	0.010	0.008	0.010
	Sept. '73	0.004	0.004	0.004	0.006	0.004	0.005	0.005
	Dec. '73	0.002	0.003	0.003	0.003	0.002	0.002	0.003
	Feb. '74	0.002	0.003	0.002	0.003	0.002	0.003	0.003
Cadmium mg/l	April '73	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	July '73	0.006	0.005	0.005	0.007	0.005	0.006	0.006
	Sept. '73	0.006	0.008	0.003	0.003	0.001	<0.001	<0.004
	Dec. '73	0.008	0.001	0.001	0.002	0.002	0.006	0.003
	Feb. '74	0.027	0.014	0.015	0.016	0.015	0.018	0.018
Iron (total) mg/l	April '73	11.6	11.0	12.4	12.0	11.2	12.4	11.8
	July '73	5.4	5.5	0.1	5.6	0.9	3.1	3.4
	Sept. '73	1.4	1.3	1.4	1.3	1.3	0.7	1.2
	Dec. '73	2.4	1.4	1.3	2.0	1.3	1.3	1.6
	Feb. '74	2.5	2.5	1.1	1.6	1.1	1.7	1.8
Copper mg/l	April '73	<0.02	0.66[a]	<0.02	<0.02	<0.02	<0.02	<0.13
	July '73	0.029	0.027	0.028	0.029	0.031	0.016	0.027
	Sept. '73	0.021	0.012	0.013	0.012	0.007	0.004	0.012
	Dec. '73	0.003	0.002	0.004	0.003	0.003	0.004	0.003
	Feb. '74	0.017	0.019	0.014	0.019	0.018	0.020	0.018

TABLE 2.3.1-1 (Continued)

Parameter	Sample Date	Transect A A-1	A-2	Transect B B-1	B-2	Transect C C-1	C-2	Average
Lead mg/l	April '73	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	July '73	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Sept. '73	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	Dec. '73	0.01	0.02	0.01	0.05	0.03	0.03	0.03
	Feb. '74	0.02	<0.02	0.02	0.02	<0.02	<0.02	<0.02
Mercury µg/l	April '73	<0.5	<0.5	<0.5	<0.5	<0.5	5.5[a]	<1.3
	July '73	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Sept. '73	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
	Dec. '73	0.6	0.1	<0.1	<0.1	0.4	0.3	<0.3
	Feb. '74	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium mg/l	April '73	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	July '73	0.008	0.006	0.007	0.005	0.007	0.003	0.006
	Sept. '73	0.005	0.003	0.027	<0.003	0.006	<0.003	<0.008
	Dec. '73	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	Feb. '74	0.004	0.005	0.003	0.003	0.003	0.010	0.005
Selenium mg/l	April '73	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	July '73	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Sept. '73	0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001
	Dec. '73	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001
	Feb. '74	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sulfate mg/l	April '73	63	63	56	63	55	63	61
	July '73	184	178	168	192	153	139	169
	Sept. '73	165	161	172	161	113	161	156
	Dec. '73	96	90	90	93	85	88	89
	Feb. '74	73	89	57	96	61	85	77

TABLE 2.3.1-1 (Continued)

Parameter	Sample Date	Transect A A-1	Transect A A-2	Transect B B-1	Transect B B-2	Transect C C-1	Transect C C-2	Average
Hexane Solubles mg/l	April '73	5	10	12	10	21	13	12
	July '73	2	2	3	5	3	4	3
	Sept. '73	4	6	7	7	3	3	5
	Dec. '73	10	9	6	7	8	8	8
	Feb. '74	5	6	6	6	6	7	6
Fecal Coliforms number/100 ml	April '73	3000	2000	4000	7000	7000	2000	4167
	July '73	3600	5800	4100	9600	2500	2700	4717
	Sept. '73	800	1700	1900	1600	840	2100	1490
	Dec. '73	4200	3300	2200	8700	4400	3600	4400
	Feb. '74	980	1100	670	830	700	890	862
Total Coliforms number/100 ml	April '73	17,000	30,000	6000	8000	19,000	9000	14,800
	July '73	12,000	24,000	11,000	16,000	4100	21,000	14,700
	Sept. '73	21,000	18,000	12,000	24,000	3400	4100	13,800
	Dec. '73	8100	9400	9200	41,000	32,000	27,000	21,100
	Feb. '74	6800	7400	4300	1200	2600	2200	4100

[a]Possible Sample Contamination

TABLE 2.3.1-2

HISTORICAL DATA ON MISSOURI RIVER WATER QUALITY
(From EPA STORET System)

Sampling Site: Hermann, Missouri
Longitude: 38-42-36 N
Latitude: 91-26-21 W

Time of Record: 7/31/69 to 4/18/72
(Based on flow data)

Parameter	Number of Samples	Mean Value	Maximum Value	Minimum Value
Water Temperature, °C	18	12.9	27	0
Dissolved Oxygen, mg/l	18	8.9	13	5.6
Turbidity, JTU	11	132	380	19
Flow, cfs. entire	18	80,500	230,000	19,000
pH, units	18	7.9	8.3	7.7
Dissolved Solids, mg/l	18	375	499	253
Specific Conductance, micromhos/cm	18	577	770	359
Total Hardness, mg/l as $CaCO_3$	18	213	260	140
Calcium, mg/l	11	56	70	38
Magnesium, mg/l	11	17	21	11
Alkalinity, mg/l as $CaCO_3$	18	157	197	112
Ammonia Nitrogen, mg/l	18	0.06	0.49	0
Organic Nitrogen, mg/l	10	0.71	1.20	0.44
Total Phosphorous, mg/l	18	0.39	1.70	0.03
Chemical Oxygen Demand, mg/l	8	12.3	28	5.6
Sulfate, mg/l	18	120	186	56
Chloride, mg/l	12	16	25	8
Iron, μg/l	11	182	900	0
Cadmium, μg/l	11	1	5	0
Chromium, μg/l	11	3.2	16	0
Copper, μg/l	11	38.5	180	0
Lead, μg/l	10	7.3	15	0
Manganese, μg/l	15	31	221	0
Mercury, μg/l	1	0.5	0.5	0.5
Zinc, μg/l	11	67.4	210	14

TABLE 2.3.1-3

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE VALUES FOR DIFFERENCES AMONG STATIONS AND SEASONS IN WATER QUALITY PARAMETERS

	Station Variance[a]		Seasonal Variance[b]	
Water Quality Parameter	H Value	Significance[c]	H Value	Significance
pH	0.2799	ns	27.8408	*
Turbidity	0.3160	ns	27.1733	*
Temperature	0.0270	ns	27.8407	*
Conductivity	1.1932	ns	26.9677	*
Dissolved oxygen	0.3109	ns	27.6712	*
Chemical oxygen demand	1.4718	ns	23.5880	*
Total suspended solids	1.6885	ns	23.7195	*
Total dissolved solids	0.8887	ns	16.0878	*

[a]Tests for differences among stations for all sampling periods.

[b]Tests for seasonal differences in data from the same station.

[c]ns = nonsignificant, $p > 0.05$
* = significant

(All significant p values in these analyses were ≤ 0.001)

TABLE 2.3.1-4

WILCOXAN'S TWO SAMPLE TEST RESULTS FOR DIFFERENCES BETWEEN STATIONS IN WATER QUALITY PARAMETERS[a]

Stations Compared	pH	Turbidity	Temperature	Conductivity	Dissolved Oxygen	Chemical Oxygen Demand	Total Suspended Solids	Total Dissolved Solids
A1, A2	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025
A1, B1	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025
A1, B2	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025
A1, C1	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.005	p=.025
A1, C2	p=.025	p=.025	p=.025	p=.025	p=.005	p=.005	p=.025	p=.025
A2, B1	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025
A2, B2	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025
A2, C1	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025
A2, C2	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025
B1, B2	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025
B1, C1	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.005	p=.025
B1, C2	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025
B2, C1	p=.025	p=.025	p=.025	p=.005	p=.025	p=.025	p=.025	p=.025
B2, C2	p=.025	p=.025	p=.025	p=.005	p=.025	p=.005	p=.025	p=.025
C1, C2	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025	p=.025

[a]p=.005 is significant
p=.025 is nonsignificant

TABLE 2.3.1-5

LOGAN CREEK WATER QUALITY DATA

Parameter	Sample Date	Station D-1	Station E-1	Missouri River Average
Temperature °C	April '73	12.5	-	12.0
	July '73	27.2	23.5	29.1
	Sept. '73	21.5	21.0	24.7
	Dec. '73	2.0	0.9	2.9
	Feb. '74	5.0	5.5	4.0
pH Standard Units	April '73	6.3	-	6.6
	July '73	8.6	7.8	8.3
	Sept. '73	7.7	8.1	8.0
	Dec. '73	7.4	7.8	7.9
	Feb. '74	7.2	7.3	7.4
Conductivity µmhos/cm	April '73	296	-	272
	July '73	750	264	546
	Sept. '73	600	430	671
	Dec. '73	425	295	467
	Feb. '74	225	220	321
Turbidity FTU	April '73	220	-	571
	July '73	70	90	194
	Sept. '73	23	3	19
	Dec. '73	10	7	41
	Feb. '74	5	3	121
Chloride mg/l	April '73	17	-	19
	July '73	7	2	22
	Sept. '73	5	3	25
	Dec. '73	5	5	27
	Feb. '74	3	2	20

TABLE 2.3.1-5 (Continued)

Parameter	Sample Date	Station D-1	Station E-1	Missouri River Average
Nitrate mg/l N	April '73	5.3	-	3.6
	July '73	0.2	1.2	2.7
	Sept. '73	0.1	0.1	0.5
	Dec. '73	<0.1	0.6	1.3
	Feb. '74	0.5	0.3	1.6
Organic Nitrogen mg/l	April '73	-	-	-
	July '73	1.2	0.2	3.0
	Sept. '73	0.7	0.5	0.6
	Dec. '73	0.7	0.4	0.9
	Feb. '74	1.4	1.1	1.4
Total Organic Carbon mg/l	April '73	34	-	58
	July '73	-	-	-
	Sept. '73	-	-	-
	Dec. '73	-	-	-
	Feb. '74	-	-	-
Orthophosphate mg/l P	April '73	<0.01	-	<0.01
	July '73	0.06	0.01	<0.02
	Sept. '73	0.13	0.02	0.17
	Dec. '73	0.02	0.01	0.17
	Feb. '74	0.03	0.06	0.11
Total Phosphorus mg/l P	April '73	0.17	-	0.52
	July '73	0.15	0.02	0.61
	Sept. '73	0.23	0.05	0.20
	Dec. '73	0.12	0.10	0.25
	Feb. '74	0.12	0.06	0.20

TABLE 2.3.1-5 (Continued)

Parameter	Sample Date	Station D-1	Station E-1	Missouri River Average
Dissolved Oxygen mg/l	April '73	9.4	-	7.6
	July '73	5.6	5.8	6.1
	Sept. '73	3.4	6.4	7.4
	Dec. '73	9.8	10.2	12.8
	Feb. '74	11.8	12.3	11.8
Chemical Oxygen Demand mg/l	April '73	127	-	96
	July '73	22	4	52
	Sept. '73	20	8	14
	Dec. '73	8	5	18
	Feb. '74	32	23	24
Total Suspended Solids mg/l	April '73	384	-	631
	July '73	76	1	733
	Sept. '73	118	18	100
	Dec. '73	18	5	120
	Feb. '74	98	34	179
Total Dissolved Solids mg/l	April '73	117	-	508
	July '73	364	210	274
	Sept. '73	476	320	511
	Dec. '73	394	496	498
	Feb. '74	270	318	462
Total Solids mg/l	April '73	501	-	1139
	July '73	440	211	1007
	Sept. '73	594	338	611
	Dec. '73	412	501	618
	Feb. '74	368	352	641

TABLE 2.3.1-5 (Continued)

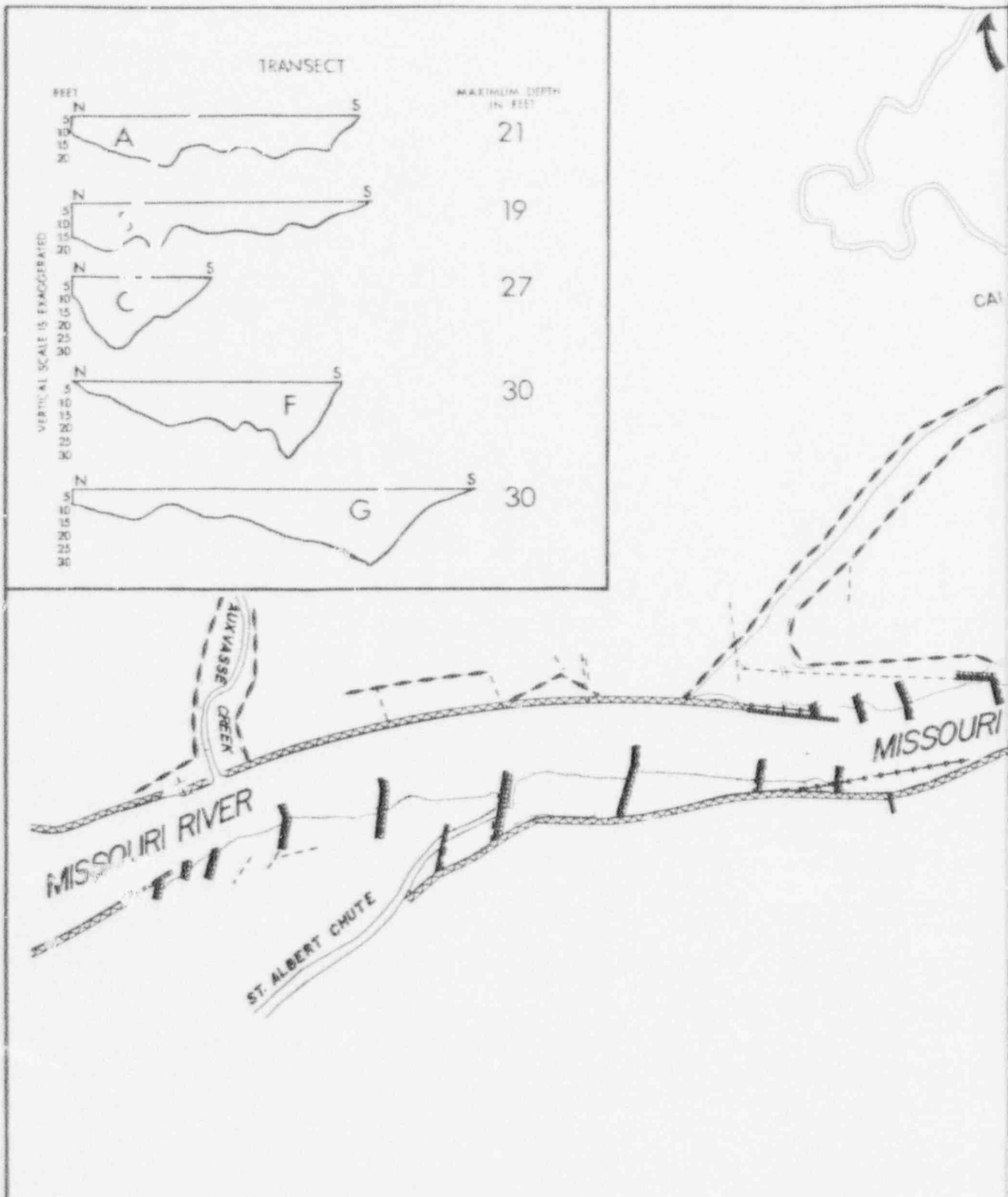
Parameter	Sample Date	Station D-1	Station E-1	Missouri River Average
Hardness	April '73	-	-	-
mg/l $CaCO_3$	July '73	-	-	-
	Sept. '73	351	247	223
	Dec. '73	340	264	239
	Feb. '74	92	102	188
Arsenic	April '73	<0.01	-	<0.01
mg/l	July '73	0.006	<0.001	0.010
	Sept. '73	0.004	<0.001	0.005
	Dec. '73	0.004	<0.001	0.003
	Feb. '74	<0.001	<0.001	0.003
Cadmium	April '73	<0.02	-	<0.02
mg/l	July '73	0.005	0.005	0.006
	Sept. '73	0.008	0.005	<0.004
	Dec. '73	0.002	0.001	0.003
	Feb. '74	0.009	0.009	0.018
Iron (total)	April '73	3.0	-	11.8
mg/l	July '73	5.6	5.2	3.4
	Sept. '73	1.8	0.1	1.2
	Dec. '73	1.2	0.3	1.6
	Feb. '74	3.1	0.7	1.8
Copper	April '73	<0.02	-	<0.13
mg/l	July '73	0.010	0.008	0.027
	Sept. '73	0.015	0.005	0.012
	Dec. '73	<0.002	0.003	0.003
	Feb. '74	0.014	0.016	0.018

TABLE 2.3.1-5 (Continued)

Parameter	Sample Date	Station D-1	Station E-1	Missouri River Average
Lead	April '73	<0.05	-	<0.05
mg/l	July '73	<0.01	<0.01	<0.01
	Sept. '73	<0.02	<0.02	<0.02
	Dec. '73	0.07	0.02	0.03
	Feb. '74	0.02	<0.02	<0.02
Mercury	April '73	<0.5	-	<1.3
mg/l	July '73	<0.1	<0.1	<0.1
	Sept. '73	<0.1	0.1	<0.1
	Dec. '73	0.4	0.4	<0.3
	Feb. '74	<0.1	<0.1	<0.1
Chromium	April '73	<0.02	-	<0.02
mg/l	July '73	0.004	0.005	0.006
	Sept. '73	0.008	0.009	<0.008
	Dec. '73	<0.003	<0.003	<0.003
	Feb. '74	0.006	0.004	0.005
Selenium	April '73	<0.1	-	<0.1
mg/l	July '73	<0.001	<0.001	<0.001
	Sept. '73	<0.001	<0.001	<0.001
	Dec. '73	<0.001	<0.001	<0.001
	Feb. '74	<0.001	<0.001	<0.001
Sulfate	April '73	66	-	61
mg/l	July '73	30	8	169
	Sept. '73	17	19	156
	Dec. '73	29	23	89
	Feb. '74	15	17	77

TABLE 2.3.1-5 (Continued)

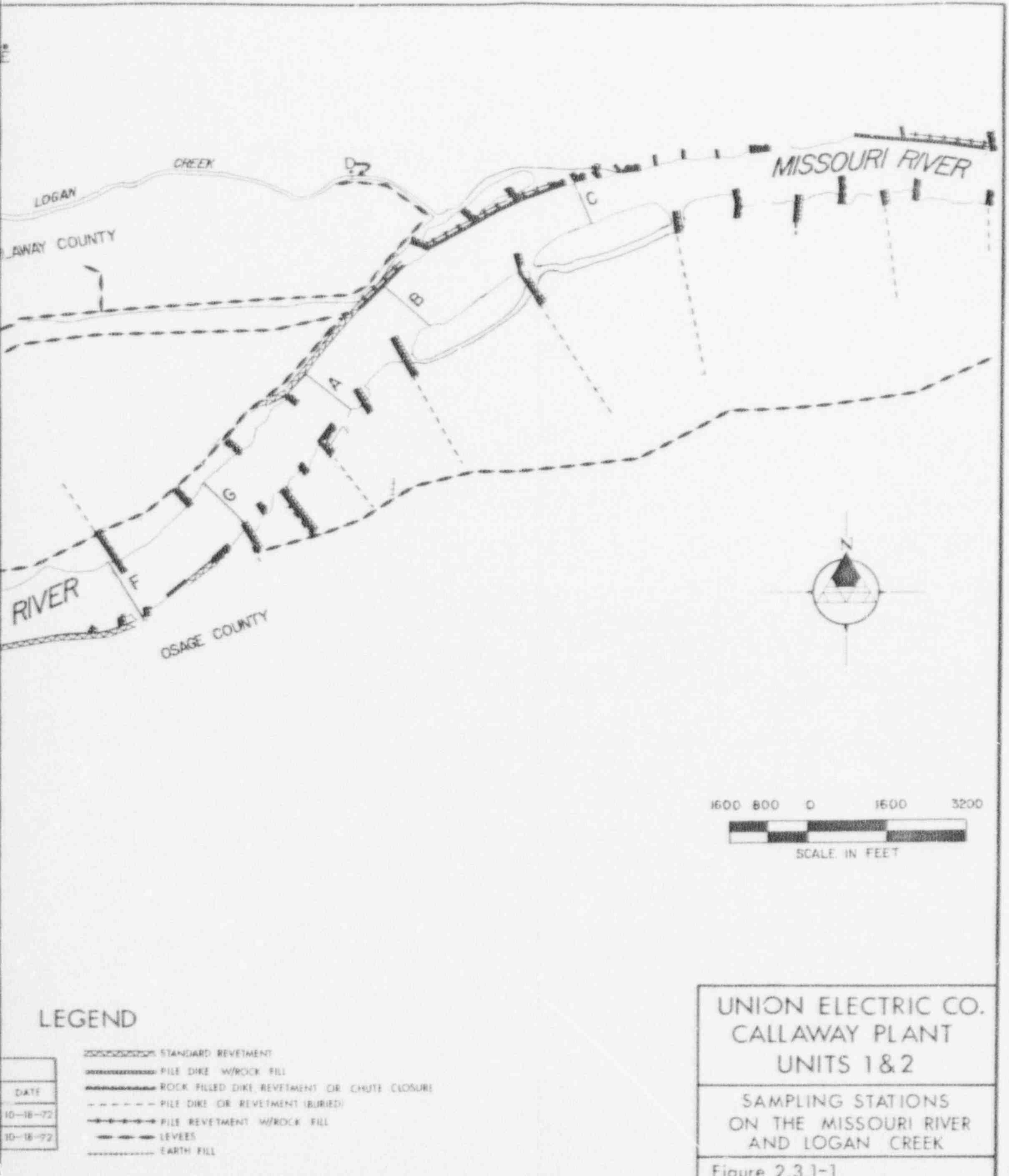
Parameter	Sample Date	Station D-1	Station E-1	Missouri River Average
Hexane Solubles mg/l	April '73	8	-	12
	July '73	1	2	3
	Sept. '73	4	1	5
	Dec. '73	7	6	8
	Feb. '74	4	6	6
Fecal Coliforms number/100 ml	April '73	1000	-	4167
	July '73	120	130	4717
	Sept. '73	20	380	1490
	Dec. '73	210	90	4400
	Feb. '74	1100	440	862
Total Coliforms number/100 ml	April '73	10,000	-	14,800
	July '73	120	2,200	14,700
	Sept. '73	110	13,000	13,800
	Dec. '73	260	200	21,100
	Feb. '74	1600	830	4100



Reference:

Missouri River Hydrographic Survey, Mile 113 to 121.5, U.S. Army Corps of Engineers, Kansas City District, November, 1972.

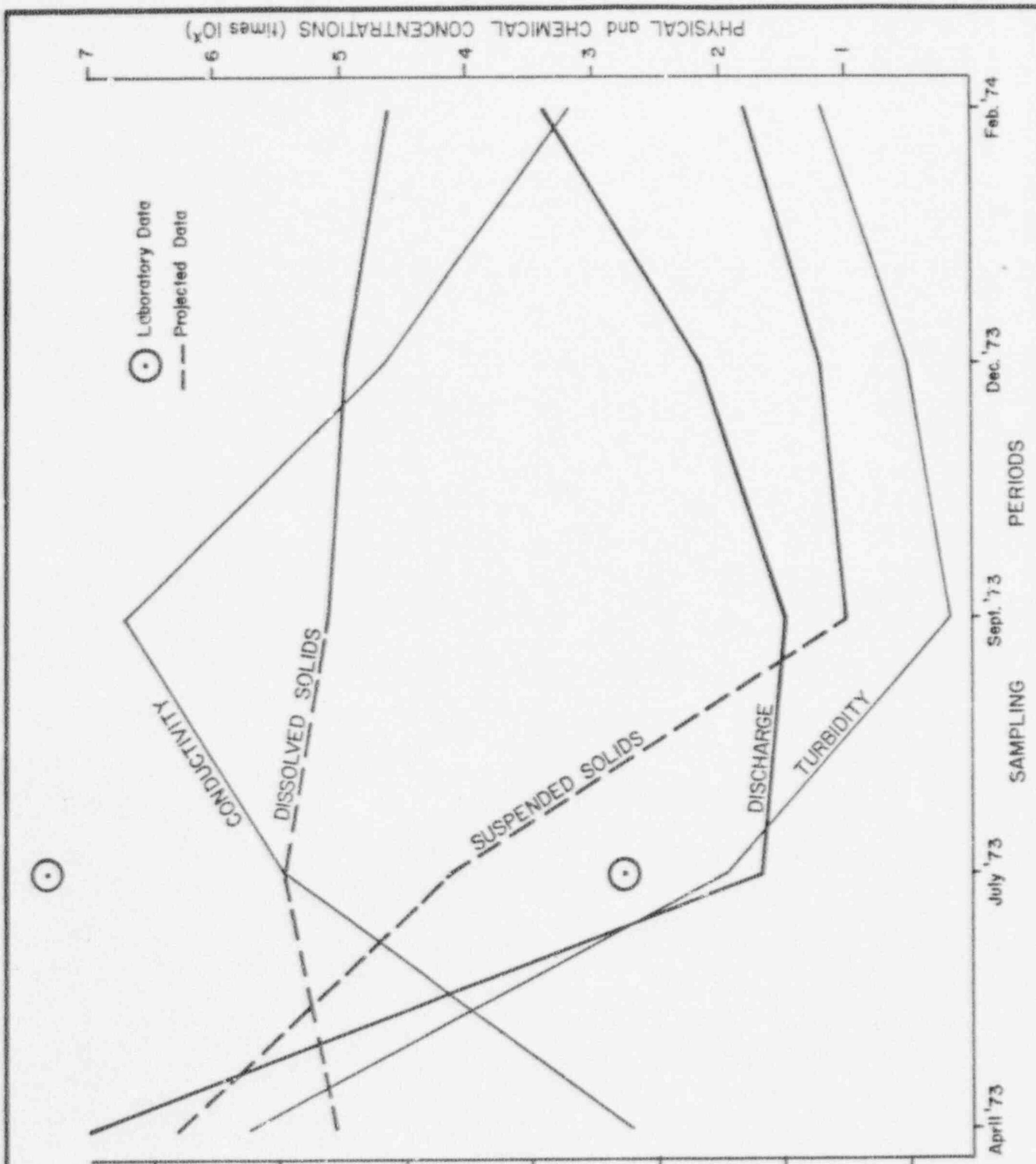
GAGE DATA			
LOCATION	READING	DISCHARGE	C.R.P
HERMANN	9.2	62000	+4.7
HERMANN	9.2	62000	+4.7



UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

SAMPLING STATIONS
ON THE MISSOURI RIVER
AND LOGAN CREEK

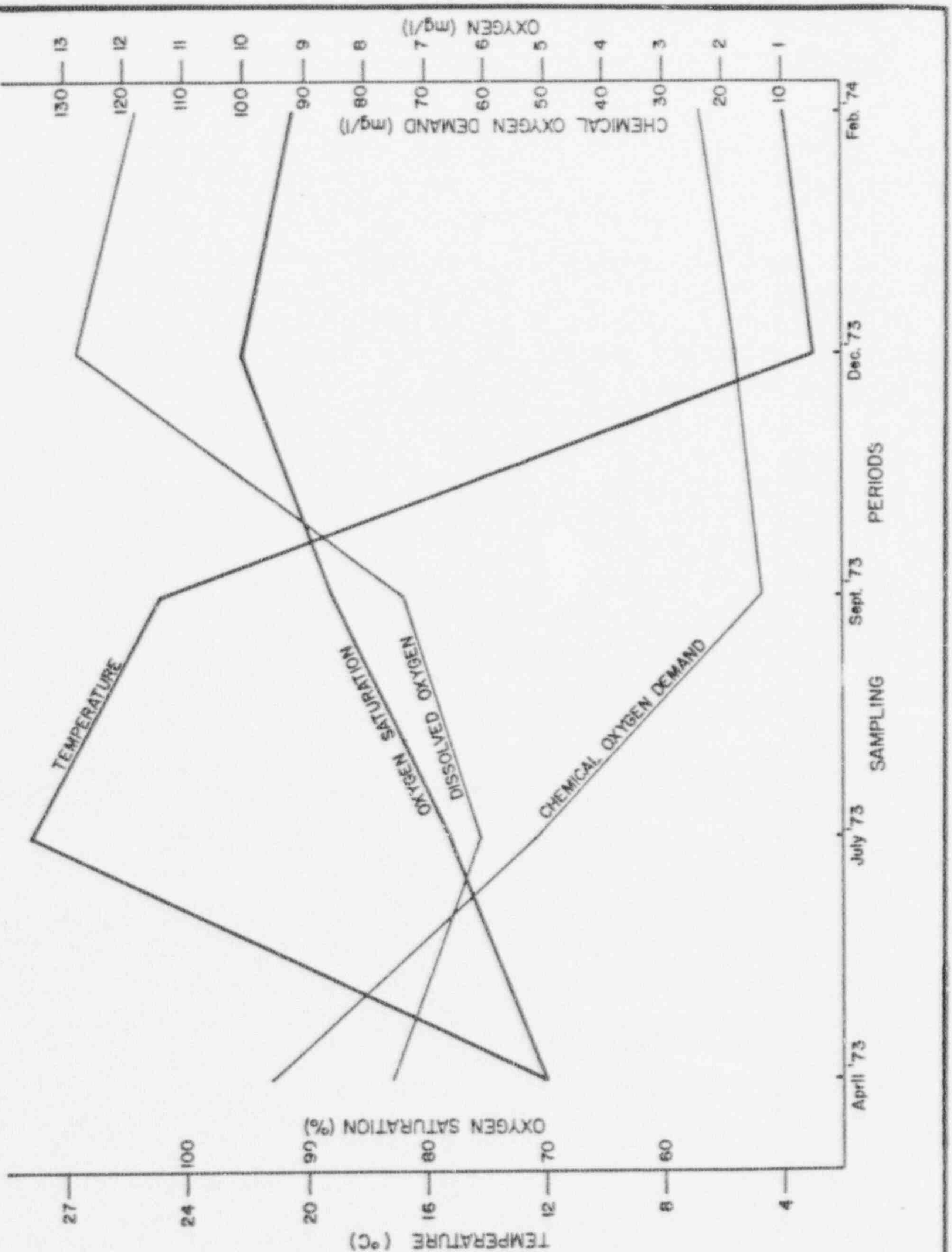
Figure 2.3.1-1



UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

WATER QUALITY PARAMETERS
RELATED TO DISCHARGE

Figure 2.3.1-2



UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

OXYGEN AND TEMPERATURE RELATIONSHIP

Figure 2.3.1-3

2.3.2 PHYTOPLANKTON

2.3.2.1 Missouri River

Phytoplankton samples collected in the Missouri River near the site in July, September, and December, 1973, and February, 1974, included 118 algal taxa, almost half of which were diatoms (Table 2.3.2-1). Except in July, when green algae were dominant, diatoms were the dominant group numerically and included the greatest number of taxa. According to Hynes (1972), diatoms typically dominate the plankton of large temperate rivers.

The highest number of taxa occurred in the December samples, which contained 70 taxa, including 45 diatoms. The average phytoplankton density of the six Missouri River stations was 241 organisms per liter (range: 193-290 per liter). Sixty-one taxa were observed in September samples; these samples were characterized by the highest densities (an average of 587 organisms per liter; range: 179-776 per liter). February samples had 53 taxa but the lowest average density (168 per liter; range: 125-286 per liter). The lowest number of taxa, 24, occurred in July samples, which had an average of 276 organisms per liter (range: 143-625 per liter).

The relatively low plankton densities characterizing the Missouri River near the site were similar to those previously recorded for the lower Missouri River (University of Missouri-Rolla, 1972; Berner, 1951; Williams, 1966). Although phytoplankton levels recorded in the present study were somewhat higher than those from net plankton collected by Berner (1947), they were 3 orders of magnitude lower than those of total plankton collected by Damann (1951). However, Damann's collections included nannoplankton organisms and these cannot be collected in nets because of their small size. Phytoplankton levels during July and September of the present study were also substantially lower than Logan Creek densities recorded during that time (see Figures 2.3.2-1 and 2.3.2-2). Damann (1951) likewise found that Missouri River populations, which averaged 4.6×10^5 plankters per liter, were lower than those of 19 Missouri River tributaries, which averaged 7.9×10^6 plankters per liter.

The paucity of phytoplankton in the Missouri River apparently is related to excessive turbidities, high current velocities, and the lack of adjoining lentic waters (Berner, 1951). Turbidity is probably the major factor limiting plankton populations because it inhibits photosynthesis, respiration, and other physiological processes by decreasing light penetration and dissolved oxygen levels (Berner, 1951). During the present study, the lowest turbidities occurred in September and probably accounted in part for the maximum phytoplankton populations then observed. September turbidity values ranged from 16-22 Formazin Turbidity Units (FTU: equivalent to Jackson Turbidity Units [JTU]); they were thus well within the 50 JTU maximum recommended by the Federal Water Pollution Control Administration (1968) as satisfactory for the aquatic life of warm water streams. With the exception of Station C-1 in February, all other turbidity values exceeded the recommended maximum.

Channelization of the river has increased current velocities and removed the standing water chutes, sloughs, and backwaters where plankton typically proliferates (Whitley and Campbell, 1972). Several studies have shown that plankton numbers generally are inversely proportional to stream flow (Hynes, 1972). This inverse relationship was demonstrated throughout the present study, although a complex of seasonal and physicochemical factors affected populations. The relationship between discharge and several water quality parameters is illustrated in Figure 2.3.1-2.

Algae are likely to suffer a nutrient deficiency when nitrogen concentration is below 0.2 mg/l and phosphorus below 0.05 mg/l (Chu, 1942). Nitrogen levels exceeded 0.2 mg/l at all river stations throughout the study, and phosphorus exceeded 0.05 mg/l at all stations during all sampling periods except July, 1973. The deficiency of phosphorus during July in combination with the excessive turbidity (average, 194 FTU) and high water levels may have inhibited phytoplankton.

Figure 2.3.2-1 illustrates the component breakdown of phytoplankton numbers for each station and sampling period. The seasonal fluctuations illustrated are typical of large temperate rivers, where plankton populations almost always show a summer maximum and winter minimum (Hynes, 1972). However, seasonal variations were statistically significant only in the comparison of February populations with those of September and December (Table 2.3.2-2).

The composition of Missouri River phytoplankton is also characteristic of large temperate streams and reflects seasonal variation in temperature and light. In temperate climates during winter, phytoplankton communities largely consist of diatoms (Williams, 1966), but increasing temperatures encourage the development of Chlorophyta (green algae) and Cyanophyta (blue-green algae), which attain maximum development in warmer waters. Green algae were significantly more abundant in July and September samples than in December and February samples (Table 2.3.2-2). Similarly, numbers of blue-green algae were significantly higher in summer than winter, although they were also statistically higher in December than in February, when they were nearly absent. Diatom numbers were similar for September, December, and February, but were significantly lower during July, when green algae dominated all stations.

Principal taxa are those composing at least 5 percent of the phytoplankters in a sample. The green filamentous alga, Ulothrix cylindricum, was the most abundant taxa in July, comprising as much as 60 percent of one sample. Another green alga, Pediastrum, ranked second in abundance and was numerically dominant at one station, comprising 24 percent of the sample. The diatoms Fragilaria brevistriata, Asterionella formosa, and Synedra ulna also were relatively abundant, but seldom did any of these species exceed 10 percent of a sample. In September, diatoms were dominant at all stations. The centric diatom, *Cyclotella*, was the most abundant genus, comprising as much as 31 percent of one sample. The green alga *Scenedesmus* ranked second in abundance, numerically dominating Stations A-1 and B-1 by comprising 15 and 18 percent of the totals, respectively. Other principal genera in September included *Nitzschia*, a pennate diatom, and *Ulothrix*. All the principal algae in December were diatoms except for the blue-green species, *Aphanizomenon flos-aquae*. As in September, *Cyclotella* was the dominant genus. The other principal taxa included *Melosira granulata*, *Fragilaria construens*, and *Synedra ulna*. Most of the principal taxa collected during the July, September, and December surveys were classified as true plankters, independent of a substrate. These include the following genera: *Pediastrum*, *Scenedesmus*, *Aphanizomenon*, *Cyclotella*, *Synedra*, *Fragilaria*, *Melosira*, and *Asterionella* (Hynes, 1972; Blum, 1956). According to Hynes, numbers of benthic species increase disproportionately to true plankters during periods of high discharge. The scouring effect of the high February discharge is reflected in the principal taxa *Navicula*, *Nitzschia*, and *Gomphonema olivaceum*, all benthic diatoms. However, the most abundant species in February was a planktonic diatom, *Asterionella formosa*.

Missouri River levels of chlorophyll *a*, *b*, and *c* are presented in Table 2.3.2-3. According to Odum (1959), chlorophyll content appears to be a better measure of productivity than of relative abundance. Chlorophyll levels determined during the present study do not correlate with phytoplankton densities as chlorophyll concentrations may vary among different species and with select environmental parameters. In addition, nannoplankton population densities were not reported during the study and no doubt would considerably affect chlorophyll concentration values and pigment content ratios. Total chlorophyll ranged from 0 at Station C-1 in July to 1.3 mg/l at Station A-1 in September. High chlorophyll values during September are the result of more favorable environmental conditions, i.e., warm temperatures, reduced turbidity, and sufficient nutrients.

2.3.2.2 Logan Creek

Phytoplankton populations of Logan Creek during July and September, 1973, averaged 8.76×10^5 and 5.97×10^3 phytoplankters per liter, respectively. These populations were 1 to 4 orders of magnitude higher than those characterizing the Missouri River near the site. Similarly, Damann's (1951) collections during the summer of 1950 showed an average of 7.88×10^6 plankters per liter for 19 Missouri River tributaries, in contrast to an average of 4.60×10^5 organisms per liter for the Missouri River. These higher plankton populations in Logan Creek relative to the Missouri River may be related to its more stable substrates, lower current velocities, and lower turbidity levels. July turbidity levels at the two Logan Creek stations were 70 and 90 FTU's, respectively, in contrast to the range of 100-215 units for Missouri River stations. September levels at the Logan Creek stations were only 23 and 3 units, respectively, but the levels for Missouri River stations also were low. Minimum plankton populations occurred in December, 1973, and February, 1974, and averaged 319 and 142 per liter, respectively. Winter minima are typical of phytoplankton communities of temperate climates (Hynes, 1972). Winter levels near the site were similar for both Logan Creek and the Missouri River.

During the present study, 76 phytoplankton taxa from Logan Creek were identified, including 39 diatom taxa (Table 2.3.2-1). Figure 2.3.2-2 illustrates the average densities and Table 2.3.2-4 includes the component breakdown of phytoplankton numbers for each station and sampling period. Seasonal variations in the composition of Logan Creek phytoplankton are typical of temperate streams, where green and euglenoid species attain maximum development during the warmest months but are almost absent during winter, when diatoms predominate (Williams, 1966; Hynes, 1972).

During all sampling periods, phytoplankton was more abundant upstream at Station E than downstream at Station D. This does not appear to reflect differences in nutrient levels or flow characteristics, but may be related to differences in substrates. The bottom at Station E is gravel and rock, which undoubtedly provides a more favorable habitat for benthic algae than the bottom at Station D, which is composed of several inches of fine mud and organic debris.

Most of the principal taxa in Logan Creek samples were benthic diatoms, although the unicellular euglenoid Phacus was extremely abundant in July at Station D, comprising 81 percent of the phytoplankters. According to Smith (1950), this genus is rarely abundant. The factors stimulating its extremely high abundance in this case are undetermined. Dominant benthic forms in the remaining samples included the genera Cymbella, Navicula, Nitzschia, and Gomphonema. The predominance of benthic forms in Logan Creek is in contrast to the dominance of planktonic taxa in the Missouri River. Williams (1964) found the number of detached plankters to be proportionally higher in creek and very shallow river plankton populations than in large river plankton populations.

Chlorophyll a, b, and c levels in Logan Creek are presented in Table 2.3.2-5. Total chlorophyll levels varied widely, ranging from 0.1 to 7.6 mg/l at Station D and from 0.1 to 1.3 mg/l at Station E. The chlorophyll value of 7.6 mg/l at Station D was obtained during July as the result of a euglenoid bloom (Phacus sp.).

TABLE 2.3.2-1

PHYTOPLANKTON COLLECTED FROM THE MISSOURI RIVER AND LOGAN CREEK IN JULY (J), SEPTEMBER (S), AND DECEMBER (D), 1973, AND FEBRUARY (F), 1974

Division Class Scientific Name	Occurrence in Missouri River				Occurrence In Logan Creek			
	J	S	D	F	J	S	D	F
Chlorophyta								
Chlorophyceae								
Actinastrum hantzschii	x	x	x			x		
Ankistrodesmus falcatus			x	x			x	x
Ankistrodesmus spp.		x			x			
Characium sp.	x	x				x		
Chlamydomonas sp.			x	x			x	x
Cladophora pacta						x		
Closteridium sp.			x					
Closteriopsis sp.		x				x		
Closterium gracilis			x					
Closterium setaceum					x			
Closterium spp.	x		x	x			x	x
Cosmarium sp.		x						
Crucigenia crucifera			x					
Crucigenia tetrapedia			x	x				
Crucigenia sp.		x		x				
Elakatothrix gelatinosa			x	x				
Golenkinia radiata		x						
Kirchneriella sp.		x						
Micractinium pusillum			x					
Microspora floccosa		x						
Oocystis sp.		x						
Pediastrum boryanum	x	x						
Pediastrum duplex	x	x	x			x		x
Pediastrum integrum		x						

TABLE 2.3.2-1(Continued)

Division Class Scientific Name	Occurrence in Missouri River				Occurrence in Logan Creek			
	J	S	D	F	J	S	D	F
Pediastrum simplex	x	x	x					
Pediastrum spp.	x	x	x	x			x	
Scenedesmus acuminatus			x	x			x	
Scenedesmus anomalus							x	
Scenedesmus bijuga			x					
Scenedesmus dimorphus		x				x		
Scenedesmus quadricauda		x	x	x		x		
Scenedesmus spp.	x	x			x	x		x
Spirogyra sp.	x		x	x				
Staurastrum paradoxum	x						x	
Staurastrum pentacerum	x							
Tetradesmus sp.		x						
Tetrastrum staurogeniaeforme			x					
Treubaria setigerum		x						
Ulothrix cylindricum	x				x			
Ulothrix sp.		x				x		x
Volvox sp.				x				
Chrysophyta								
Bacillariophyceae								
Achnanthes sp.			x				x	
Amphora ovalis		x	x	x			x	
Amphora sp.		x				x		
Anomoeoneis sp.		x				x		
Asterionella formosa	x		x	x	x		x	x
Caloneis sp.								x

TABLE 2.3.2-1(Continued)

Division Class Scientific Name	Occurrence in Missouri River				Occurrence in Logan Creek			
	J	S	D	F	J	S	D	F
Cocconeis placentula			x					
Cocconeis sp.		x	x	x		x	x	x
Cyclotella spp.		x	x	x		x	x	x
Cymbella spp.		x	x	x	x	x	x	x
Diatoma hiemale		x				x		
Diatoma vulgare			x	x				
Eunotia maior			x					
Eunotia praerupta			x					
Eunotia sp.			x	x			x	
Fragilaria brevistriata	x							
Fragilaria capucina			x	x				
Fragilaria construens			x	x			x	x
Fragilaria crotonensis	x	x			x	x	x	
Fragilaria intermedia			x	x			x	
Fragilaria sp.		x				x		x
Gomphonema acuminatum			x	x				
Gomphonema angustatum				x				
Gomphonema constrictum			x	x				
Gomphonema olivaceum			x	x			x	x
Gomphonema sp.		x						x
Gyrosigma sp.		x	x	x		x	x	x
Mastogloia braunii		x						
Melosira granulata			x	x			x	x
Melosira varians			x	x			x	
Melosira sp.		x	x	x		x	x	x
Meridion circulare				x				x
Navicula exigua			x	x			x	

TABLE 2.3.2-1(Continued)

Division Class Scientific Name	Occurrence in Missouri River J	S	D	F	Occurrence in Logan Creek J	S	D	F
Navicula pupula			x	x			x	
Navicula rhynchocephala			x	x			x	
Navicula sp.		x	x	x	x	x	x	x
Nitzschia acicularis		x	x	x	x		x	x
Nitzschia filiformis			x	x				
Nitzschia hungarica			x					
Nitzschia linearis			x					
Nitzschia lorenziana	x	x				x		
Nitzschia parvula			x					
Nitzschia sigmoidea	x	x	x			x		
Nitzschia spp.	x	x	x	x		x	x	x
Pinnularia sp.			x	x			x	
Rhoicosphenia curvata			x	x		x	x	
Stauroneis anceps			x					
Stauroneis phoenicenteron			x					
Stauroneis sp.							x	
Stephanodiscus spp.	x	x	x					
Surirella angustata			x	x				
Surirella ovata			x	x			x	x
Surirella sp.		x						
Synedra actinastroides			x					
Synedra acus	x		x	x				
Synedra ulna	x	x	x	x	x	x	x	
Synedra sp.		x	x	x		x	x	x
Tabellaria fenestrata	x	x	x	x	x	x	x	
Tabellaria flocculosa			x	x			x	
Tabellaria sp.		x						x

TABLE 2.3.2-1(Continued)

Division Class Scientific Name	Occurrence in Missouri River				Occurrence in Logan Creek			
	J	S	D	F	J	S	D	F
Coscinodiscaceae-Unid. spp.		x				x		
Naviculaceae-Unid. spp.		x				x		
Centrales-Unid. spp.		x				x		
Pennales-Unid. spp.		x	x	x		x	x	x
Chrysophyceae								
Chrysamoeba sp.		x						
Dinobryon sertularia							x	
Dinobryon sp.			x					
Xanthophyceae								
Characiopsis sp.		x						
Tribonema sp.		x				x		
Cyanophyta								
Myxophyceae								
Anabaena sp.		x				x		
Aphanizomenon flos-aquae			x	x			x	
Chroococcus sp.		x				x		
Dactylococcopsis smithii		x						
Glaucocystis sp.		x						
Gloeotrichia echinulata		x						
Gomphosphaeria lacustris		x				x		
Lyngbya contorta				x				
Merismopedia sp.		x				x		

TABLE 2.3.2-1 (Continued)

Division / Class / Scientific Name	Occurrence in Missouri River				Occurrence in Logan Creek			
	J	S	D	F	J	S	D	F
Microcystis aeruginosa			x					
Microcystis sp.		x						
Oscillatoria sp.	x	x				x		
Spirulina sp.	x	x	x	x			x	x
Euglenophyta								
Euglenophyceae								
Euglena spirogyra		x						
Euglena sp.			x	x				x
Phacus sp.		x	x	x	x			x
Trachelomonas sp.		x		x		x	x	x
Pyrrhophyta								
Dinophyceae								
Ceratium hirundinella							x	x
Glenodinium sp.			x	x				x

TABLE 2.3.2-2

WILCOXAN'S TEST VALUES FOR DIFFERENCES BETWEEN SAMPLING DATES IN OCCURRENCE OF GREEN ALGAE, BLUE-GREEN ALGAE, DIATOMS, AND TOTAL PHYTOPLANKTON PER LITER

	green algae/liter		blue-green algae/liter		diatoms/liter		phytoplankton/liter	
Months Compared	Smallest Rank	Significance[a]	Smallest Rank	Significance	Smallest Rank	Significance	Smallest Rank	Significance
7/73 & 9/73	32	ns	29	ns	24	*	34	ns
7/73 & 12/73	21	**	25.5	*	21	**	38	ns
7/73 & 2/74	21	**	21	**	25	*	31	ns
9/73 & 12/73	21	**	37.5	ns	33	ns	31	ns
9/73 & 2/74	21	**	21	**	37	ns	25	*
12/73 & 2/74	27.5	ns	21	**	29	ns	26	*

[a] ns = nonsignificant, $p > 0.025$

* = $p \leq 0.025$

** = $p \leq 0.005$

TABLE 2.3.2-3

CHLOROPHYLL LEVELS IN MISSOURI RIVER PHYTOPLANKTON IN JULY, SEPTEMBER, AND DECEMBER, 1973, AND FEBRUARY, 1974

Station	Chl *a* (mg/l)	Chl *b* (mg/l)	Chl *c* (mg/l)	Total Chl
		JULY 1973		
A-1	0.1	0	0	0.1
A-2	0.1	0	0	0.1
B-1	0.1	0	0	0.1
B-2	0	0	0	0
C-1	0	0	0	0
C-2	0.2	0	0	0.2
		SEPTEMBER 1973		
A-1	1.1	0	0.2	1.3
A-2	1.0	0	0	1.0
B-1	1.1	0	0	1.1
B-2	1.1	0	0	1.1
C-1	1.0	0	0.2	1.2
C-2	1.0	0	0	1.0
		DECEMBER 1973		
A-1	0.2	0	0	0.2
A-2	0.1	0	0.1	0.2
B-1	0.1	0	0	0.1
B-2	0.1	0	0	0.1
C-1	0.2	0	0.1	0.3
C-2	0.2	0	0.1	0.3
		FEBRUARY 1974		
A-1	0.2	0	0	0.2
A-2	0.2	0	0	0.2
B-1	0.2	0	0	0.2
B-2	0.2	0	0	0.2
C-1	0.1	0	0	0.1
C-2	0.2	0	0	0.2

TABLE 2.3.2-4

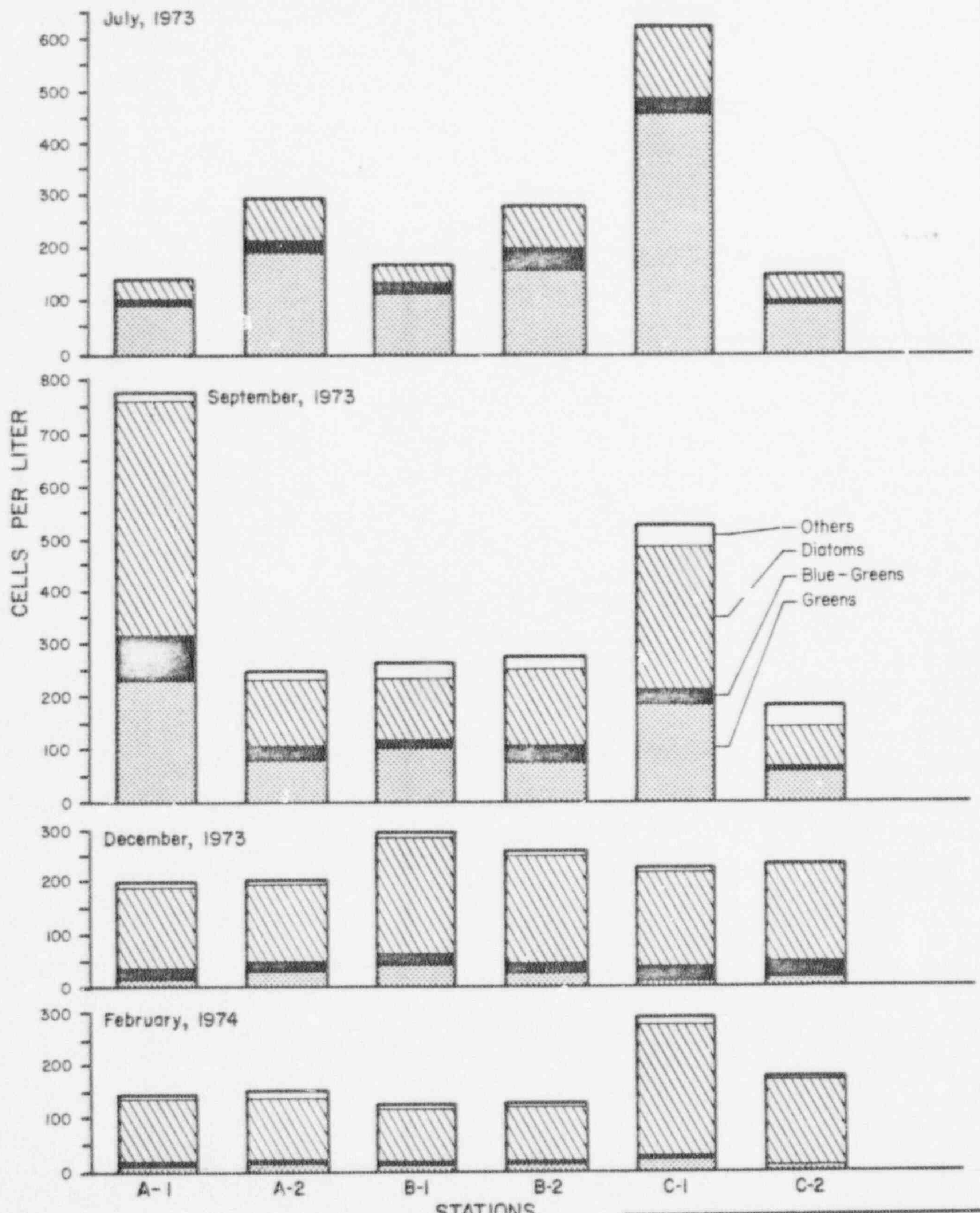
AVERAGE DENSITIES (CELLS PER LITER) OF PHYTOPLANKTON COLLECTED IN LOGAN CREEK IN JULY, SEPTEMBER, AND DECEMBER, 1973, AND FEBRUARY, 1974

Sampling Periods	Station D					Station E				
	Greens	Diatoms	Blue-greens	Others	Total	Greens	Diatoms	Blue-greens	Others	Total
July 1973	69,000	54,000	513,000	0	636,000	15,000	1,100,000	0	0	1,115,000
September 1973	281	1,427	3.5	70	1,718.5	402	9,507.5	0	312.5	10,222
December 1973	6	31	0	5	42	6	566.5	7.5	15	595
February 1974	1	65	0.5	4.5	71	2	208	1	1	212

TABLE 2.3.2-5

CHLOROPHYLL LEVELS IN LOGAN CREEK PHYTOPLANKTON IN JULY, SEPTEMBER, AND DECEMBER, 1973, AND FEBRUARY, 1974

Station	Chl a (mg/l)	Chl b (mg/l)	Chl c (mg/l)	Total Chl
JULY 1973				
D	4.0	1.8	1.8	7.6
E	0.1	0	0	0.1
SEPTEMBER 1973				
D	1.1	0	0	1.1
E	1.1	0	0.2	1.3
DECEMBER 1973				
D	0.1	0	0.1	0.2
E	0	0	0.1	0.1
FEBRUARY 1974				
D	0.1	0	0	0.1
E	0.1	0	0	0.1



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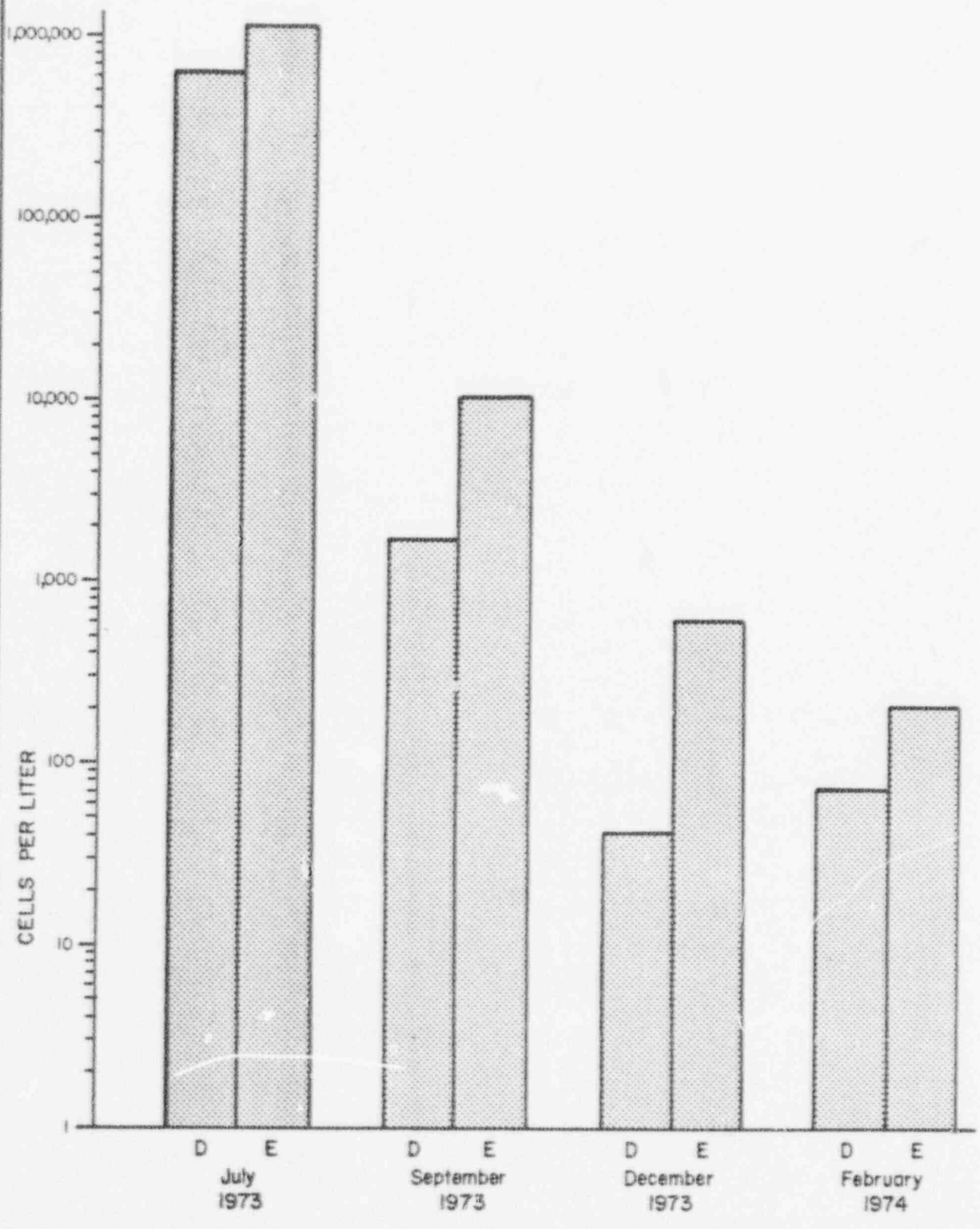
UNITS 1&2

PHYTOPLANKTON DENSITIES AT MISSOURI RIVER STATIONS

Figure 2 3.2-1



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PHYTOPLANKTON AT
LOGAN CREEK STATIONS

Figure 2.3.2-2

2.3.3 ZOOPLANKTON

2.3.3.1 Missouri River

Zooplankton populations sampled near the site in July, September, and December, 1973, and February, 1974, included 52 taxa. Thirty-six of these taxa were rotifers, while most remaining taxa were cladoceran and copepod crustaceans (Table 2.3.3-1). The maximum density per liter and the greatest array of taxa occurred in the September samples. They contained a mean of 49.5 organisms per liter (range: 36.4-74.8 per liter) and consisted of 33 taxa, including 25 rotifers. Populations of zooplankters were statistically lower during the remaining sampling periods than in September (Table 2.3.3-2). Average densities for July and December, 1973, and February, 1974, were 7.6, 8.2, and 4.2 zooplankters per liter, respectively. Of these, the largest number of taxa, 26, occurred in December. The July samples included 16 taxa and the February samples, 17 taxa.

Figure 2.3.3-1 illustrates the component breakdown of zooplankton numbers for each station and sampling period. The summer maximum of rotifers is typical of large temperate rivers. Rotifers per liter were significantly higher in September samples than in other samples (Table 2.3.3-2). According to Williams (1966), higher rotifer densities are usually associated with warm water of high clarity and low turbidity, conditions prevailing during the September sampling period. This maximum may also be related to relative increases in diatom numbers. Hynes (1972) reports that when diatom numbers increase, rotifers become more common. This may indicate either a trophic effect or that similar conditions favor both types of organisms (Hynes, 1972). Rotifers were significantly less abundant in February than in other sampling periods. Williams (1966) found that most rotifers disappear during winter and during periods of high stream flow, such as occurred in February.

Copepod crustaceans persisted in similar numbers throughout the study (range: 1.0-10.2 per liter). They were the most numerous group occurring in December and February (Figure 2.3.3-1). Anderson (1969), studying a North Dakota prairie lake, found that copepods were the only plankters commonly occurring in winter and suggested that temperature was not a controlling factor in their distribution.

The principal taxa (those comprising at least five percent of a sample) were primarily planktonic zooplankters. Principal taxa in July included the rotifers *Monostyla*, *Brachionus calyciflorus*, and *Brachionus caudatus* and copepod nauplii and copepodites, but no single taxon dominated. However, the rotifers *Brachionus* and *Keratella* ranked first and second in abundance, respectively, at all stations during September. Together they comprised 61 to 92 percent of the total zooplankters in the sample. *Brachionus calyciflorus* and *Keratella cochlearis* were particularly abundant. *Brachionus* was the dominant rotifer collected during the Missouri River Environmental Inventory (University of Missouri-Rolla, 1972).

Brachionus calyciflorus was the most abundant species at stations near Hermann and also a major species at other stations. Keratella cochlearis was the most abundant species collected in the Missouri River by Williams (1966), but it was not reported among net plankton of the Missouri River Environmental Inventory. No single species comprised a large percentage of zooplankton samples in December or February, although cyclopoid copepods were the dominant group. Of 14 rotifer species collected in December, principal taxa were Asplanchna priodonta, Brachionus calyciflorus, and Brachionus variabilis.

Specific zooplankters in these collections have not been discussed as trophic indicators because present knowledge of their ecology is inadequate to classify them by this criterion (Gannon, 1972). The indicator organism concept is not supported among dominant rotifers in a sample because dominant species apparently are determined by edaphic factors within a watershed (Williams, 1966).

Zooplankton populations during this study were generally quite low. Zooplankton was also sparse in the Missouri River Environmental Inventory collections (University of Missouri-Rolla, 1972). Figure 2.3.3-1 shows that rotifers comprised high percentages of total zooplankters in September, but their numbers were still low compared to other aquatic ecosystems. Most plankton communities average 40 to 500 rotifers per liter (Pennak, 1953). The highest rotifer density recorded at any station was 54.6 per liter. Rotifer populations during July were similar to those Williams (1966) reported from samples collected near St. Joseph, Kansas City, and St. Louis. He concluded that the Missouri Basin is generally rotifer poor. As with phytoplankton, excessive turbidity appears to be the limiting factor.

2.3.3.2 Logan Creek

Zooplankton collections in Logan Creek contained 26 taxa, ncluding 18 rotifers (Table 2.3.3-1). With the exception of Lepadella, all rotifer genera collected in Logan Creek also occurred in Missouri River samples. Maximum densities, averaging 1,100 per liter, occurred in July and included 13 taxa. Seventeen taxa were included in the September samples, but the average density was much lower: 124 per liter. The December and February samples were extremely low, both averaging less than two organisms per liter. These samples included four and six zooplankton taxa, respectively.

Figure 2.3.3-2 illustrates the average densities and Table 2.3.3-3 includes the component breakdown of zooplankton numbers for each station and sampling period. The abundance of rotifers during summer is in sharp contrast to their winter occurrence. According to Williams (1966), most rotifers are associated with warm water of high clarity, while in winter they almost disappear.

In contrast to the situation at the Missouri River stations near the site, rotifers were more prevalent in July than in September in spite of the higher turbidity levels occurring in July. The

July sample from Station D had an extremely high population, 2,133 zooplankters per liter, and contained more than 90 percent rotifers. According to Pennak (1953), most plankton populations average 40 to 500 rotifers per liter. Brachionus calyciflorus and Keratella cochlearis comprised 50 and 34 percent of this sample, respectively. These were also the most abundant rotifers at Missouri River stations. A possible explanation for this extremely high number of rotifers is that logs and debris deposited by spring floods had formed pools in the vicinity of Station D, perhaps favoring the proliferation of rotifers. These pools no longer existed in September, when zooplankton numbers were much lower and similar to those for Station E upstream. Also, rotifer proliferation may have been in response to the Phacus bloom occurring at that time.

In addition to Brachionus and Keratella, principal zooplankton taxa in summer collections included the rotifers Trichotria, Lepadella, Lecane, and copepod nauplii. Because zooplankters were so sparse in winter collections, identification of principal species was not considered meaningful.

TABLE 2.3.3-1

ZOOPLANKTON COLLECTED FROM THE MISSOURI RIVER AND LOGAN CREEK IN JULY(J), SEPTEMBER(S), AND DECEMBER(D), 1973, AND FEBRUARY(F), 1974

	Occurrence in Missouri River				Occurrence in Logan Creek			
	J	S	D	F	J	S	D	F
Rotatoria								
Ascomorpha sp.		x						
Asplanchna priodonta		x	x	x		x		x
Asplanchna sp.	x				x			
Brachionus angularis		x	x			x		
Brachionus bidentata		x				x		
Brachionus calyciflorus	x	x	x	x	x	x		
Brachionus caudatus	x				x			
Brachionus havanaensis	x	x						
Brachionus plicatilis	x	x				x		
Brachionus quadridentata		x				x		
Brachionus variabilis			x	x				x
Brachionus sp.		x						
Chromogaster sp.		x						
Collotheca sp.		x						
Colurella sp.				x				
Filinia longiseta		x	x					
Filinia opoliensis	x				x			
Kellicottia bostoniensis			x	x				
Kellicottia longispina		x						
Kellicottia sp.		x						
Keratella cochlearis	x	x	x		x	x		
Keratella earlinae			x					
Keratella quadrata	x	x	x					
Keratella sp.		x						
Lecane sp.		x				x		

TABLE 2.3.3-1(Continued)

	Occurrence in Missouri River				Occurrence in Logan Creek			
	J	S	D	F	J	S	D	F
Lepadella ovalis					x			
Monostyla sp.	x	x				x		
Notholca sp.		x	x					
Platyias patulus			x					
Platyias quadricornis		x						
Platyias sp.	x							
Ploesoma sp.		x						
Polyarthra sp.	x	x	x		x	x		
Synchaeta sp.			x			x		x
Testudinella sp.			x					
Trichotria tetrades		x				x		
Trichotria sp.					x			
Vanogella sp.		x						
Cladocera								
Bosmina coregoni			x	x				
Bosmina sp.	x	x				x		
Ceriodaphnia reticulata	x	x	x	x				
Chydorus sphaericus			x	x			x	x
Daphnia longiremis			x	x				
Daphnia pulex		x						
Daphnia sp.			x					
Diaphanosoma brachyurum		x				x		
Holopedium gibberum		x						
Latonopsis sp.	x				x			
Immature cladoceran				x				

TABLE 2.3.3-1 (Continued)

	Occurrence in Missouri River				Occurrence in Logan Creek			
	J	S	D	F	J	S	D	F
Copepoda								
Cyclops bicuspidatus		x	x	x				
Cyclops vernalis		x				x		
Diaptomus forbesi				x				
Diaptomus siciloides			x	x				
Calanoid copepodite			x	x			x	
Cyclopoid copepodite	x		x	x		x	x	x
Harpacticoid copepod				x				
Nauplii	x	x	x	x	x	x	x	x
Nematoda								
Unidentified sp.			x					
Tardigrada								
Unidentified sp.			x					

TABLE 2.3.3-2

WILCOXAN'S TEST VALUES FOR DIFFERENCES BETWEEN SAMPLING DATES IN OCCURENCE OF ROTIFERS, COPEPODS, AND TOTAL ZOOPLANKTON PER LITER

Months Compared	rotifers/liter		copepods/liter		zooplankton/liter	
	Smallest Rank	Significance[a]	Smallest Rank	Significance	Smallest Rank	Significance
7/73 & 9/73	21	**	36.5	ns	21	**
7/73 & 12/73	30.5	ns	31.5	ns	35	ns
7/73 & 2/74	21	**	38.5	ns	27	ns
9/73 & 12/73	21	**	27	ns	21	**
9/73 & 2/74	21	**	32	ns	21	**
12/73 & 2/74	21	**	23	**	21	**

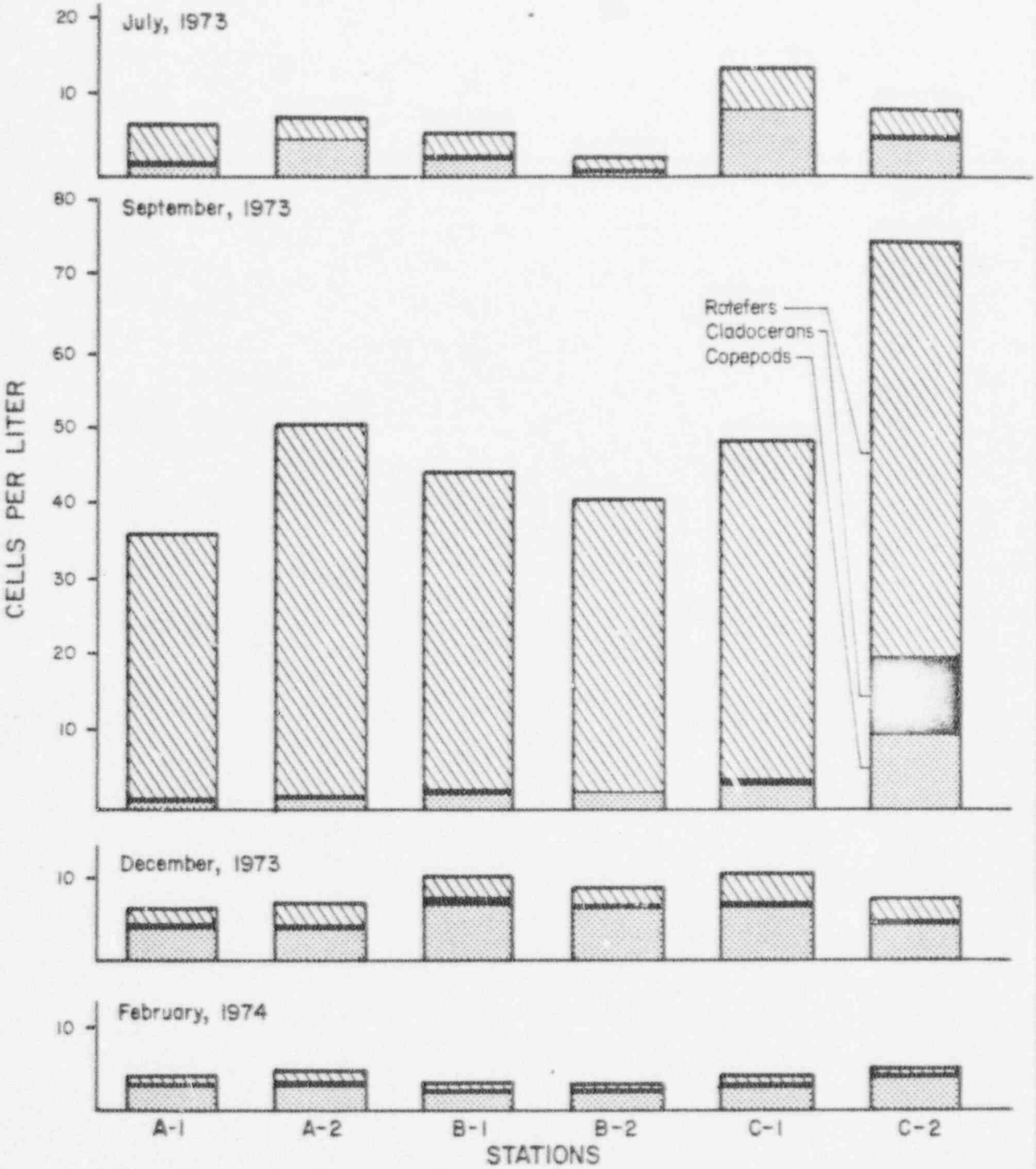
[a] ns = nonsignificant, $p > 0.025$

** = $p \leq 0.005$

TABLE 2.3.3-3

AVERAGE DENSITIES (ORGANISMS PER LITER) OF ZOOPLANKTON COLLECTED IN LOGAN CREEK IN JULY, SEPTEMBER, AND DECEMBER 1973, AND FEBRUARY 1974

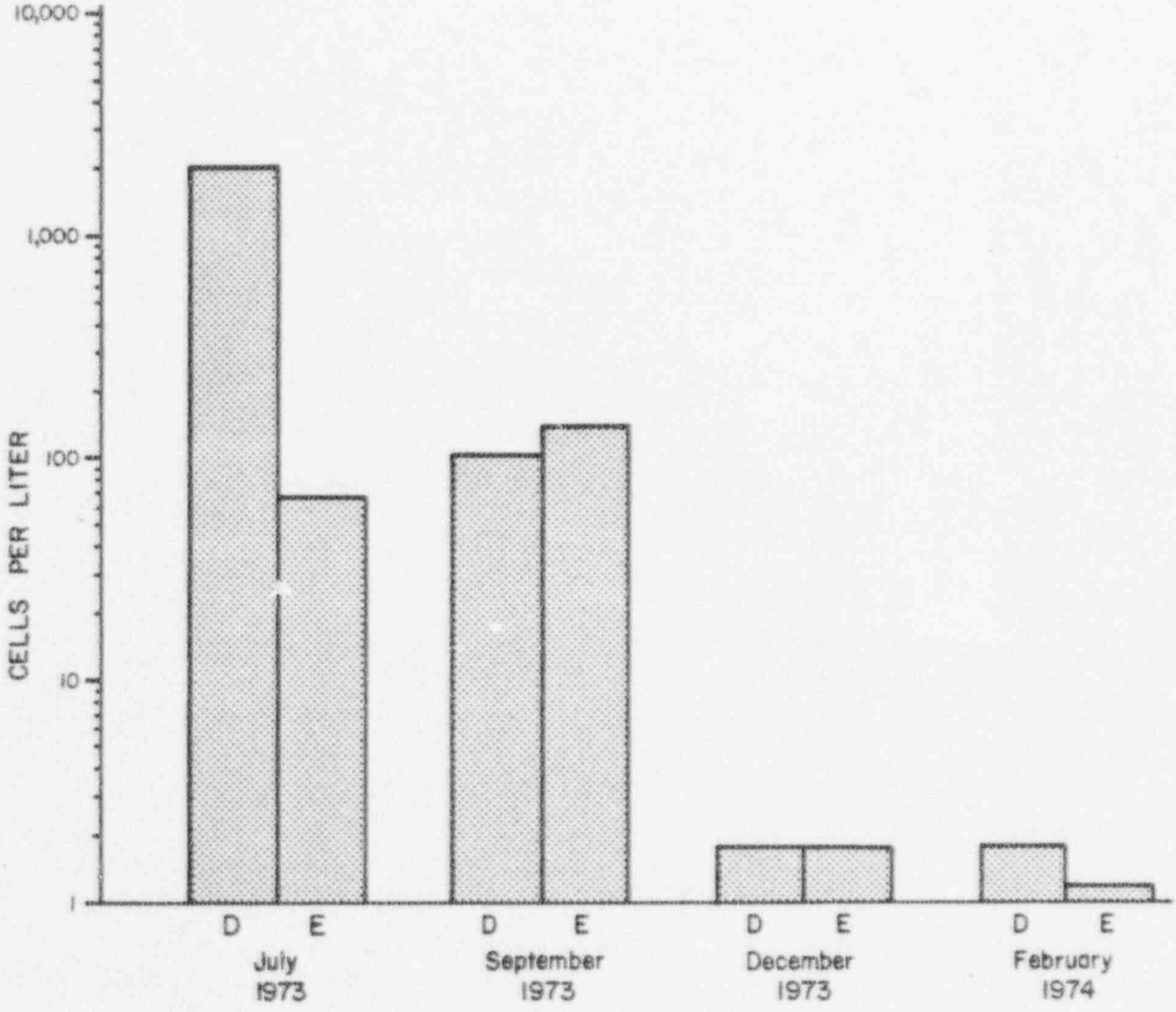
Sampling Periods	Station D				Station E			
	Rotifers	Cladocerans	Copepods	Total	Rotifers	Cladocerans	Copepods	Total
July 1973	1,992.1	44.6	95.9	2,132.6	62.5	0	5.0	67.5
September 1973	79	11	13	103	60.6	1	82.6	144.2
December 1973	0	0.35	1.35	1.7	0	0.35	1.35	1.7
February 1974	0.8	0.4	0.6	1.8	0.4	0	0.8	1.2



UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

ZOOPLANKTON DENSITIES
AT MISSOURI RIVER STATIONS

Figure 2.3.3-1



UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

ZOOPLANKTON AT
LOGAN CREEK STATIONS

Figure 2.3.3-2

2.3.4 VASCULAR HYDROPHYTES

2.3.4.1 Missouri River

During the present study, no vascular hydrophytes were observed in the Missouri River near the site. Berner (1947) also reported a complete absence of rooted aquatic plants in the channels, chutes, and backwaters of the Missouri River. He attributed their absence to turbidity, water level fluctuations, and the instability of the fine river substrates. Excessive turbidities create shading effects, decreasing light penetration essential for phytosynthesis in submergent species characterized by completely immersed foilage. The distribution of these plants also may be inversely related to stream flow (Dames & Moore, 1974). Hynes (1972) notes that very turbid tropical rivers, such as the Amazon and rivers in Africa, are also devoid of higher plants.

2.3.4.2 Logan Creek

In contrast to the Missouri River near the site, vascular hydrophytes were observed in Logan Creek during July and September of the present study, although they were sparse. None were observed during the December and February sampling period.

During July, small populations of water primrose (Jussiaea), water willow (Dianthera), and duckweed (Lemna) were observed upstream at Station E. Water primrose and sedges (Carex) occurred there in September. No vascular hydrophytes were observed downstream at Station D in July or September. This absence is probably related to the soft silty substrates at D. Station E is characterized by coarser sand and rocky substrates; these probably provide greater stability for plant colonization.

The presence of vascular hydrophytes in Logan Creek, in contrast to the Missouri River, is explained in part by its more suitable substrate and lower turbidities. However, as in the Missouri River, water levels in Logan Creek fluctuate considerably, probably limiting the abundance of higher aquatic plants.

2.3.5 BENTHIC MACROINVERTEBRATES

2.3.5.1 Missouri River

Benthic macroinvertebrates collected from the Missouri River near Fulton, Missouri, are listed in Table 2.3.5-1 (Transects A, B, and C) and Appendix Table 2A-3 (Transects F and G). Approximately 65 different species of benthic organisms were collected. Dipteran larvae, aquatic oligochaetes, and mayfly nymphs were usually numerically dominant in the collections, with coleopterans, trichopterans, odonates, and pelecypods also present in smaller numbers. Dipteran populations were dominated by midge larvae, while tubificids were the dominant oligochaetes. The only other numerically important organisms near the site were mayflies.

Predominant oligochaete populations consisted of *Limnodrilus* spp. and *Branchiura sowerbyi*; both species are pollution-tolerant (Weber, 1973). The majority of midge larvae collected are considered facultative, with the remaining species being nearly equally divided between tolerant and intolerant species. The most common mayfly was a burrowing mayfly (*Pentagenia vittigera*), which is listed as being intolerant to pollution.

Pentagenia vittigera is similar to *Hexagenia limbata*, another relatively common burrowing mayfly in the Missouri River, but *Pentagenia* apparently live in faster waters (Winona State College, 1970). In contrast to other mayfly nymphs, burrowing mayfly gills are held over their bodies and cause an axial current down the length of the body (Hynes, 1972). These mayflies are markedly hairy; the long hairs apparently keep the body free of fine particles and prevent smothering. *Ephemerella* sp., *Stenonema* sp., and other mayfly nymphs found near the site also are well adapted to live in fast, turbid waters. These species are flattened dorso-ventrally for less resistance to water flow. They also have dorsally placed gills that can maintain a respiratory current without becoming clogged with silt. The mayfly, *Caenis* sp., a fourth species of mayfly nymph collected near the site, has dorsal gills covered by an operculum, which allows the species to inhabit silty substrata.

Results of the quantitative sampling are presented in Table 2.3.5-2. Mid-channel stations (A-1, B-1, and C-1) were almost completely dominated by dipteran larvae. Only one mayfly nymph, one caddis fly larva, and two oligochaetes were collected at the mid-channel stations during the four surveys. The benthic density for these three stations averaged $42/m^2$ and $187/m^2$ during the July and September surveys, respectively. Samples were not collected from mid-channel Station A-1 in December nor A-1 and B-1 in February because high waters scoured the bottom and prevented dredge samples from being taken. Stations B-1 and C-1 had an average density of 11 benthic organisms/m^2 during December, and no organisms were found at Station C-1 during February.

In contrast to the dipteran-dominated mid-channel stations, oligochaetes and mayflies numerically dominated the benthic community at most of the north shore stations. Average benthic densities for the three north shore stations (A-2, B-2, and C-2) were 72/m^2, 506/m^2, 1090/m^2, and 278/m^2 during July, September, December, and February, respectively.

Major factors affecting the benthic density and distribution among the Missouri River stations appear to be river velocity and bottom substrates. High current velocities scour the bottom, removing silt, clay, and organic matter deposited during low flow conditions. Organisms inhabiting this soft substrate may be swept along with the current, migrate to more favorable habitat, or be killed by the grinding action of moving sand and gravel. These conditions were readily apparent at the normally sandy-bottomed mid-channel stations (A-1, B-1, and C-1), where benthic density was found to be low.

Improved conditions, slower currents, and a more silty substrata were noted at the north shore stations; however, species composition and density of benthic macroinvertebrates were still low.

Rivers, like the Missouri, liable to floods are known to have less abundant and less varied faunas than others (Hynes, 1972). Burrowing animals, such as tubificids, midge larvae, and burrowing mayfly nymphs, are better able to survive the rapidly changing river conditions resulting from floods.

Species diversity indices of the benthic community also reflect differences between mid-channel and north shore stations (Table 2.3.5-3). The average species diversity indices for the mid-channel and north shore stations were 0.60 and 1.86, respectively. Wilhm and Dorris (1968) indicated that systems possessing indices of approximately 1.00 were grossly polluted, 2.00 moderately polluted, and 3.00 unpolluted. This would suggest that the Missouri River mid-channel stations were grossly polluted and north shore stations were moderately polluted. Pollution, in this sense, refers to physical stresses consisting of high river velocities, high turbidity, and lack of favorable substrates. Although chemical stresses do occur in the Missouri River, their effects on the benthos in the study area appear to be only minor.

Wet-weight biomass data for each major benthic group are presented in Table 2.3.5-4. Oligochaetes and dipterans (predominately chironomids) generally dominated standing crop biomass of each station; however, mayflies (ephemeropterans) were important at north shore stations (A-2, B-2, and C-2). Biomass for north shore and mid-channel (A-1, B-1, and C-1) stations during the four surveys averaged 1141.8 mg/m^2 (10.3 lb/acre) and 19.3 mg/m^2 (0.17 lb/acre), respectively. Berner (1951) studied the average wet-weight benthic biomass in the lower Missouri River from April through October, 1945. He determined that the benthic biomass averaged 0.01 lb/acre near the middle of the river and 2.17 lb/acre near a steep bank. Although biomass values from the present survey were considerably higher than Berner's, benthic biomass near the site would still be considered low when compared to other systems. Investigations of unchannelized portions of the Illinois River between Chillicothe and Grafton, for example, yielded average biomass values of 261 lb/acre (Berner, 1951).

Berner (1951) sampled the river at 11 different sites between Watson and St. Charles, Missouri, including one station at Hermann (approximately 20 river miles downstream from the site). Very few organisms were found in any of the four different ecological habitats sampled (middle of channel, near a steep bank, near a sand bar, and the downstream side of a pile dike). The most productive area appeared to be near the steep bank; no organisms appeared to be produced in mid-channel.

Numerically, Berner's collections were dominated by midge larvae (35 percent) and aquatic oligochaetes (20 percent); however, immature stages of other dipterans, plecopterans, ephemeropterans, odonates, and trichopterans were also found. Clams, snails, and crayfish were absent from the dredged samples. Berner attributed the low benthic productivity (0.4 lb/acre) to siltation, shifting substrates, fluctuating water levels, swift currents, and the absence of aquatic vegetation. He indicated that such factors were also probably responsible for the presence of "syrton," or drift organisms, which are similar in species composition to the benthos and average almost 0.07 pounds per surface acre.

During the Missouri River Environmental Inventory (University of Missouri-Rolla, 1972), three benthic dredge samples were taken near Hermann on 29 September 1972. Aquatic oligochaetes comprised at least 98 percent of the total number of organisms in all three samples. Other benthic species included midge larvae (Polypedilum sp. and Cryptochironomus sp.), mayfly nymphs (Hexagenia limbata) and clams (Corbicula sp.). Total densities ranged from $1000/m^2$ in sand to $4940/m^2$ in clay sediments. Ballentine et al. (1970) collected benthos from pile dikes and adjacent backwater areas between St. Joseph and Hermann during the fall of 1968. Tubificid worms accounted for more than 70 percent of the total benthos from dredge samples, although midge larvae and mayfly nymphs also occurred. Qualitative samples from rock dikes yielded several amphipods, flatworms, clams, snails, and leeches. They found that immediately downstream from major metropolitan areas, the number of pollution-sensitive organisms decreased while pollution-tolerant organisms increased.

Channelization appears to have had quite an adverse effect on the benthic biota in the Missouri River (Whitley and Campbell, 1972). Studies by Langemeier compared the standing crop of benthos in channelized and unchannelized portions of the river (Whitley and Campbell, 1972); channelization appeared to result in a substantial decrease in benthic standing crop. Standing crops were generally higher in areas with a silt substrate and little or no water movement, areas which are generally absent in channelized portions of the river.

Benthic organisms from the Missouri River near the site have low species composition, diversity, abundance, and standing crop. Major factors contributing to this condition appear to be channelization and reduction of favorable habitats, flooding and high water velocities, turbidity, and shifting substrates. Stresses are also imposed by water quality reduction that has resulted from municipal wastes, acid mine areas, industrial effluents, increased siltation, and chemical runoff from farming activities (see Section 2.3.1). Major benthic organisms in the Missouri River are midge larvae, tubificids, and burrowing mayflies, which are adapted to withstand these existing environmental conditions.

2.3.5.2 Logan Creek

Species composition of the benthic community in Logan Creek is similar to the Missouri River. Although densities were higher in Logan Creek than the Missouri, they would still be considered low when compared to other systems. Major species collected during July and September, 1973, were oligochaetes and dipterans (Table 2.3.5-1).

Logan Creek Station D was located on the Missouri River floodplain below the confluence of Mud and Logan Creeks. Oligochaete populations numerically dominated the benthic fauna, comprising 71 percent of the total benthos in July, 91 percent in September, 85 percent in December, and 86 percent in February (Table 2.3.5-5). Dipterans, mainly chironomids, were the second most abundant benthic group collected at this station and comprised from 9 to 29 percent of the total community. Total densities for Station D samples averaged $103/m^2$ in July, $1248/m^2$ in September, $2059/m^2$ in December, and $2861/m^2$ in February.

Station E was located in the upper reaches of Logan Creek and, although species composition was similar to Station D during the four sampling periods, the dominant forms changed (Table 2.3.5-5). Dipterans were numerically dominant during July and September, and represented 91 and 88 percent, respectively, of the total benthos collection. Oligochaetes became numerically dominant during December and February, when they comprised 65 and 60 percent, respectively, of the total benthos. Mayflies, clams, nematodes, and springtails were also collected. Total Station E densities averaged $1093/m^2$ in July, $4033/m^2$ in September, $882/m^2$ in December, and $736/m^2$ in February.

Species diversity indices averaged 2.05 and 3.00 at Stations D and E, respectively (Table 2.3.5-3). This indicates that Station D is moderately polluted and Station E is unpolluted. The lower species diversity at Station D probably reflects its location in the Missouri River floodplain. During periods of high flow, Missouri River water backs up into Logan Creek and influences the species inhabiting these waters. The higher species diversity at Station E corresponds to the higher water quality at this station.

Water quality and seasonal variations appear to have major influences on benthic development in Logan Creek. Water quality is better upstream at Station E (Section 2.3.1), and this station was generally found to support a more diverse and dense macrobenthic community. High temperatures, lower dissolved oxygen, greater turbidities, and more pronounced water level fluctuations are associated with Station D during the summer and would tend to limit benthic production. Although the majority of organic matter is probably allochthonous (produced outside the creek), Station E does have a rocky substrate that supports benthic algae and is utilized by invertebrates for food and shelter.

During December and February, benthic densities at Station E decreased, while densities at Station D increased. During the winter, reduced flows and shallower waters at Station E appear to result in lower temperatures that subsequently stress benthic populations.

TABLE 2.3.5-1

BENTHIC MACROINVERTEBRATES COLLECTED FROM THE MISSOURI RIVER AND LOGAN CREEK DURING JULY(J), SEPTEMBER(S), DECEMBER(D) 1973 AND FEBRUARY(F) 1974

Species	Missouri River				Logan Creek			
	J	S	D	F	J	S	D	F
Oligochaeta								
Enchytraeidae								
Unidentified species			X	X				X
Lumbriculidae								
Unidentified species							X	
Tubificidae								
Branchiura sowerbyi	X	X	X	X		X	X	X
Aulodrilus pigneti							X	X
Ilyodrilus templetoni				X				
Limnodrilus cervix			X	X			X	X
L. claparedeanus			X	X			X	X
L. hoffmeisteri			X	X			X	X
L. udekemianus	X		X	X			X	X
Limnodrilus spp.	X	X	X	X	X	X	X	X
Tubifex sp.		X						
Peloscolex sp.		X						
Unidentified species	X	X	X	X	X	X	X	X
Naididae								
Aulophorus sp.						X		
Dero digitata			X	X			X	X
Nais elinguis			X	X				
Nais sp.								X
Paranais frici			X	X				
Diptera								
Culicidae								
Chaoborus punctipennis				X			X	
Chaoborus sp.		X	X			X		

TABLE 2.3.5-1 (Continued)

Species	Missouri River				Logan Creek			
	J	S	D	F	J	S	D	F
Chironomidae								
Ablabesmyia janta			X					
Zavrelimyia spp.	X				X			
Procladius adumbratus			X	X			X	X
P. riparius	X		X	X	X		X	X
Procladius spp.	X							
Paralauterborniella sp.	X	X	X					
Rheotanytarsus sp.		X	X	X	X	X		
Polypedilum halterale				X			X	
P. scalaenum					X			
Polypedilum sp.		X		X	X	X		
Cryptochironomus blarina			X					
Cryptochironomus fulvus			X	X	X		X	X
Cryptochironomus sp.	X	X				X		
Trissocladius sp.			X	X			X	X
Tendipedini spp.		X	X					
Paracladopelma sp.				X			X	
Paratendipes sp.		X	X		X			
Chironomus spp.		X	X	X	X	X	X	X
Cricotopus exilis			X	X				X
Stictochironomus sp.				X	X			X
Conchapelopia sp.			X					
Coelotanypus sp.			X					
Pseudochironomus sp.		X				X	X	
Orthocladius sp.				X				
Dicrotendipes sp.		X	X	X	X	X	X	
Trichocladius sp.		X						
Glyptotendipes lobiferus			X					X
Glyptotendipes senilis					X			
Glyptotendipes sp.				X		X		
Unidentified species		X						

TABLE 2.3.5-1 (Continued)

Species	Missouri River J	Missouri River S	Missouri River D	Missouri River F	Logan Creek J	Logan Creek S	Logan Creek D	Logan Creek F
Ceratopogonidae								
Bezzia sp.					X			
Unidentified sp.			X	X				X
Psychodidae								
Psychoda sp.				X				
Ephemeroptera								
Hexagenia sp.			X					
Pentagenia vittigena		X						
Pentagenia sp.	X		X					
Caenis sp.	X							
Stenonema femoratum			X			X		
Ephemerella frisoni		X				X		
Trichoptera								
Neureclipsis sp.			X					
Hydropsyche orris			X	X				
Cheumatopsyche sp.			X	X				
Unidentified sp.	X							
Odonata								
Argia sp.			X					
Gomphus sp.				X				
Coleoptera								
Dubiraphia sp.	X			X				
Unidentified sp.								
Collembolla								
Unidentified sp.			X	X	X			
Amphipoda								
Hyalella azteca		X						
Gastropoda								
Ferrisia sp.			X					
Pelecypoda								
Corbiculidae								
Corbicula sp.		X						
Sphaeriidae								
Unidentified sp.								X

TABLE 2.3.5-2

MACROBENTHIC INVERTEBRATES COLLECTED FROM THE MISSOURI RIVER
DURING JULY, SEPTEMBER, DECEMBER, AND FEBRUARY

Date	Organisms	Station A-1 No/m²	Station A-1 % Total	Station A-2 No/m²	Station A-2 % Total	Station B-1 No/m²	Station B-1 % Total	Station B-2 No/m²	Station B-2 % Total	Station C-1 No/m²	Station C-1 % Total	Station C-2 No/m²	Station C-2 % Total
July 1973	Oligochaeta	7	50	49	32	0	-	14	25	0	-	7	100
	Diptera	0	-	21	14	98	100	0	-	14	100	0	-
	Ephemeroptera	7	50	77	50	0	-	35	63	0	-	0	-
	Trichoptera	0	-	0	-	0	-	7	13	0	-	0	-
	Coleoptera	0	-	7	5	0	-	0	-	0	-	0	-
	TOTAL	14	100	154	101	98	100	56	101	14	100	7	100
September 1973	Oligochaeta	0	-	231	52	0	-	505	96	0	-	539	99
	Diptera	42	100	35	8	42	100	7	1	476	100	7	1
	Ephemeroptera	0	-	173	39	0	-	14	3	0	-	0	-
	Pelecypoda	0	-	7	2	0	-	0	-	0	-	0	-
	TOTAL	42	100	446	101	42	100	526	100	476	100	546	100
December 1973	Oligochaeta	Not collected		0	-	0	-	364	68	7	33	2205	81
	Diptera	bottom scoured		21	100	0	-	154	29	7	33	434	16
	Ephemeroptera	by high water		0	-	0	-	14	3	7	33	56	2
	Trichoptera			0	-	0	-	0	-	0	-	21	1
	TOTAL	-	-	21	100	0	-	532	100	21	99	2716	100
February 1974	Oligochaeta	Not collected		0	-	Not collected		525	67	0	-	21	60
	Diptera	Bottom scoured		0	-	Bottom scoured		224	29	0	-	14	40
	Trichoptera	by high water		14	100	by high water		14	2	0	-	0	-
	Odonata			0	-			14	2	0	-	0	-
	Coleoptera			0	-			7	1	0	-	0	-
	TOTAL	-	-	14	100	-	-	784	101	0	-	35	100

TABLE 2.3.5-3

MACROBENTHIC SPECIES DIVERSITY INDICES FOR STATIONS ON THE MISSOURI RIVER AND LOGAN CREEK

Date	A-1	A-2	B-1	B-2	C-1	C-2	D	E
July 1973	1.00	2.42	0.75	1.30	0.00	0.00	1.16	3.44
September 1973	0.00	1.66	0.00	0.74	2.66	1.00	1.43	2.76
December 1973	N.C.[a]	1.59	0.00	3.36	1.59	3.57	2.75	3.12
February 1974	N.C.[a]	0.92	N.C.[a]	3.58	0.00	2.16	2.85	2.70
Average	0.50	1.65	0.25	2.25	1.06	1.69	2.05	3.00

[a]Not collected - bottom scoured by high water.

TABLE 2.3.5-4

WET-WEIGHT BENTHIC BIOMASS - MISSOURI RIVER AND LOGAN CREEK

Date	Station	(Number of Organisms) Wet-Weight in mg/m²								Total
		Oligochaeta	Diptera	Ephemeroptera	Trichoptera	Pelecypoda	Odonata	Coleoptera	Other	Wet-Wt
July 1973	A-1	(7)2.1	-	(7)2.8	-	-	-	-	-	4.9
	A-2	(49)11.6	(21)3.2	(77)28.7	-	-	-	(7)19.6		63.1
	B-1	-	(98)7.0	-	-	-	-	-	-	7.0
	B-2	(14)2.8	-	(35)9.8	(7)40.6	-	-	-	-	53.2
	C-1	-	(14)2.1	-	-	-	-	-	-	2.1
	C-2	(7)3.5	-	-	-	-	-	-	-	3.5
	D	(73)33.6	(30)9.8	-	-	-	-	-	-	43.4
	E	(73)27.7	(991)317.6	-	-	-	-	-	(29)5.8	351.1
September 1973	A-1	-	(42)13.4	-	-	-	-	-	-	13.4
	A-2	(231)234.5	(35)11.2	(173)192.5	-	(7)161.7	-	-	-	599.9
	B-1	-	(42)13.4	-	-	-	-	-	-	13.4
	B-2	(505)648.9	(7)2.2	(14)16.1	-	-	-	-	-	667.2
	C-1	-	(476)152.3	-	-	-	-	-	-	152.3
	C-2	(539)990.5	(7)2.2	-	-	-	-	-		992.7
	D	(1130)711.2	(118)37.8	-	-	-	-	-	-	749.0
	E	(205)91.0	(3549)1135.7	(206)58.1	-	-	-	-	(73)1.4	1286.2
December 1973	A-1	Not Collected								
	A-2	-	(21)8.4	-	-	-	-	-	-	8.4
	B-1	-	-	-	-	-	-	-	-	-
	B-2	(364)327.6	(154)81.6	(14)1.4	-	-	-	-	-	410.6
	C-1	(7)21.0	(7)4.2	(7)0.7	-	-	-	-	-	25.9
	C-2	(2205)5512.5	(434)173.6	(56)89.6	(21)21.0	-	-	-	-	5796.7
	D	(1750)7227.5	(235)517.0	(15)33.0	-	-	-	-	(59)5.9	7783.4
	E	(573)879.0	(309)669.5	-	-	-	-	-	-	1548.5

TABLE 2.3.5-4 (Continued)

Date	Station	Oligochaeta	Diptera	Ephemeroptera	Trichoptera	Pelecypoda	Odonata	Coleoptera	Other	Total Wet-Wt
		(Number of Organisms) Wet-Weight in mg/m^2								
February 1974	A-1	Not Collected								
	A-2	-	-	-	(14)186.2	-	-	-	-	186.2
	B-1	Not Collected								
	B-2	(525)525.0	(224)107.1	-	(14)9.8	-	(14)487.9	(7)2.4	-	1132.2
	C-1	-	-	-	-	-	-	-	-	-
	C-2	(21)12.6	(14)1.4	-	-	-	-	-	-	14.0
	D	(2484)18,795.6	(382)636.7	-	-	(15)57.0	-	-	-	19,489.3
	E	(441)1367.1	(221)839.8	-	-	(74)532.8	-	-	-	2739.7

TABLE 2.3.5-5

MACROBENTHIC INVERTEBRATES COLLECTED FROM LOGAN CREEK DURING JULY, SEPTEMBER, DECEMBER, AND FEBRUARY

		Station D		Station E	
Date	Organisms	No/m^2	% Total	No/m^2	% Total
July 1973	Oligochaeta	73	71	73	7
	Diptera	30	29	991	91
	Other	0	-	29	3
TOTAL		103	100	1093	101
September 1973	Oligochaeta	1130	91	205	5
	Diptera	118	9	3549	88
	Ephemeroptera	0	-	206	5
	Other	0	-	73	2
TOTAL		1248	100	4033	100
December 1973	Oligochaeta	1750	85	573	65
	Diptera	235	11	309	35
	Ephemeroptera	15	1	0	-
	Other	59	3	0	-
TOTAL		2059	100	882	100
February 1974	Oligochaeta	2484	86	441	60
	Diptera	382	13	221	30
	Pelecypoda	15	1	74	10
TOTAL		2881	100	736	100

2.3.6 FISH

2.3.6.1 Missouri River

The high turbidity, swift currents, and unstable sand and silt bottom characterizing the Missouri River are the principal factors controlling and limiting the distribution of fish in this waterway. Generally, in streams and rivers receiving a heavy inorganic sediment load, fish populations have a reduced standing crop and individual fish a slower growth rate (Gammon, 1970). The fisheries of the lower two-thirds of the Missouri River are not very productive, not only because of the high turbidity, but also because of the lack of fish food organisms (University of Missouri-Rolla, 1972), which are also limited by the ecological factors influencing fish.

Stream channelization has directly affected fishes by eliminating quiet water habitats, with their associated brush and log substrates favorable to aquatic insects and other fish food organisms. Because of these habitat changes, small rivers and streams entering the Missouri have become increasingly prominent as spawning and nursery areas for fish. Before channelization of the river, there were extensive side channels and backwater areas that served as spawning sites. Because spawning and nursery sites and fish food organisms have been reduced, the ecosystem cannot support large and diverse fish populations. Those fish found in the Missouri River are specialized for this particular habitat.

The discussion of Missouri River fish is divided into two parts: a presentation of the life histories data gathered during the literature review and a presentation of data obtained from the sampling stations during the sampling program.

Thermal tolerances of representative fish species are presented in Table 2.3.6-1.

2.3.6.1.1 Life Histories

Important species of game fish collected in the Missouri near the site during the present study were white crappie, catfish (blue, channel, and flathead), and freshwater drum.

The white crappie is common in ponds, lakes, rivers, and streams east of the Rocky Mountains. They generally prefer quiet water where cover is provided by aquatic plants, submerged trees, or brush. Spawning usually occurs from May through June, when water temperatures are from 63.5° to 68°F (Calhoun, 1966). White crappies spawn under a variety of conditions of bottom, water depth, and proximity to embankments, vegetation and wooden structures, but they prefer to deposit their eggs on plant material in quiet water (Hansen, 1951). The number of eggs produced per female in a season ranges from 22,800 to 194,000, according to a sample of 24 fish examined by Siefert (1969). The maximum length recorded for the species is 381 mm (Goodson, 1966).

Channel catfish have been widely introduced in this country, but their original range was from Montana, southern Manitoba to southern Quebec, south and west of the Appalachians, Florida, and Mexico. Young channel catfish feed primarily on aquatic insects or other arthropods; as they mature, they feed on other fish and crayfish. Channel catfish prefer moderate to swiftly flowing streams. They often inhabit deep pools in the main channel of the river and wait for food to be carried to them by the current. Spawning occurs from late May to early July at optimal temperatures of 80°F (Miller, 1966). Adult channel catfish appear to be highly migratory, often ascending streams to spawn. They prefer to nest in a dark cavity or crevice along a stream bank or beneath debris lodged in the channel. Berner (1947) found that debris associated with pile dikes in the Missouri River provided suitable spawning habitat for channel catfish. Females have been estimated to produce 3,000 to 4,000 eggs per pound of body weight per year (Miller, 1966).

The flathead catfish occurs in Lake Erie and in the large rivers of the Mississippi Valley south to Mexico. Larval catfish feed primarily on insect larvae, while adults feed primarily on other fish. Spawning occurs from May to late June. The average number of eggs produced per female is 9,000 (Carlander, 1969).

The blue catfish occurs in large rivers from South Dakota to Ohio and south into Mexico, preferring to live in streams with moderately to swiftly flowing water. Larvae and fingerlings feed primarily on zooplankton and larval aquatic insects, while adults feed mainly on crayfish and other fish. There is very little information in the literature on the spawning habits of this fish; however, they are thought to migrate long distances during the spawning season (Pflieger, 1971). Blue catfish up to 1194 mm long and 10 years old have been captured (Carlander, 1969).

The freshwater drum are found southward from Canada throughout the Mississippi River system and eastern Mexico to Guatemala. They spawn from May to August at water temperatures of 64° to 76°F (Swedberg and Walburg, 1970). They lay pelagic eggs in lakes and probably in rivers. Spawning usually occurs when the discharge of the river is increasing, thus carrying the eggs out to the channel and onto flooded land. This tends to minimize losses downstream and enables hatching to occur in suitable nursery areas. The eggs of the freshwater drum are very clear, making them difficult to see and therefore less subject to predation. Approximately 13,800 eggs are produced per female per season (Swedberg and Walburg, 1970).

During the present study, one paddlefish specimen was observed, although none were collected. Though edible, the paddlefish is not considered a game species because it cannot be captured by ordinary game fishing methods. It occurs in the large rivers of the Mississippi drainage system. The major food of the paddlefish is plankton; however, they also eat insects and small fish. They spawn in schools, preferably over large gravel bars or over sand and pebbles in a strong current at a water temperature of 61°F (Purkett, 1963). Spawning usually occurs from March to June. Before fertilization, a coating forms on the eggs, making them very adhesive and allowing them to attach to the first object they contact, usually a rock or pebble (Purkett, 1963). The most favorable location for hatching is over a clear gravel bar, where the eggs will not be subject to siltation, and aeration is good, enhancing the possibility of development. Eggs hatch within 7 days at water temperatures of 64° to 68°F. Carlander (1969) reports that two female paddlefish examined had 137,247 and 141,531 eggs.

Important rough species collected near the site include carp, river carpsucker, longnose and shortnose gar, and smallmouth and largemouth buffalo.

Carp have been introduced into most of the United States and southern Canada. It is generally considered a rough species, but it is also sought as a game species in Callaway County. Carp are successful because they are highly adaptable and able to survive in a variety of habitats, from clear to grossly polluted waters. Because of their tolerance to high turbidity and their specialized feeding habits, they have adapted well to the Missouri River. They are primarily bottom feeders, sucking mud and silt from the bottom and straining out food particles. They thrive in the Missouri River by living along the banks out of the main channel and foraging on detrital matter deposited by the current. Spawning occurs from March to August, and two spawns in one season are not uncommon. Spawning usually begins when the water temperature reaches 58°F and greatest activity occurs at temperatures of 65° to 68°F. The fecundity of the carp is high. The number of eggs per female ranges from 100,000 to 700,000, depending on the size of the fish (Carlander, 1969). Over 2 million eggs have been reported to occur in one female. Carp are generally less than 750 mm long, but specimens up to 1219 mm have been reported (Carlander, 1969).

The river carpsucker occurs from Montana to Pennsylvania and south to Tennessee and Texas. Habitats preferred by river carpsucker are calm pools, backwaters, or gentle eddies, where sediments accumulate, rather than the turbulent main channels of streams. Like the carp, they thrive in the Missouri River by living along the banks and foraging on detritus. Their feeding habits and diet are very similar to carp. Spawning occurs from April to August at water temperatures of 65° to 75°F (Jester, 1972). The peak of spawning activity occurs near the beginning of June at around 70°F. River carpsuckers prefer to deposit their eggs along the banks of streams near roots and fallen logs. Eggs produced per female averaged 28,305 in Age Group II to 273,000 in Age Group X (Jester, 1972). River carpsuckers have been known to live up to 11 years and attain a length of 643 mm (Carlander, 1969).

The longnose gar occurs from Montana to Quebec and south to the Gulf of Mexico and the Rio Grande. It is found frequently in brackish water. Larval and fingerling gar feed primarily on insect larvae, but adults feed almost exclusively on fish. Spawning occurs from late April to June in quiet backwaters of smaller streams. Approximately 30,000 eggs are produced per female (Carlander, 1969). Longnose gar up to 1600 mm long have been reported by Carlander.

The shortnose gar occurs in silty rivers in the Mississippi and Ohio River drainage from southern Minnesota and Ohio to northern Louisiana and Texas. Larval and fingerling specimens feed on mosquito larvae and other fish. The spawning season and average fecundity are the same as the longnose gar (Carlander, 1969). Spawning usually occurs in quiet backwaters and pools of the rivers.

The smallmouth buffalo occurs mainly in larger streams, preferring shallow water areas with a firm bottom. Smallmouth buffalo are bottom feeders; their diet consists largely of crustaceans, insect larvae, and small mollusks. Spawning occurs in May; the eggs are deposited randomly over the bottom or in vegetation.

The largemouth buffalo is usually found in calm areas of rivers or lakes. It is both a bottom and pelagic feeder, consuming small crustaceans, insect larvae, algae, other vegetation, and, occasionally, small fish and fish eggs. Spawning occurs when water temperatures reach 60° to 65°F; eggs are deposited randomly over mud bottoms or in submerged vegetation (Herlan and Speaker, 1969). As many as 400,000 eggs have been found in 10 lb. females (Harlan and Speaker, 1969). Specimens 20 years old have been reported, but most do not attain 6 years (Carlander, 1969).

Forage species are those fish that, at some stage of their life cycle, serve as food for other fish. The gizzard shad was the principal forage species collected near the site; it was also the most numerous species collected. The gizzard shad occurs from Minnesota to the St. Lawrence River and New Jersey, south to the Gulf and into Mexico. It is a valuable forage fish, forming an important link in the food chain of game fish and other piscivores. Because it has a high reproductive potential and rapid growth rate, this species tends to overpopulate some waters to the detriment of other fish populations. It is highly successful in the Missouri River because of its tolerance to excessive turbidity and waters supporting little or no vegetation and sparse benthic fauna. However, gizzard shad may quickly succumb to abrupt temperature changes or reduction in water oxygen levels (Jester and Jensen, 1972). Food preferences of the gizzard shad also favor its success in the Missouri River, since adults feed primarily on detritus (Hynes, 1972). Spawning occurs during May and June at temperatures from 64° to 75°F (Jester and Jensen, 1972). A second spawning may occur in late summer. Spawning is offshore, preferably in shallow water, but shad have been observed spawning at the surface over deep water. The eggs are scattered; there is no preparation of a nest site. The average number of eggs produced per female is 40,500, but a decline in fecundity with increasing size and age has been noted (Jester and Jensen, 1972).

Five chestnut lamprey were collected from the Missouri. This species cannot be classified as a game, rough, or forage species, but is parasitic on such fish as carp, buffalo, redhorse, paddlefish, and the larger sunfish. They attach themselves to the sides of large fish by their funnellike mouths and then use their toothed tongue to create a shallow wound, from which they draw their host's body fluids. When satiated, they detach themselves. Many of these hosts survive, because some fish captured commercially in the Missouri bear scars of lamprey wounds (Cross, 1967). After an undetermined period of parasitic existence, lamprey mature and move upstream in the spring to spawn. Preferred spawning sites are swift, shallow riffles where the bottom is composed of clear gravel. Upon hatching, the young move downstream to slack-water areas. Here they burrow into the soft sediment and feed on minute organisms. After one to several years, the larvae emerge and assume the parasitic habit. Commercial fishermen reported a decline in lamprey and scarred fish in the 1950's (Cross, 1967). Cross postulates that former spawning habitats have been modified by watershed cultivation and the resulting siltation and instability of flow.

2.3.6.1.2 Species Composition, Age, Growth, and Condition Factor

Sixty-seven fish species representing 16 families have been reported from the Missouri segment of the Missouri River (Pflieger, 1971). In 1971, during the Missouri River Environmental Inventory, 19 species representing 12 families were collected at Hermann, Missouri, approximately 20 river miles downstream from the site (University of Missouri-Rolla, 1972). During the present study, 28 fish species representing 13 families were collected at the north shore transects on the Missouri River. Table 2.3.6-2 compares the known species composition of fish in the Missouri River with those known to occur near the site and provides a checklist of the common and scientific names of the species discussed below. Table 2.3.6-3 summarizes the number of fish captured per sampling period, their size range, and the percentage of the total catch (all periods) comprised by each species. Because of the relatively low numbers of fish captured during the survey, data from Transects F and G collected during September and December have been included in the analyses (this data is not utilized in analyses of other aquatic biota; see Section 2.1).

Nineteen fish representing 11 species were collected in July, while 217 fish representing 14 species were collected in September, and 399 fish representing 21 species were collected in December (Table 2.3.6-3). The higher numbers of fish collected in September and December relative to July not only reflect the increased number of sampling transects (F and G), but also the increased use of fyke nets.

The gizzard shad, a forage species, was the most abundant species collected from the Missouri River near the site. It comprised approximately 66 percent of all fish collected during the study. (It was similarly the most abundant species in the collections of the Missouri River Environmental Inventory [University of Missouri-Rolla, 1972]). The gizzard shad also occurs in every principal stream in the state and inhabits lowland lakes, ponds, and man-made impondments (Pflieger, 1967). Near the site, it was especially abundant along the river banks in quieter waters, where large schools were observed. Because the gizzard shad was more abundant than any other species, it was possible to calculate the mean length, weight, and condition factor for each age group taken in the September and December samples (Table 2.3.6-4). Generally, these values were low in comparison with other studies. This may be related to the high turbidities and unstable bottom characteristic of the Missouri, since these conditions restrict the production of fish food organisms. The condition factor for comparable age groups were generally lower in December than in September, probably the result of sample size variations or decreased availability of food organisms in winter.

The carp was the second most abundant species collected, comprising approximately 7.9 percent of the total. It was the most abundant species in commercial catches in the Missouri River from 1965 to 1971 (Robinson, 1973a). Although the carp is commonly known as a rough fish, local fishermen take this species by hook and line, as well as with trotline sets. A creel survey taken by Dames & Moore aquatic biologists in July and September at the Mokane access ramp (approximately 8 miles upstream from the site area) indicated that about 80 percent of the catch consisted of carp. Size and age of carp are highly variable, depending on environmental conditions. According to Carlander (1969), most individuals of natural populations do not attain 7 years. Most specimens captured in the present study were 6 years old or under, with one individual 12 years old. Captured carp ranged from 277 to 668 mm total length. Carp collected near Hermann during the Missouri River Environmental Inventory ranged from 379 to 836 mm total length and were 2 to 6 years old (University of Missouri-Rolla, 1972).

Other rough fish collected near the site were the river carpsucker, longnose and shortnose gar, smallmouth and largemouth buffalo, the goldeye, and mooneye. Only a few specimens of each species were captured.

The river carpsucker was the fourth most abundant species collected in the Missouri near the site. The 29 specimens collected during the study ranged from 2 to 7 years old and 132 to 445 mm total length. Longnose and shortnose gar were collected in similar numbers. The largest longnose gar specimen collected near the site was 932 mm total length. Shortnose gar collected during the Missouri River Environmental Inventory ranged from 422 to 740 mm long (University of Missouri-Rolla, 1972). Specimens collected during the present study were within this range.

Although buffalo were the second most abundant fish in commercial catches in the Missouri River from 1965 to 1971 (Robinson, 1973a), only one smallmouth and three largemouth buffalo were collected near the site during the study. The largemouth buffalo collected during the program ranged from 426 to 512 mm total length and from 4 to 8 years old.

Game fish collected were the white crappie, freshwater drum, largemouth bass, bluegill, catfish, sauger, and northern pike. With the exception of the white crappie, most of these species were represented by only a few specimens (Table 2.3.6-3).

The white crappie was the most abundant sport fish captured in the Missouri during the survey; it was the third most abundant of all species captured, comprising 5.4 percent of the total. The white crappie was also found during the Missouri River Environmental Inventory to be the most abundant sport fish in the Missouri River at five stations between Rulo, Nebraska, and St. Louis (University of Missouri-Rolla, 1972). During the present study, white crappies up to 286 mm total length and 4 years old were collected. Specimens ranging from 155 to 250 mm long were taken in the Missouri River near Hermann during the Missouri River Environmental Inventory.

The freshwater drum was the second most abundant sport fish taken near the site. Large numbers of freshwater drum fry and fingerlings were observed in the backwaters of the downstream sides of groins. Twenty-two freshwater drum 92 to 363 mm total length and up to 5 years old were collected. During the Missouri River Environmental Inventory (University of Missouri-Rolla, 1972), 9 specimens 112 to 352 mm long and up to 3 years old were collected near Hermann.

A field survey of fishermen's catches during July and September of the survey found that catfish are the game fish most frequently sought near the site. They are commonly captured with trotline sets. The three species captured during the present study were the channel, blue, and flathead. Channel catfish are important commercial as well as game fish in Callaway County, but only one specimen was captured during the present study. Five specimens of the blue catfish were captured; these ranged from 418 to 818 mm total length. Only a few flathead catfish were captured.

One paddlefish was observed, but none were collected. Sport fish collected during the Missouri River Environmental Inventory but not captured during the present study were the smallmouth bass and black crappie.

Five chestnut lamprey ranging from 315 to 325 mm total length were collected during the December sampling period.

Of the 33 species of native fish considered threatened or endangered in Missouri (Miller, 1972), the only one reported from the Missouri River bordering Callaway County is the sicklefin chub (Pflieger, 1971). No specimens of this species were collected during the present study.

No larval forms were collected in the larval fish tows. Apparently sampling periods and/or depths did not coincide with their seasonal or diurnal distributions

2.3.6.1.3 Food Habit Studies

Food studies provide details of the ecological relationships among organisms and help to explain the condition and growth rate of fish. Food habits of the more important fish were studied to determine what items were being utilized as forage. These findings may be compared to later studies to determine if feeding habits have changed. Extensive environmental changes in an area can lead directly or indirectly to changes in the feeding habits of fishes. However, changes in feeding habits are not necessarily detrimental, unless the organisms' feeding habits are very specialized.

Food habits of fish vary with seasons, food availability, and life cycle stages. For example, the diet of most young fishes probably consists of microscopic plants and animals, including algae, protozoans, and crustaceans found on plants, in bottom material, or floating in the water column. As fish develop and attain sexual maturity, feeding adaptations develop, and the diets of some species become very restricted according to the niche that they occupy in the aquatic habitat. For example, some fish, such as gizzard shad and paddlefish, become plankton feeders at an early stage and remain so throughout their life. Some fish are herbivorous, including most of the smaller cyprinids. Others are strictly carnivorous, such as pike, gar, bass. Most of the sunfishes and others such as carp are omnivorous.

Aquatic insects are an important food source for most fishes at some stage of their development. The groups utilized include the mayflies, stoneflies, dragonflies, damselflies, water striders, back swimmers, fish flies, helgrammites, caddisflies, beetles, midges, mosquitos.

As indicated previously, most fishes prefer to feed on certain groups of organisms, depending on whether they are herbivores, omnivores, or carnivores. However, they also are opportunistic to a certain extent and will crop off organisms that are available. This has led to the concept of the availability factor of individual prey species (Hynes, 1972), a ratio of the percentage of that species in the food of the fish to its percentage in the fauna. When there is only one prey species, obviously there is no selection, but if there are more prey species than fish, the prey can be preferentially selected or rejected.

The stomach content data collected in this study identified at least eight food item taxa, and possibly more could be accounted for in the category of "unidentified organic material." Thus, Missouri River fish can be somewhat selective in their feeding habits, depending on the niche they occupy in the aquatic ecosystem.

All of the major groups of macroinvertebrates collected (listed in Section 2.3.5) were utilized by most fish, with the exception of the piscivores (including longnose and shortnose gar and flathead catfish), which did not ingest any macroinvertebrates (Table 2.3.6-5). Dipterans and ephemeropterans were the most numerous organisms collected in the Missouri River and were found in some of the fish stomachs during each collecting period. They comprised 25 percent of the diet of all noncarnivorous species selected for stomach analysis. Trichopterans were also important as a food source, being utilized by some of the fish during each collecting period.

There were very few empty stomachs in the fish captured during September. This may be related to conclusion of the spawning activities. Zweiacker (1972) found that there was an increase in feeding rate after spawning, indicated by a lower percentage of empty stomachs than before and during spawning. The small percentage of empty stomachs during the months of July and September also may be related to higher summer water temperatures. During these months, feeding and digestion rates are assumed to be highest, especially in a flowing body of water, such as the Missouri River, where the water is well mixed and does not stratify, as in a lake or reservoir.

When water temperatures decline during winter, fish do not grow; their only bodily functions are for maintenance. The food ingested normally requires a long period for digestion and may be difficult to identify in excised stomachs. When water temperatures averaged 2.8°C during December, approximately 44 percent of the stomachs examined were empty.

Table 2.3.6-5 summarizes stomach analysis data for Missouri River species for all sampling periods. A total of 158 fish stomachs were taken from 14 fish species collected in Transects A, B, and C during July, September, and December. Data from major species are discussed in greater detail below. Food habit data collected during September from Transects F and G are summarized in Appendix Table 2A-4. The stomachs taken from fish collected in Transects F and G during December contained no food items.

Eighty-six stomachs were examined from gizzard shad, the most abundant species collected in the Missouri River near the site. Gizzard shad are specialized in their feeding habits, having long gill rakers enabling them to sieve organisms from the water. Jude (1973) found that gizzard shad in the Missouri River fed on some bottom materials and also filtered suspended material from the water. The most important food items in the gizzard shad stomachs collected in September were diatoms (45 percent of the stomach contents) and green algae (6 percent of the stomach contents). Ephemeropterans were also found, but they comprised only 1 percent of the stomach contents. The remaining food items could not be identified. Of the 44 gizzard shad captured in December, 20 had empty stomachs. Stomach content organisms of the remaining fish were broken apart and partially digested and could not be identified.

The stomachs of twenty-five carp, the second most abundant species collected in the river near the site, were also examined. The carp is typically a bottom feeder, sucking up organic mud and detritus indiscriminately. Thus, organic material that has settled to the bottom may be ingested by the carp. Fly larvae comprised 40 percent of the contents taken from stomachs collected in September. No other food items were identifiable. Of 18 stomachs taken in December, seven were empty. The remaining stomachs contained unidentifiable organic matter.

A total of 18 river carpsuckers collected from the Missouri River were chosen for stomach analysis. Jester (1972) reports that food studies of the river carpsucker taken from the Des Moines River showed the major food items to be algae and microcrustacea. The carpsucker usually feeds near the bottom and sucks up material containing organic deposits; it is very difficult to identify the stomach contents. Seven of the stomachs examined contained no food, and the only identifiable food item found in the other stomachs was the dipteran larvae, which comprised a very small percentage of the total weight of the stomach contents: 10 and 20 percent for September and December, respectively.

According to Goodson (1966), larval white crappies feed primarily on zooplankton, while crustaceans, insects, and fish largely constitute the diets of adults. Five white crappie stomachs were taken during the survey; the principal food item was found to be fish. July sample stomachs were found to contain the fry of freshwater drum; aquatic insects comprised the remainder of the diet.

Swedberg and Walburg (1970) determined that freshwater drum young of the year feed mainly on microcrustaceans (Daphnia sp. and Cyclops sp.); as they mature, they feed on aquatic insect larvae. Of the 12 freshwater drum stomachs analyzed, three were empty, while the remainder contained immature forms of aquatic insects and unidentifiable organic material.

2.3.6.2 Logan Creek

The discussion of Logan Creek fish is in two parts. The first presents the life histories data from the literature review; the second presents the sampling data obtained during the sampling program.

2.3.6.2.1 Life Histories

The following discussion of the life histories of important Logan Creek fish species does not include information on those species - gizzard shad, carp, river carpsucker, white crappie - found in greater abundance in the Missouri River. Life histories of these species can be found in Section 2.3.6.1.1.

Sunfish (bluegill, green, and longear), largemouth bass, bullhead, and white crappie are the game species found in Logan Creek. Although there has been some sport fishing in the creek in past years, creel census data are not available. According to the local game warden, bullhead, largemouth bass, and white crappie are the species most commonly caught in Logan Creek (Wilson, 1973).

The bluegill originally ranged from southern Ontario through the Great Lakes and Mississippi drainages to Georgia, Texas, and northeastern Mexico, but widespread introductions have greatly extended the range. Only two specimens were collected in the Missouri River. This concurs with their preference for protected areas with clear, quiet water, scattered beds of vegetation, and substrates of sand or gravel. Bluegills feed mainly on zooplankton and aquatic insects, but other foods ingested include small fish, fish eggs, snails, small crayfish, and amphipods. Because of differential maturity of fish or of eggs within a single fish, bluegills spawn over an extended time period, beginning when water temperatures reach 70°F and continuing until fall (Emig, 1966a). However, the peak of spawning activity is usually in May or early June. The fecundity averages approximately 18,000 eggs per female (Emig, 1966a). Emig (1966a) reports that bluegills can attain a length of 253 mm.

The green sunfish is widely distributed and is very successful in surviving drought in residual pools of streams. Its diet is mainly comprised of insects, both aquatic and terrestrial, but fish are also eaten. Green sunfish usually reproduce during May and June. Males construct and guard nests located in shallow water areas where the bottom is smooth and clean.

The longear sunfish is usually found in streams having numerous pools with permanent or semi-permanent flow of clear water over unsilted bottoms of stone or firm clay. The reproductive period is often extended from May to July. The longear sunfish feeds mainly on aquatic and terrestrial insects but also consumes other invertebrates and small fish. Longear sunfish up to 203 mm long have been reported (Eddy, 1969).

The largemouth bass is an important, widely introduced game species which originally ranged from southeastern Canada throughout the Great Lakes region, southward through the Mississippi Valley to Mexico and Florida and on the Atlantic Coast as far north as Virginia. During the present study, most specimens were collected in Logan Creek, reflecting their preference for a habitat characterized by clear water and aquatic vegetation, although vegetation is sparse in Logan Creek. High turbidities, typical of the Missouri River, are considered detrimental to reproduction and growth of largemouth bass (Emig, 1966c). Young specimens feed primarily on zooplankton and small crustaceans, but as they mature they eat more aquatic insect larvae. The adult diet consists mainly of fish, but also includes worms, mussels, frogs, crayfish and snails. Spawning usually occurs at water temperatures of 61° to 65°F, beginning in late spring and continuing until early July (Emig, 1966c). Largemouth bass will not spawn on silt bottoms but utilize a substrate of sand, gravel, roots, or aquatic vegetation. Normally about 5,000 eggs are produced per female (Emig, 1966c).

The brown bullhead originally ranged from Saskatchewan to Nova Scotia, south to Mississippi and Florida, but it has also been introduced extensively in western North America. It is considered by Miller (1972) as a rare Missouri species. In the Missouri River system, the species has been reported previously only in tributaries to the Missouri near Rocheport, approximately 60 miles upstream from the site (Fisher, 1962). Pflieger (1971) reports that the species has also been collected in two areas in southwestern Missouri and has been stocked in a few ponds in the state. Young brown bullheads have been reported to feed chiefly on chironomid larvae and zooplankton, but the adults are omnivorous. In large rivers, brown bullheads are most common in sloughs or backwaters. They prefer to inhabit deep, weedy waters with a sand, gravel or muck substrate. The species is hardy, able to tolerate relatively high temperatures, high carbon dioxide levels and low oxygen levels. Spawning usually begins in late April or in May when water temperatures approach 70°F (Emig, 1966b) and may continue through September, sometimes occurring more than once a year. Females from 8 to 13 inches long may lay from 2,000 to 13,000 eggs per season (Emig, 1966b).

Forage species abundant in Logan Creek included the gizzard shad, mosquitofish, blackstripe topminnow, bluntnose minnow and stoneroller.

The mosquitofish occurs from southern Indiana and Illinois, south to Mexico and Florida and north to New Jersey and has been widely introduced in warm parts of the world for mosquito control. It prefers calm, shallow waters where it feeds principally on mosquito larvae, pupae, algae, and small fish. Overwintering mortality of mosquitofish is high because they have limited tolerance to cold weather. The species is a livebearer, spawning from May to September at temperatures of 72° to 75°F. Average number of eggs produced by females is 40 (Carlander, 1969).

The blackstripe topminnow occurs from Iowa to Ohio, south to Mississippi and east Texas. The species feeds primarily on surface-dwelling insects and on crustaceans. Spawning occurs from May to mid-August, and the fish tend to remain paired (Carlander, 1969).

The bluntnose minnow occurs from southern Manitoba to Quebec, south to North Carolina, Alabama, Louisiana, and Oklahoma. Small organisms and debris constitute the diet of the bluntnose minnow. It spawns from late May to late August at water temperatures above 70°F. Females are estimated to produce about 2,500 eggs (Carlander, 1969).

The stoneroller occurs from southern North Dakota to Texas, east to the Appalachians and north to western New York. During the present study it was collected only at Station E in Logan Creek, where it was abundant. Permanent flow is not an essential habitat requirement for stonerollers because they live in pools throughout much of the year. Their diet consists of diatoms, blue-green algae, and larvae of aquatic insects, which they obtain by scraping the thin film of organic material from the substrate. Spawning occurs from late March to May, with maximum activity occurring when the water temperature reaches 65°F (Carlander, 1969).

2.3.6.2.2 Species Composition, Age, and Growth

During the present study, the fish fauna of Logan Creek was almost as diverse as that of the Missouri River near the site. Compared to the Missouri, Logan Creek generally has lower turbidity, slower waters, more varied substrates, a greater abundance of plantonic and benthic fish food organisms, and at least some vegetation, which, though sparse, could provide fish with food and protection. These conditions are more favorable for certain species and provide more diverse habitats than are found in the Missouri River near the site.

Logan Creek's flow characteristics create its varied habitats. The creek is subject to frequent water level fluctuations; these are caused by surface runoff in the immediate area or by water backing up into the creek from an increased discharge in the Missouri River. During periods of low flow, isolated pools of water may be created in the stream's upper reaches. These pools may have high water temperatures and depleted oxygen in warm weather.

Certain species, such as bluegills, longear sunfish, white crappie, creek chubs, and bullheads, are better able than other species to tolerate the type of habitat conditions found in Logan Creek (Hynes, 1972). In the upper reaches of Logan Creek, where the stream is free flowing, with riffles and small pools, typical riffle habitat species - Johnny darter, logperch, and redbelly dace - are also found. These fish have certain features that help them adapt to this type of habitat: negative buoyancy, created by the absence of swim bladders, or modified fins, which allow the fish to stay in the riffle current.

There were two sampling stations, D and E, on Logan Creek. Station D was located on the Missouri River floodplain, downstream from the confluence of Logan and Mud Creeks. The most abundant species at this station were the bluegill sunfish, a sport species, and the gizzard shad and mosquitofish, both forage species. Other sport species found at Station D were the white crappie, largemouth bass, and one fingerling freshwater drum. Other forage species collected were the blackstripe topminnow and the brook silverside.

Station E was located in the creek's upper reaches, which are free-flowing, with riffles and small pools. Three forage species, the stoneroller, bluntnose minnow, and blackstripe topminnow, were the most abundant species. Other forage species collected at this station were the redfin shiner, southern redbelly dace, logperch, sand shiner, and Johnny darter. Game species captured were the bluegill, green, and longear sunfish, the bluegill-green sunfish hybrids, and the brown bullhead (classified in Missouri as rare: Miller, 1972).

Mosquitofish were the most abundant species found in Logan Creek, comprising over 20 percent of the total number collected, although it was found only at Station D. The second most abundant species was the bluegill sunfish, which comprised over 16 percent of the total. Captured bluegills ranged from 98-174 mm total length. The blackstripe topminnow, comprising over 12 percent of the total, was the third most abundant species. The gizzard shad, bluntnose minnow, and the stoneroller were also among the more abundant species. The bluntnose minnow was found only at Station E. Green sunfish comprised about 4 percent of all fish collected. About 3 percent of captured fish were longear sunfish; these ranged from 92 to 139 mm total length and were 1 to 2 years old. The largemouth, the brown bullhead, the carp, and the river carpsucker comprised the remaining species collected. The carp and river carpsuckers were present in very low numbers (Table 2.3.6-6).

Altogether, 27 species from 11 families were collected from the two Logan Creek stations during July, September, and December, 1973, and February, 1974 (Table 2.3.6-2). Larger numbers of fish, as well as more species, were collected in July than in the other sampling periods (Table 2.3.6-6); this may have reflected recent spawning activities, because many specimens collected were young of the year. By September, spawning had ended for most species; fish that had migrated to tributaries like Logan Creek to spawn had probably returned downstream.

2.3.6.2.3 Food Habit Studies

A total of 11 stomachs from fish captured in Logan Creek during July and September were analyzed for stomach contents. The results are summarized in Table 2.3.6-7. No stomach samples were taken in December or February.

Two of the 11 stomachs were empty, but the remaining nine primarily contained beetle larvae, crustaceans, and dipterans. Only seven different types of organisms were identified. This low number of fish food organisms in Logan Creek samples relative to Missouri River samples probably reflects the difference in numbers of stomachs examined.

TABLE 2.3.6-1

THERMAL TOLERANCES OF CERTAIN FRESHWATER FISHES AS DETERMINED BY LABORATORY EXPERIMENTS[a]

	Acclimation Temperature °F	Final Lethal Temperature °F
Shovelnose sturgeon	-	82.4 - 86.0
Paddlefish	-	82.4 - 86.0
Longnose gar	-	96.8 -100.4[b]
Shortnose gar	-	96.8 -100.4[b]
Gizzard shad	86.0	96.6[c]
Skipjack herring	-	89.6 - 93.2
Carp	-	96.8 -100.4
Sicklefin chub	-	86.0 - 89.6[b]
Stoneroller	-	89.6 - 93.2
River carpsucker	-	86.0 - 89.6
Largemouth buffalo	-	89.6 - 93.2
Smallmouth buffalo	-	89.6 - 93.2
Blue catfish	-	93.2 - 96.8[b]
Black bullhead	-	93.2 - 96.8
Yellow bullhead	-	93.2 - 96.8
Channel catfish	77.0	93.2[d]
Flathead catfish	-	93.2 - 96.8
Mosquitofish	95.0	98.6[d]
White bass	-	86.0 - 89.6
Largemouth bass	86.0	101.5[c]
Green sunfish	-	93.2 - 96.8
Longear sunfish	-	93.2 - 96.8[b]
Bluegill	86.0	93.2[d]
White crappie	-	93.2 - 96.8
Freshwater drum	-	93.2 - 96.8[b]

[a]All temperatures from Bush et al. (1972), except those otherwise noted.

[b]Estimated from data on nearest related species.

[c]Battelle's Columbus Laboratories (1971).

[d]Wurtz and Renn (1965).

TABLE 2.3.6-2

SPECIES OF FISH COLLECTED IN THE MISSOURI RIVER AND LOGAN CREEK

FAMILY Species	Common Name	Missouri River Pflieger[a]	Missouri River MREI[b]	Missouri River D&M[c]	Logan Creek[d]
PETROMYZONTIDAE					
Ichthyomyzon castaneus	Chestnut lamprey	X	X	X	
ACIPENSERIDAE					
Scaphirhynchus platorynchus	Shovelnose sturgeon	X		X	
POLYDONTIDAE					
Polyodon spathula	Paddlefish[e]			X	
LEPISOSTHEIDAE					
Lepisosteus osseus	Longnose gar	X		X	
Lepisosteus platostomus	Shortnose gar	X	X	X	
CLUPEIDAE					
Dorosoma cepedianum	Gizzard shad	X	X	X	X
Alosa chrysochloris	Skipjack herring			X	
HIODONTIDAE					
Hiodon alosoides	Goldeye	X	X	X	X
Hiodon tergisus	Mooneye			X	
ESOCIDAE					
Esox lucius	Northern pike			X	
CYPRINIDAE					
Cyprinus carpio	Carp	X	X	X	X
Notemigonus crysoleucas	Golden shiner	X			
Semotilus atromaculatus	Creek chub	X			
Hybopsis storeriana	Silver chub	X			
Hybopsis x-punctata	Gravel chub	X			
Hybopsis aestivalis	Speckled chub	X			

TABLE 2.3.6-2 (Continued)

FAMILY Species	Common Name	Missouri River Pflieger[a]	Missouri River MREI[b]	Missouri River D&M[c]	Logan Creek[d]
CYPRINIDAE (continued)					
Hybopsis gracilis	Flathead chub	X			
Hybopsis meeki	Sicklefin chub	X			
Phenacobius mirabilis	Suckermouth minnow	X			
Notropis atherinoides	Emerald shiner	X	X	X	
Notropis rubellus	Rosyface shiner	X			
Notropis umbratilis	Redfin shiner	X		X	X
Notropis shumardi	Silverband shiner	X			
Notropis zonatus	Bleeding shiner	X			
Notropis boops	Bigeye shiner	X			
Notropis lutrensis	Red shiner	X			X
Notropis stramineus	Sand shiner	X			X
Notropis topeka	Topeka shiner	X			
Notropis heterolepis	Blacknose shiner	X			
Notropis volucellus	Mimic shiner	X	X		
Notropis buchanani	Ghost shiner	X			
Phoxinus erythrogaster	Southern redbelly dace	X			X
Hybognathus argyritis	Western silvery minnow	X			
Hybognathus placitus	Plains minnow	X	X		
Pimephales notatus	Bluntnose minnow	X			X
Campostoma anomalum	Stoneroller	X			X
CATOSTOMIDAE					
Carpiodes carpio	River carpsucker	X	X	X	X
Carpiodes cyprinus	Quillback	X		X	X
Carpiodes velifer	High-finned carpsucker			X	
Catostomus commersoni	White sucker	X		X	
Catostomus catostomus	Longnose sucker			X	
Hypentilium nigricans	Northern hog sucker	X			

TABLE 2.3.6-2 (Continued)

FAMILY Species	Common Name	Missouri River Pflieger[a]	 MRE[b]	 D&M[c]	Logan Creek[d]
CATOSTOMIDAE (Continued)					
Ictiobus cyprinellus	Largemouth buffalo			X	
Ictiobus bubalus	Smallmouth buffalo			X	
Moxostoma duquesnei	Black redhorse	X			
Moxostoma erythrurum	Golden redhorse	X	X		
Moxostoma macrolepidotum	Northern redhorse	X			
ICTALURIDAE					
Ictalurus furcatus	Blue catfish	X		X	
Ictalurus melas	Black bullhead	X			
Ictalurus natalis	Yellow bullhead	X			X
Ictalurus nebulosus	Brown bullhead				X
Ictalurus punctatus	Channel catfish	X	X	X	
Plyodictis olivaris	Flathead catfish	X	X	X	
Noturus exilis	Slender madtom	X			
Notorus flavus	Stonecat	X			
CYPRINODONTIDAE					
Fundulus catenatus	Northern studfish	X			
Fundulus olivaceus	Black spotted topminnow	X			
Fundulus notatus	Blackstripe topminnow	X			X
POECILIIDAE					
Gambusia affinis	Mosquitofish	X			X
ATHERINIDAE					
Labidesthes sicculus	Brook silverside	X			X
PERCICHTHYIDAE					
Morone chrysops	White bass	X	X	X	

TABLE 2.3.6-2 (Continued)

FAMILY Species	Common Name	Missouri River Pflieger[a]	 MREI[b]	 D&M[c]	Logan Creek[d]
CENTRARCHIDAE					
Micropterus dolomieui	Smallmouth bass	X	X		
Micropterus salmoides	Largemouth bass	X		X	X
Lepomis cyanellus	Green sunfish	X			X
Lepomis humilus	Orange spotted sunfish	X			
Lepomis megalotis	Longear sunfish	X			X
Lepomis macrochirus	Bluegill	X	X	X	X
Lepomis cyanellus x macrochirus	Hybrid sunfish				X
Pomoxis nigromaculatus	Black crappie	X			
Pomoxis annularis	White crappie	X	X	X	X
PERCIDAE					
Stizosteidon canadense	Sauger	X	X	X	
Percina phoxocephala	Slenderhead darter	X			
Percina caprodes	Logperch	X			X
Etheostoma nigrum	Johnny darter	X			X
Etheostoma spectabile	Orangethroat darter	X			
Etheostoma flabellare	Fantail darter	X			
Etheostoma punctulatum	Stippled darter				X
Etheostoma exile	Iowa darter				X
SCIAENIDAE					
Aplodinotus grunniens	Freshwater drum	X	X	X	X

[a]Collected from 14 stations by Pflieger, 1962-63 (University of Missouri, Rolla, 1972)

[b]Collected from 1 station at Hermann, Missouri (Missouri River Environmental Inventory, 1972). An unidentified *Notropis* species was also collected near Hermann, but has not been included in the table.

[c]Collected from 5 stations near the site area by Dames & Moore, July, September, and December, 1973.

[d]Collected from 2 stations by Dames & Moore, July, September and December, 1973 and February, 1974.

[e]Observed in the Missouri River during the survey, but not collected.

TABLE 2.3.6-3

NUMBERS AND SIZE RANGES (TOTAL LENGTH IN MM) OF FISH TAKEN FROM THE MISSOURI RIVER DURING EACH SAMPLING PERIOD

Species	July	September	December	Total All Surveys	Percent of Total Catch
Chestnut lamprey			5(31[illegible]-325)[a]	5	0.8
Shovelnose sturgeon		1(618)	5(347-642)	6	0.9
Longnose gar	1	10(562-93[illegible])	1(653)	12	1.9
Shortnose gar	2(542)	9(435-608)		11	1.7
Gizzard shad	5(129-325)	116(78-388)	297(72-329)	418	65.8
Skipjack herring		2(302,346)	13(134-375)	15	2.4
Goldeye		3(92-248)		3	0.5
Mooneye			3(211-296)	3	0.5
Northern pike			1(670)	1	0.2
Carp		23(205-545)	27(277-668)	50	7.9
Emerald shiner			qualitative[b]		
Redfin shiner			qualitative		
River carpsucker	1(445)	23(168-427)	5(132-443)	29	4.6
Quillback	1(3[illegible]0)		3(390-476)	4	0.6
Highfin carpsucker			1	1	0.2
Longnose sucker			1(494)	1	0.2
White sucker			1	1	0.2
Largemouth buffalo			3(426-512)	3	0.5
Smallmouth buffalo			1(165)	1	0.2
Blue catfish	1([illegible]	4(418-540)		5	0.8
Channel catfish	1(2[illegible])			1	0.2
Flathead catfish	2(3[illegible],336)	1(204)		3	0.5
White bass	1			1	0.2
Largemouth bass		2(233,510)		2	0.3
Bluegill		1(104)	1(64)	2	0.3

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TABLE 2.3.6-3 (Continued)

Species	July	September	December	Total All Surveys	Percent of Total Catch
White crappie	1(205)	15(188-273)	18(68-286)	34	5.4
Sauger			1(347)	1	0.2
Freshwater drum	3(176-300)	7(194-356)	12(92-363)	22	3.5
TOTAL ALL SPECIES	19	217	399	635	

[a]All length data available is included in parentheses.

[b]No numerical data were recorded.

TABLE 2.3.6-4

AGE, GROWTH AND CONDITION OF GIZZARD SHAD TAKEN FROM MISSOURI RIVER DURING SEPTEMBER AND DECEMBER, 1973

SEPTEMBER

Age (Yr)	Sample Size	Total Length (mm) Mean	Range	Weight (gm) Mean	Range	Mean Condition Factor (K_{TL})	Percent of Sample
<1	10	94	78-115	8	2- 22	0.92	10
1	10	138	104-185	25	12- 42	0.95	10
2	26	223	146-310	99	24-288	0.86	25
3	34	263	164-344	179	42-380	0.95	33
4	15	317	285-388	267	148-402	0.85	15
5	6	300	198-340	275	80-362	0.97	6
6	1	308	-	358	-	1.23	1
7	1	324	-	356	-	1.05	1

DECEMBER

Age (Yr)	Sample Size	Total Length (mm) Mean	Range	Weight (gm) Mean	Range	Mean Condition Factor (K_{TL})	Percent of Sample
<1	44	94	74-168	7	2- 38	0.56	56
1	1	159	-	28	-	0.70	1
2	13	191	167-213	58	38- 82	0.81	17
3	15	216	169-243	86	42-128	0.84	19
4	5	266	239-292	166	128-218	0.88	6

TABLE 2.3.6-5

SUMMARY TABLE OF ALL FOOD ITEMS FOUND IN THE STOMACHS OF FISH COLLECTED FROM THE MISSOURI RIVER DURING JULY, SEPTEMBER AND DECEMBER, 1973 (NUMBERS REPRESENT PERCENT OF TOTAL WEIGHT)

Fish Species	Number of Stomachs Examined	Number of Empty Stomachs	FOOD ITEM: Diatoms	Green Algae	Ephemeroptera	Hemiptera	Trichoptera	Diptera	Crustacea	Fish	Unidentified Organic Material	Inorganic Material	Mean Weight/ Stomach	Total Weight
Shortnose Gar	2	1								100			2.63	2.63
Longnose Gar	1	0								100			7.13	7.13
Gizzard Shad	86	20	45	6	1						24	25	0.54	35.59
Carp	25	9						37			63		0.24	3.86
River Carpsucker	18	7						11			89		0.32	3.52
Largemouth Buffalo	1	1												
Goldeye	1	0			45		45				10		0.43	0.43
Skipjack Herring	1	0				9		63				27	0.11	0.11
Channel Catfish	1	0			18		25	2		56			0.68	0.68
Flathead Catfish	3	0							64	36			0.29	0.89
Blue Catfish	1	1												
White Crappie	5	1			3	3	1	1		93			0.66	2.64
Bluegill	1	0			67			33					0.03	0.03
Freshwater Drum	12	3			6		11	4			79		0.06	0.54
TOTALS	158	43												

TABLE 2.3.6-6

NUMBERS AND SIZE RANGES (TOTAL LENGTH IN MM) OF FISH TAKEN FROM LOGAN CREEK DURING EACH SAMPLING PERIOD

Species	July	September	December	February	Total All Surveys	Percent of Total Catch
Goldeye				3(138-156)	3	0.9
Gizzard shad	17(40-162)[a]	10			27	7.8
Carp	5(109-157)				5	1.4
Redfin shiner	5				5	1.4
Sand shiner			1		1	0.3
Red shiner			1		1	0.3
Southern redbelly dace	4				4	1.2
Bluntnose minnow	12			12	24	6.9
Stoneroller	15			1	16	4.6
River carpsucker	6(59-119)				6	1.7
Quillback	qualitative[b]					
Yellow bullhead		8		2(143,214)	10	2.9
Brown bullhead	2(114,118)	8			10	2.9
Blackstripe topminnow	5	15		23	43	12.4
Mosquitofish	20	25	25		70	20.2
Brook silverside	5				5	1.4
Largemouth bass	6(55-220)	2(147,149)		1(266)	9	2.6
Green sunfish	2		5(111-178)	7(74-198)	14	4.0
Longear sunfish	1(125)		4(92-127)	6(96-139)	11	3.2
Bluegill	28	10(139-174)	3(98-103)	16(87-155)	57	16.5
Bluegill-green sunfish hybrid	2(101,110)				2	0.6
White crappie	8(116-173)			3(65-180)	11	3.2
Logperch	3	1			4	1.2
Stippled darter	1				1	0.3
Johnny darter	2	4			6	1.7
Iowa darter	qualitative					
Freshwater drum	1				1	0.3
TOTAL ALL SPECIES	150	83	39	74	346	

[a]All length data available is included in parentheses.

[b]No numerical data were recorded.

TABLE 2.3.6-7

ITEM ANALYSIS OF STOMACH CONTENTS OF FISH FROM LOGAN CREEK COLLECTED DURING JULY AND SEPTEMBER, 1973 (NUMBERS REPRESENT PERCENT OF WEIGHT)

Fish Species	Number of Stomachs Examined	Number of Empty Stomachs	FOOD ITEM: Odonata	Ephemeroptera	Hemiptera	Coleoptera	Diptera	Crustacea	Fish	Unidentified Organic Material	Mean Weight/ Stomach	Total Weight
July												
Largemouth Bass	2	1	21			79					0.14	0.14
White Crappie	4	0		14	31		41		14		0.07	0.29
Hybrid Sunfish	3	1	21					79			0.55	1.11
September												
Logperch	2	0					60			40	0.17	0.35
TOTALS	11	2										

2.3.7 ECOLOGICAL SUMMARY

The abundance and diversity of aquatic biota near the site have been limited by naturally occurring excessive turbidities and fluctuating water levels. Low primary productivity has resulted from heavy silt loads, which reduce the amount of light available for photosynthesis by phytoplankton organisms. Because these small organisms represent an important aspect of the aquatic food web, their low productivity is similarly reflected in higher trophic levels. As with plankton, fish and macroinvertebrate productivity near the site is relatively low compared to other large river systems, although nutrient levels are sufficiently high to support larger aquatic populations. Most of the nutrients apparently are obtained from allochthonous materials transported to the aquatic system.

Human activities have modified the aquatic ecology by further increasing the turbidity, channelization of the Missouri River, acid mine and agricultural runoffs, and municipal and industrial effluents. Channelization has resulted in the elimination of backwaters and marshy areas valuable as aquatic habitats. Because of this, relatively unpolluted tributaries, such as Logan Creek, have become increasingly important as aquatic habitats, especially if they provide spawning and nursery sites for fish.

Discharge appears to be the major influence on Missouri River water quality. During the present survey, turbidity and suspended solids generally varied directly with river discharge, while total dissolved solids and conductivity varied inversely. Recorded maximum historical values for chemical oxygen demand (COD), turbidity, total dissolved solids (TDS), and total iron were exceeded in the river during April, 1973. These values were extremely high because the data were collected during a near-record flood, when runoff was unusually high. Although, as mentioned previously, TDS values generally decrease during flood conditions, sudden increases in discharge, such as occurred during April, produce first water higher in mineral content than the dilute runoff water. Low pH values were recorded during April; they fell below the state standard of 6.5 at one station. These low values probably resulted from acid mine runoff upstream from the site.

The state standard for fecal coliform bacteria (2000/100 ml) was exceeded at four stations in April, one station in September, and all six river stations in July and December. Fecal coliform bacteria are indicative of relatively recent pollution. Historically, and during the survey, the heavy metals, copper and cadmium, were found in concentrations that may be toxic to aquatic organisms. Whether and to what extent this will effect the Missouri River biota depends upon the extent of their exposure to high concentrations and the presence of other stresses. Chlorinated pesticides were present in April, but only in low concentrations. Analyses for specific pesticides in July, September, and December samples showed all concentrations to be below detectable limits.

Data from the present study indicate that water quality is generally higher in Logan Creek than in the Missouri River. Chemical concentrations are generally lower in the upper reaches of the creek than nearer the river, but fecal coliform counts are higher in the upper section, reflecting human influence. Low pH and dissolved oxygen values were recorded for the lower section of the creek; this condition may limit aquatic productivity.

Relatively low phytoplankton and zooplankton levels in the Missouri River near the site apparently are related to high current velocities, excessive turbidities, and a lack of adjoining lentic waters. Seasonal fluctuations in plankton populations during the present study are typical of large temperate rivers in which populations almost always show a summer maximum and winter minimum. An inverse relationship between plankton numbers and flow was also found throughout the present study. The plankton composition of the Missouri River is also typical of temperate stream and reflects seasonal variations in temperature and light. Green and blue-green algae attained their maximum development during the warmer months, while the phytoplankton communities in winter were largely composed of diatoms. Most of the principal taxa collected during the July, September, and December surveys are classified as true plankters. However, the principal taxa collected in February were all benthic diatoms, reflecting the scouring effect of the high discharge. Rotifers attained their maximum densities in the warmer months and were particularly abundant in September zooplankton samples. Higher rotifer densities are usually associated with warm water of high clarity and low turbidity, conditions prevailing during the September sampling period. Copepod crustaceans were the most numerous zooplankters in December and February; apparently temperature is not a controlling factor in their distribution. The principal zooplankton taxa were primarily planktonic.

Plankton populations in Logan Creek during July and September were substantially higher than in the Missouri River. The more stable substrate, lower current velocities, and lower turbidities of Logan Creek appear to be more favorable for plankton. Winter phytoplankton populations in the creek were similar to those in the Missouri River, while winter zooplankton populations were slightly lower. Phytoplankton was consistently more abundant upstream than downstream, probably reflecting the more favorable rock and gravel substrate upstream.

Vascular hydrophytes are completely absent in the Missouri River, their absence being caused by excessive turbidity, fluctuating water levels, and the instability of fine substrates. Hydrophytes have been found in Logan Creek, although they are sparse. Their presence here can probably be attributed to the creek's more stable substrates and lower turbidities, since these factors favor plant colonization.

The species composition, diversity, abundance, and standing crop of benthic organisms in the Missouri River are low. Major factors limiting benthos appear to be channelization and reduction of favorable habitats, flooding and high water velocities, excessive turbidity and shifting substrates. The effects of some of these factors were apparent at the sandy-bottomed, mid-channel benthos stations, which had a lower species diversity and biomass than the north shore benthos stations. Although improved conditions, lower currents, and more silty substrates characterized north shore stations, species composition and densities were still low. Species diversity indices suggest that the Missouri River mid-channel stations were grossly polluted, while north shore stations were moderately polluted. Pollution, in this context, refers to physical stresses such as high current velocities, excessive turbidity, and unsuitable substrates. Chemical stresses occur in the river, but their effects on the benthos in the study area appear to be minor. Burrowing dipteran larvae, oligachaete, and mayfly nymphs, which are adapted to survive turbid high flow, conditions, were generally numerically dominant in the samples, but coleopterans, trichopterans, odonates, and pelecypods were also collected.

Benthic densities in Logan Creek were higher than in the Missouri River, but their numbers were still low compared to other systems. The downstream station was numerically dominated during all sampling periods by oligochaetes, while dipterans, mainly chironomids, were the second most abundant group. The upstream station was dominated by dipterans during July and September, while oligochaetes became dominant in December and February. Species diversity indices suggest that the downstream station is moderately polluted and the upstream station is unpolluted. The lower species diversity at the downstream station probably reflects its location in the Missouri River floodplain, where benthos are subject to high temperatures, lower dissolved oxygen, greater turbidities, and more pronounced water level fluctuations than benthos upstream in Logan Creek, where water quality is higher.

The fisheries of the Missouri River near the site are limited by high turbidities, swift currents, and unstable sand and silt substrates. These adverse factors act not only directly, but also indirectly by limiting the production of planktonic and benthic fish food organisms as previously discussed. During the present study, 28 fish species representing 13 families were collected. The gizzard shad was the most abundant species collected in the river near the site and comprised about 66 percent of all fish collected. Condition factor analyses of gizzard shad revealed low values (compared with other studies). These low condition factors were probably related to the conditions restricting production of fish food organisms. Carp was the second most abundant species, though it comprised only about 9 percent of the total catch. From 1965 to 1971, carp was the most abundant species in commercial catches from the Missouri River. The white crappie was the most abundant sport fish collected during the survey and the third most abundant of all species captured, comprising about 5 percent of the total. Catfish are the sport fish most frequently caught in the river near the site, but only a few were collected during the survey.

Because of habitat changes in the Missouri River, small streams like Logan Creek have become increasingly prominent as spawning and nursery areas for fish. During the present study the fish fauna of Logan Creek was almost as diverse as that of the Missouri River near the site. Twenty-seven fish species from 11 families were collected. Compared to the Missouri, Logan Creek generally has lower turbidity, slower waters, more varied substrates, a greater abundance of fish food organisms, and at least some vegetation that could provide fish with food and protection. Mosquitofish and bluegills were the most abundant species collected in Logan Creek, comprising over 20 and 16 percent of the total, respectively. Species collected included the brown bullhead, classified in Missouri as rare.

2.4 CONCLUSIONS AND RECOMMENDATION

The Missouri River is in an early stage of maturity, as indicated by meandering channels, eroding banks, channel scour, and high sediment content. This river has been called "Big Muddy" and "Muddy Mo" because of its high turbidity. The river near the site exhibits many existing stresses, the majority of which have resulted from human activities. The prime stresses affecting the aquatic ecology near the site include excessive turbidity, channelization of the Missouri River, acid mine and agricultural run-offs, and municipal and industrial effluents. These factors have all directly or indirectly contributed to the reduced production and low biotic abundance and diversity within the Missouri River.

Major factors influencing the aquatic system near the site appear to be channelization, turbidity, and surface run-off. Turbidity and water quality changes from surface run-off are directly related to channelization. Channelization results in a more immediate transport of run-off water downstream and prevents normal modification of water quality. Channelized water, having a greater velocity, reduces the possibility of suspended particles settling out of the water column and increases the erosional potential that results in higher turbidities. Channelization also has resulted in elimination of productive backwaters and marshy habitats. Because of this, tributaries to the Missouri River have become increasingly important as aquatic habitats, especially if they provide spawning and nursery sites for fish.

The plant intake and discharge structures were located so as to minimize any of the Callaway Plant's adverse ecological effects, especially with regard to Logan Creek. The intake structure was designed to reduce impingement of fish and the discharge effluent to meet water quality standards. Because of these construction and operational considerations, and the already limited biota production in this section of the Missouri River, no major impacts are anticipated.

It is recommended, however, that aquatic monitoring be continued during the construction and operation phases of the project to determine their effects, if any, on the aquatic ecosystem. Monitoring will provide a basis for mitigation measures should adverse impacts occur.

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3. TERRESTRIAL ECOLOGY

3.1 INTRODUCTION

Terrestrial biological sampling of the Callaway Plant site, located in central Missouri, was conducted for the Union Electric Company, St. Louis, Missouri, between April 15, 1973, and February 15, 1974.

The Callaway Plant site is located in Auxvasse Township (T46N-R8W) in the southeast corner of Callaway County. The small town of Reform, 5-3/4 miles north of and 350 feet above the Missouri River on Coates Plateau, is located within the site boundary. The General Study Area, shown on Figure 3.1-1, included approximately 10 square miles of plateau and forested slopes. Within these two habitat types is a wide variety of terrain; this helps to produce the great diversity of flora and fauna found in this area of Missouri. A smaller area located with the General Study Area and designated the Intensive Study Area was the focus of the sampling program intensive field studies. Most surveys and all trapping were performed within the Intensive Study Area boundaries. Sampling was conducted during the spring (April 15-21), early summer (June 18-27), late summer (August 28-September 6), and fall (November 5-14) of 1973 and the winter (February 11-18) of 1974.

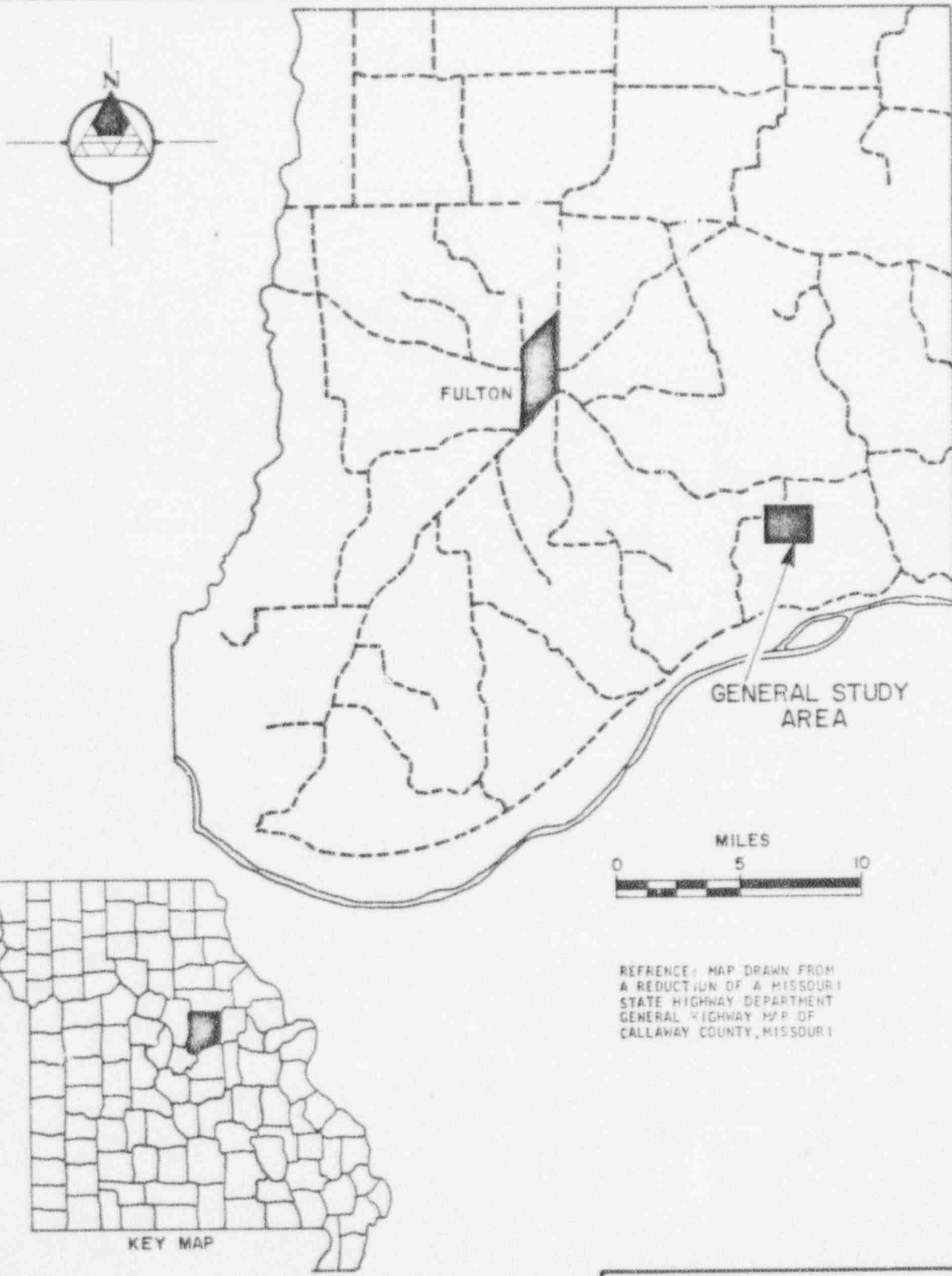
Cash cropping and beef production are principal land uses on the plateau, and beef production is the primary enterprise on forested slopes. Soils on the plateau, although well-structured, are generally poor for production of most agricultural crops. Soils on slopes are not used for cash crops because they are rocky, and the terrain is too steep for farm machinery. Drainage from the plateau is north into Cow and Auxvasse Creeks, west into Mud Creek, and east-southeast into Logan Creek.

The 1-year ecological study conducted during 1973-74 on the Callaway Plant site served three major purposes: 1) to record and describe "important" species of flora and fauna utilizing the site area during the four seasons of the year; 2) to provide baseline data that could be used to develop a monitoring program for detecting the effects of plant construction and operation on the environment; and 3) to offer recommendations to the Union Electric Power Company concerning the effect of construction on any "unique" or unusual habitats, animals, or combination of these two life forms found within zones of direct impact.

The results obtained from the initial spring and summer field surveys were not fully adequate and this precluded a thorough analysis of wildlife populations (diversity and abundances) utilizing the site area, particularly areas within the zone of direct impact. There were two reasons why the initial data were not fully adequate. First, the spring sampling was restricted to an area about 2 miles from the geographic center of the site. Subsequently, after access to the actual site had been obtained, sampling points for plants and animals were shifted to areas within the actual site environs. Data collected from these new points showed that much of the previously collected data were of limited value. Second, since the investigators had been instructed not to mention the site location, they did not contact any of the local residents who might have been of help in the overall sampling program. This and the restricted land access limited the amount of information gathered about the specific site area.

But in spite of these circumstances, the vegetation and wildlife sampling was able to provide an overview of the ecology of the area, including species abundance and general habitat types. This information enabled a preliminary assessment of the site to be made and contributed baseline information necessary for development of a monitoring program.

This portion of the report is divided into five major sections: Introduction, Methods, Results and Discussion, Conclusion and Recommendation, and References. Most major sections are divided into subsections, the number of which depends on the complexity of the subject matter. The Methods and the Results and Discussion sections are subdivided by broad terrestrial parameters (Soils, Vegetation, Mammals, Birds, and Amphibians and Reptiles). The Results and Discussion section concludes with an Ecological Summary of the material in that section. The text then ends with a Conclusion and Recommendation section that offers a description of the anticipated effects of plant construction on the environment.



UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

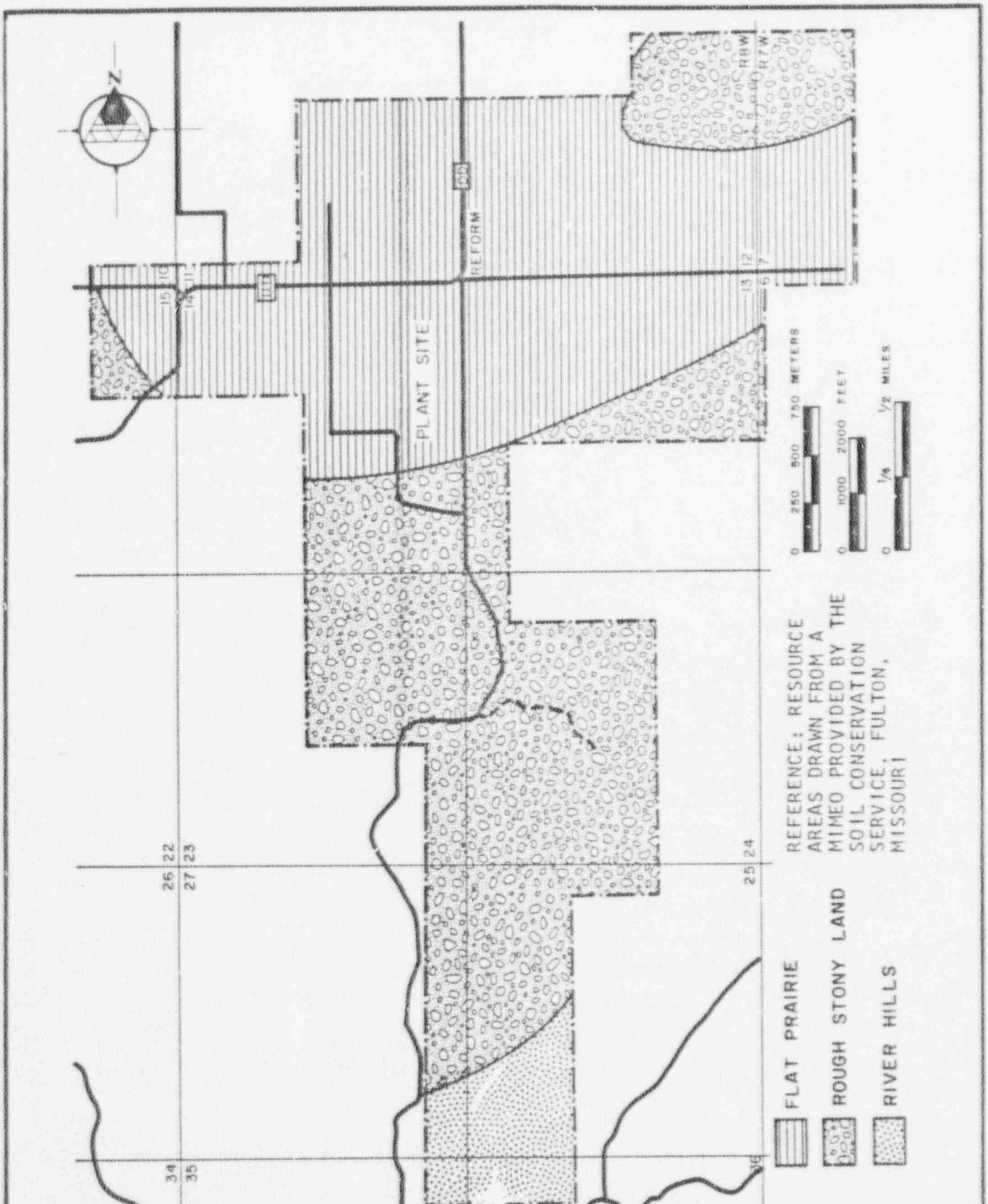
TERRESTRIAL ECOLOGY GENERAL STUDY AREA, CALLAWAY COUNTY, MISSOURI

Figure 3.1-1

3.2 METHODS

3.2.1 SOILS

Basic information about the physical resource areas and soil series for the Intensive Study Area was obtained from the Soil Conservation Service, (1972c). This information has been transformed to show the relationship of resource areas to the Intensive Study Area (Figure 3.2.1-1).



UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

RESOURCE AREAS,
INTENSIVE STUDY AREA

Figure 3.2.1-1

3.2.2 VEGETATION

Vegetation sampling in the Intensive Study Area was conducted from April to September, 1973. Sampling locations were selected following field reconnaissance and aerial photograph interpretation. Overstory, understory, and herbaceous vegetation was sampled in the forests, while herbaceous vegetation alone was sampled in the old field and pasture. Taxonomic identifications were made by the Dames & Moore staff and verified at the Missouri Botanical Garden. Nomenclature follows Fernald (1970). Voucher specimens of plants found on the site were collected and placed on file at Dames & Moore, Chicago.

3.2.2.1 Forest

Forest vegetation was sampled along eight transects (Figure 3.2.2-1). The number of sampling points established along each transect varied according to the number of samples required to sample each community adequately; species-area curves were developed to establish the number of samples necessary.

The number of sampling points and the distance between the points for each transect are as follows: FT_1 - 21 points, 100 feet apart; FT_2 - 19 points, 100 feet apart; FT_{3a} - 10 points, 150 feet apart; FT_{3b} - 10 points, 100 feet apart; FT_4 - 15 points, 100 feet apart; FT_5 - 15 points, 100 feet apart; FT_6 - 10 points, 100 feet apart; FT_7 - 15 points, 100 feet apart; and FT_8 - 10 points, 250 feet apart.

The forest overstory was sampled by the point-center quadrat method of Cottam and Curtis (1956). Density, dominance, and frequency were measured for each woody species greater than 1 inch in diameter at breast height (d.b.h.). These three parameters were then converted into their respective relative values and combined to yield an Importance Value (IV) for each of the species encountered. The Importance Value was used to assess the relative importance of each tree species in each forest community type.

The forest understory along transects FT_1 to FT_7 was measured by nested quadrats (Cox, 1967) at randomly selected points along each forest transect. The density and frequency of woody understory species less than 1 inch d.b.h. but greater than 18 inches in height were recorded in 13.1 x 19.7-foot quadrats. Woody groundlayer species less than 18 inches in height were recorded in 6.6 x 16.4-foot quadrats.

The forest understory along transect FT_8 was sampled differently to better quantify the diverse and abundant small woody and herbaceous species. All woody species greater than 24 inches in height but less than 1 inch in d.b.h. were recorded in 16.4 x 16.4-foot quadrats and woody species less than 24 inches in height and all herbaceous species were recorded in 3.3 x 3.3-foot quadrats.

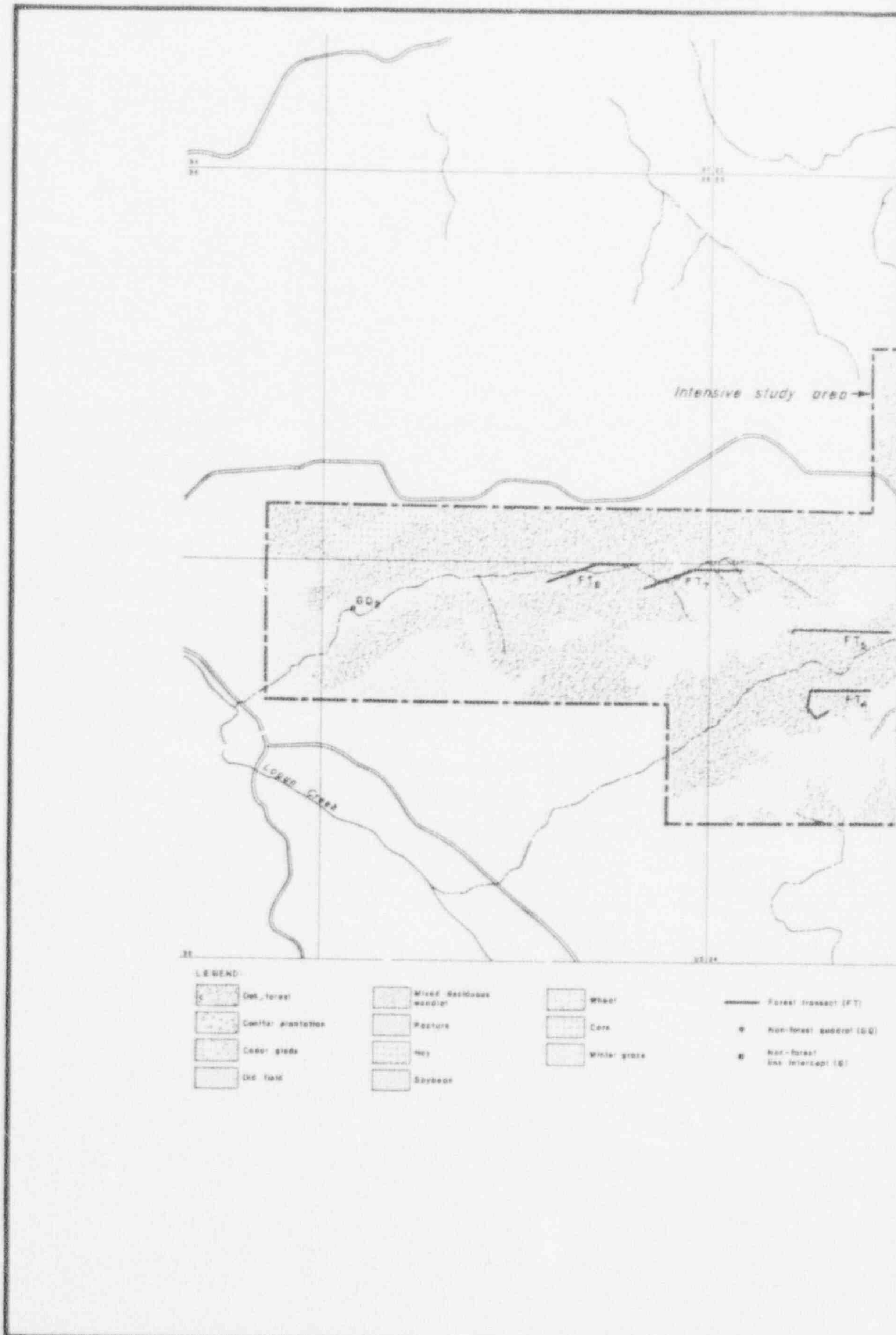
Herbaceous vegetation along these forest transects (FT_1 to FT_8) was measured by a modified line intercept method of Oosting (1956). At randomly selected points along the forest transects, a 49.2-foot tape, subdivided into 30 equal intervals, was used to measure the frequency of herbaceous vegetation occurrence. Relative frequency was calculated from the frequency of plant occurrence.

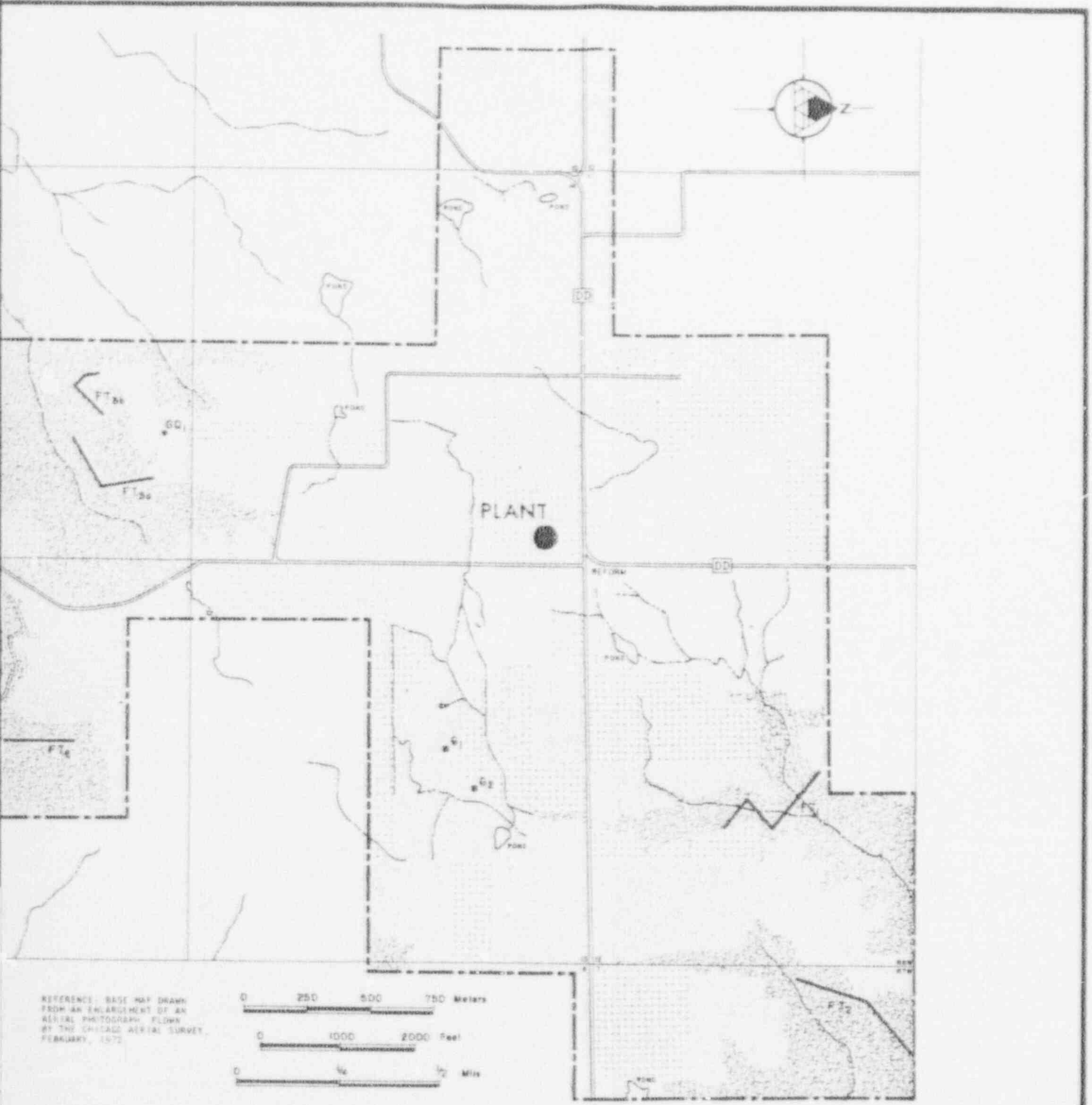
3.2.2.2 Pasture and Old Field

Two pastures and one old field were sampled (Figure 3.2.2-1). (An old field is a field where vegetation has been disturbed by man, then abandoned, and is now reverting to its natural state.) Sampling techniques were quadrats (sample location GQ, Figure 3.2.2-1) and a modified line intercept method (sample location G). Four 3.3 x 3.3-foot quadrats 100 feet apart were measured in the pasture (GQ_1), and two 3.3 x 3.3-foot, randomly selected quadrats were measured in the old field (GQ_2). Vegetative measurement was of frequency and density.

3.2.2.3 Miscellaneous Observations of Vegetation

Voucher specimens of plant species encountered and identified during the wildlife and general surveys but not collected during the quantitative vegetation surveys were collected by the terrestrial ecology field crew. Location, species, and date of collection were recorded.


Intensive study area
Logan Creek
LEGEND
Pasture
Soybean
Corn
Forest transect (FT)



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VEGETATION SAMPLING SITES, INTENSIVE STUDY AREA

Figure 3.2.2-1

3.2.3 MAMMALS

Mammals were sampled by the three techniques described below. A record of all mammals observed during other phases of field work throughout the Intensive Study Area was kept by the investigators. Recorded information includes species, number of individuals and/or sign observed, date, habitat, and location.

3.2.3.1 Small Mammals

Eight small mammal traplines (method of Kaufman et al, (1971), each having 15 stations 49.2 feet apart, yielding a total of 4,320 trap-nights, were permanently established during the early summer sampling period for use during successive sampling periods (Figure 3.2.3-1). Two Sherman collapsible live traps (9 x 3 x 3 inches) and one Sherman non-collapsible live trap (12 x 3½ x 3 inches) were set at each station along seven of these lines. The eighth trapline was set within a pasture; one rat snap-trap and two mouse snap-traps were used per station to minimize interference by cattle, which are attracted to metal traps. Traplines were established within several habitat types and along ecotones. All traps were baited with a mixture of peanut butter and rolled oats. Cotton balls were placed in each trap to provide bedding for captured individuals.

Traplines were checked each morning for 3 consecutive days. All mammals collected were identified to species (Burt and Grossenheider, 1964), weighed (100 g O'Haus spring scale), measured (total length, tail length, hind foot length, and ear length), sexed, and examined to determine breeding conditions. The measurements were used for species identification. Occasionally, individuals were found dead in the traps. These were removed, weighed (Dial-o-gram balance), and measured as described above. Individuals collected alive and those found dead constituted the voucher collections.

During the spring sampling period, several other traplines were temporarily established for preliminary sampling of the site's small mammal population. During the early summer sampling period, one trapline was established along a drainageway to determine whether the low number of captures along permanent traplines should be attributed to sampling metnods or to low population densities.

3.2.3.2 Large Mammals

A rectangular grid pattern (Figure 3.2.3-1) enclosing approximately 1.5 square miles was established during the early summer sampling period for trapping large mammals. The actual placement of traps during any given survey at the theoretical field location was governed by the number of properties to which field investigators had access. Single-door wire mesh traps (32 x 11 x 13 inches) were used. Twenty-five traps were used during the early summer; 34 were used during the remaining sampling periods.

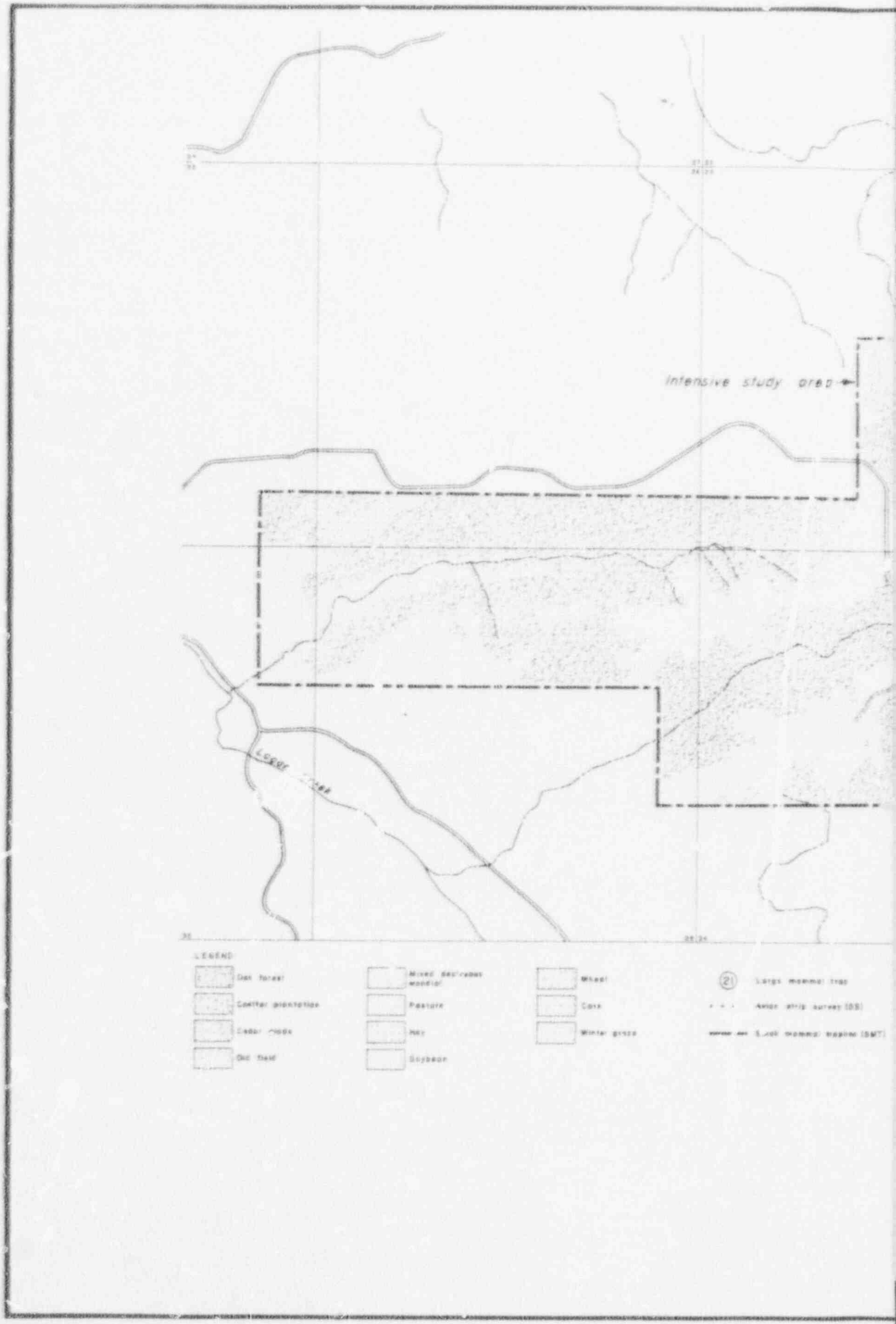
During all sampling periods, all traps were baited with apples and bologna, left in position for 3 nights, and checked each morning, yielding a total of 420 trap-nights. Bait eaten by captured individuals was replenished.

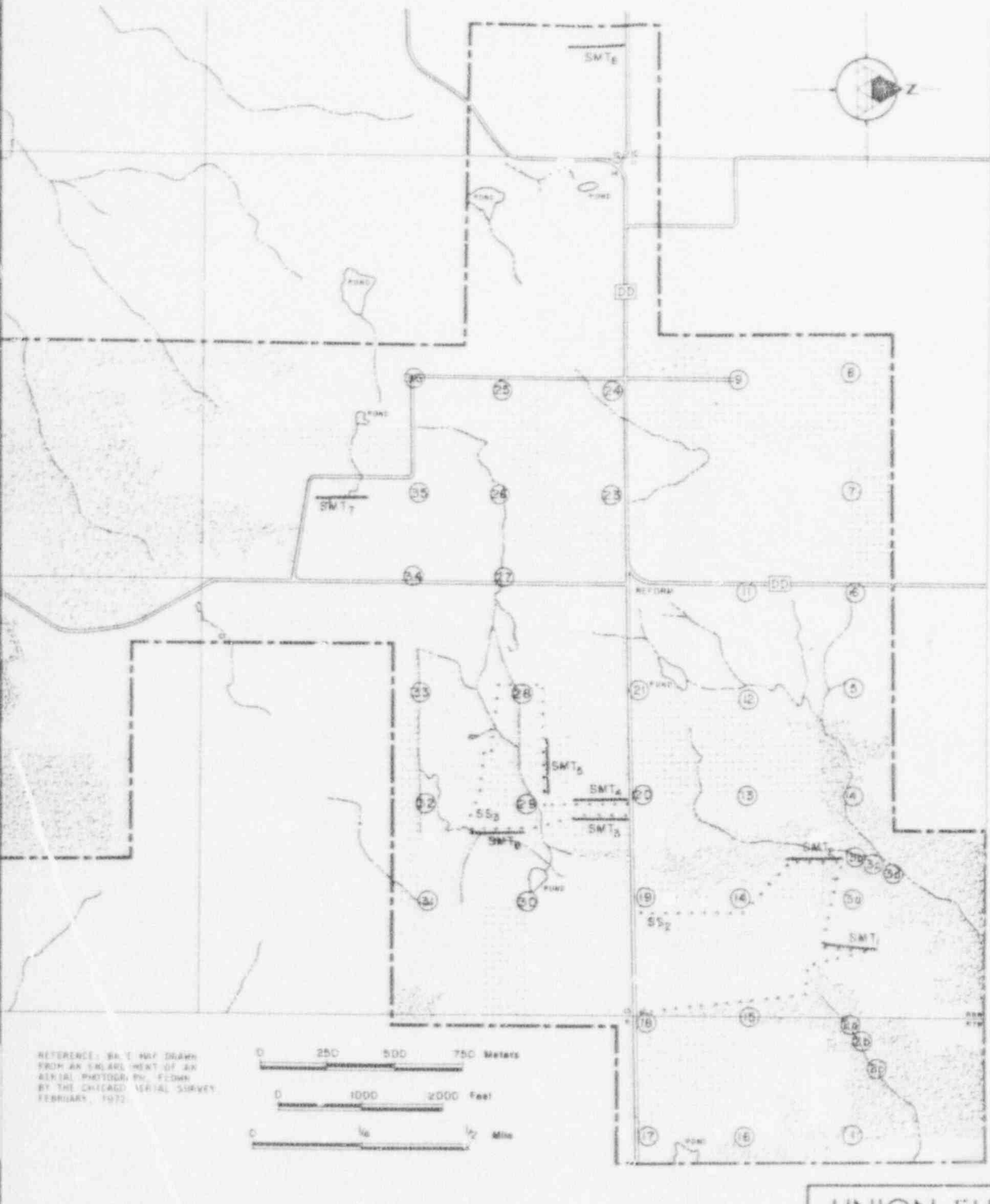
Each individual captured was identified to species (Burt and Grossenheider, 1964), tagged in both ears with metal ear tags, weighed (Chatillon spring scale), measured, sexed, examined to determine breeding condition, and released. Recaptures had their tag numbers recorded or replaced if missing, and physical condition noted. The Schnabel method of population estimation (Smith, 1966) was used to determine population densities for species having one or more individual recaptures.

3.2.3.3 Evening Automobile Survey

The evening automobile survey was conducted for 3 evenings during early summer, late summer, fall, and winter sampling periods. The survey began 1 hour before sunset on the first evening, at sunset on the second evening, and 1 hour after sunset on the third evening.

The survey route in relation to the Intensive Study Area is shown in Figure 3.2.3-2. Travel speed was 20 to 30 miles per hour. The car was stopped only when positive identification of a species needed to be made. Spotlighting was used to illuminate fields, ditches, culverts, and creeks. Two investigators recorded the species, notable activity, and number of individuals observed for all mammalian species.


Intensive study area
LEGEND
Pasture
Hay
Soybean
Corn
Winter grass



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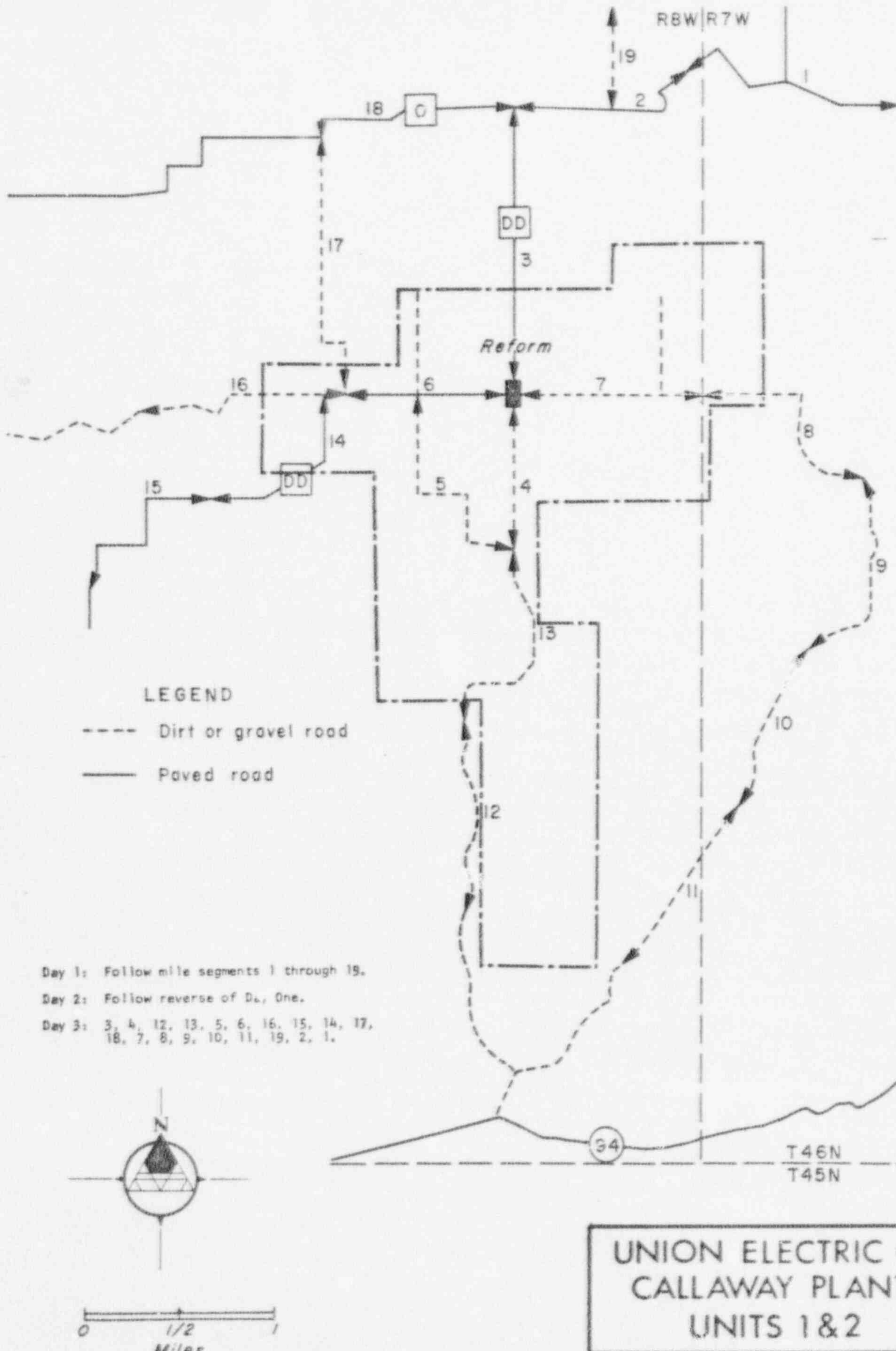
AVIAN STRIP SURVEY, SMALL MAMMAL TRAPLINES AND LARGE MAMMAL TRAPS IN THE INTENSIVE STUDY AREA

Figure 3.2.3-1



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UNITS 1&2

EVENING AND AVIAN AUTOMOBILE SURVEY ROUTE, CALLAWAY COUNTY, MISSOURI

Figure 3.2.3-2

3.2.4 BIRDS

Avifauna was sampled by the three methods described below. A record was kept of all birds not expected to be commonly observed (gamebirds and those birds considered uncommon sightings) during the avian surveys. Recorded information included the number of individuals and/or signs observed and location of each observation.

3.2.4.1 Avian Automobile Survey

During the five sampling periods, an avian automobile survey was conducted to determine the variety and relative abundance of bird species on the Callaway Plant site and adjacent areas. The survey also was designed to establish the relationship between bird activity and the various habitat types found along the automobile survey route.

The following habitat types were identified along the automobile survey route:

Forest - Stands of mixed hardwoods or oaks with their associated understory species.

Second Growth Forest - A recently cut-over forest or an advanced sapling-shrub field.

Hedgerow - A strip of shrubs and/or trees, enclosing or separating agricultural fields.

Pasture-Shrub - Those lands used for the grazing of livestock where shrubby vegetation was in evidence throughout.

Old Field - A field disturbed by man's activities which has been left to revert to its natural vegetation, including cropland which has been idle for more than 1 year and on which uncultivated grasses, forbs, and shrubs have become established.

Pasture - Those lands dominated by grasses and forbs where grazing was apparent.

Creek Bottom - Intermittent creek and stream bottom-associated vegetation.

Agricultural Crops - Agricultural fields containing farm crops other than hay. During the spring, early summer, fall, and winter surveys these same fields may have been classed as "Agricultural Stubble." Crops were primarily wheat, soybeans, and corn.

Agricultural Stubble - Agricultural fields containing the crop residue.

Farm Dwellings - A general term for farm houses, outbuildings and small dwellings on farm land, whether abandoned or occupied.

Roadway - The road surface, fences, telephone poles and lines, transmission lines, and ground cover found within the right-of-way.

Hayfield - Cultivated fields where grasses and legumes are periodically harvested as feed.

The avian automobile survey (method of Robbins and Van Velzer, 1967) was conducted by driving along 19, mile-long segments on county and state roads (Figure 3.2.3-2). The method outlined by Robbins and Van Velzer was modified by conducting the survey 3 days instead of 1 day, establishing more than one stop point per segment, and daily changing the segment sequence of the route and direction of travel through each segment. Three stop points, approximately 1/4-mile apart, were established within each of the 19 segments. These modifications were made to obtain a more accurate index of bird activity within each segment. Investigators stopped for 3 minutes at a different stop point each day. During each stop, the investigators got out of the automobile and stood by the roadside to listen for and observe birds in the area. All bird species observed or identified by call while driving or at a stop were recorded by habitat type and segment. Travel speed was 15 to 20 miles per hour. The survey began at sunrise and lasted for 3 to 4 hours. Length of time required to complete the survey depended upon the amount of time necessary for species identification, number of species observed, amount of automobile traffic along the survey route, and weather.

Equipment used included 7 x 35, 7 x 50, and 10 x 50 binoculars and field guides by Peterson (1947) and Robbins et al, (1966). Taxonomic nomenclature follows the American Ornithologists' Union Check-list (1961).

3.2.4.2 Avian Strip Survey

Two avian strip surveys (Figure 3.2.3-1) were conducted to determine the variety and relative abundance of bird species using selected habitats at the site. A modification of the strip census (Pettingill 1970), the surveys were used to obtain an index of activity for the more elusive woodland and open-field bird species in order to supplement the avian automobile survey data. The census method was modified to yield only relative abundance data by discounting the unit area sampled. Each survey route was designed to be near the small mammal traplines and to cross one or more major habitats on the site.

The survey began at sunrise and lasted approximately 2 hours on each of 3 days. Birds encountered were recorded by species, number and habitat type. Habitat types identified along these survey routes have been previously described in Section 3.2.4.1, with the following additions:

Forest Edge - The abrupt ecotone between a forest and another habitat where only a very narrow strip of vegetation exists between the two habitats.

Fallow Field - An agricultural field which is normally planted to crops but which has been left untilled this year, generally devoid of stubble and sparsely populated with herbaceous plants.

Plowed Field - An agricultural field which is planted in soybeans.

Wheat Field - An agricultural field which is planted in wheat.

Harvested Hayfield - A hayfield which has been recently harvested.

Several of the classifications listed above are not necessarily new habitat types, but the result of continuing agricultural practices which changed the character of the habitats between sampling period.

Equipment used included the previously mentioned binoculars and field guides. Taxonomic nomenclature follows the American Ornithologists' Union Check-list (1961).

3.2.4.3 Evening Automobile Survey

An evening automobile survey, consisting of driving along 19 segments on county and state roads throughout the general study areas was conducted during early summer, late summer, fall, and winter sampling periods. The survey ran for 3 consecutive evenings and began 1 hour before sunset the first evening, at sunset on the second evening, and 1 hour after sunset on the third evening. The route was identical to the evening automobile survey route described in Section 3.2.3.3. Avifauna data were recorded and handled like the mammalian and amphibian data collected at the same time.

3.2.5 AMPHIBIANS AND REPTILES

Amphibians and reptiles were sampled during the Evening Automobile Survey, described in Section 3.2.3.3. Species activity, and number of individuals were recorded. A record was kept of all amphibians and reptiles observed or identified during all other phases of field studies. Field identification and scientific nomenclature follow Conant (1958).

3.3 RESULTS AND DISCUSSION

3.3.1 SOILS AND VEGETATION

Northern Missouri is covered with glacial drift deposited during the last glacial period (Krusekopf, 1962). The southern edge of this drift is roughly delineated by the Missouri River. The terrestrial Intensive Study Area is located on soils derived from glacial drift parent material. Characteristics of these soils are given in Table 3.3.1-1.

A major portion of the Union Electric Company Callaway Plant will be constructed on a Flat Prairie (Figure 3.2.1-1). This physical resource area is composed of two major soil types, the Mexico and Putnam series. The Mexico series has a brown silt loam surface, a silt loam subsurface, and a solum thickness of 20 to 40 inches. The Putnam soil has a silt loam surface, a heavy silty clay subsurface, and a solum thickness ranging from 36 to 50 or more inches (Soil Conservation Service, 1972b, 1972d). Both soils have a claypan about 17 inches below the soil surface (Krusekopf, 1962); this restricts leaching of rainwater to lower depths. During periods of heavy rainfall, water accumulates in the upper 17 inches. The relatively shallow claypan, which restricts both moisture and root growth to the upper soil horizon, is one of the principle factors favoring development of tall prairie grassland. Agriculture, however, is quite prominent in the area; very little native prairie vegetation exists as a result.

Two other resource areas found within the plant site boundary are Rough Stony Land and River Hills. Goss series is the major soil series of the Rough Stony Land resource area. It has a solum depth of 60 to 90 inches and gradients ranging from 8 to 45 percent (Soil Conservation Services, 1972a). Menfro is the major soil series of the River Hills. It has a solum depth of about 50 to 70 or more inches and gradients ranging from 3 to 30 percent (Soil Conservation Service, 1971). Both of these soils series have a moderate permeability that permits water permeation throughout the soil horizons. Consequently, forests have developed as the native vegetation on these soils. Because both the Rough Stony Land and River Hills resources areas have steep gradients, cultivation is limited, and upland forests are the most common vegetation found on these two resource areas. Both resource areas have a potential productivity site index of 60. (The site index is an expression of forest site quality based on the height of a free-growing dominant or codominant tree at age 50 [Spenser and Thorne, 1972]).

The terrestrial Intensive Study Area (Figure 3.2.1-1) is composed of about 50 percent prairie and 50 percent forest. A species list of all plants identified in the Intensive Study Area is given in Appendix 3A-1.

3.3.1.1 Forest

Forest communities of the site have been classified in accordance with the Society of American Foresters (1967) and have been divided into four forest vegetation types within the Oak-Hickory Association: oak forest, oak-hickory forest, oak-maple forest, and black walnut-red cedar forest.

Oak Forests

The most abundant forest community found o the site was oak forest; four of the ight forest transects (FT_2, FT_3, FT_4, and FT_7; see Figure 3.2.2-1) were situated in forests dominated by oaks. White oak was the most important overstory tree species, as indicated by an average Importance Value (IV) of 34 among the four stands (Table 3.3.1-2). To compare different stands and different layers within each stand, the IV has been adjusted to 100 (the highest attained value). Only the most dominant plants are given in Table 3.3.1-2. Some species were not found in all four oak stands but were important within the stand in which they were found: red oak, white ash, sugar maple, and redbud. Fragrant sumac (average IV=20) was the only species found in the upper and lower woody understory of all oak stands (Table 3.3.1-2). Virginia creeper was also common in the lower understory of three stands, with IV's of 30.9, 4.3, and 52.5. Other species of importance in the woody lower understory of oak forests were Carolina rose, green ash, white oak, and sugar maple.

The variety of herbaceous vegetation differed in oak forest. Two stands had five species, and one stand had 18 species. Oak forest herbs were mostly unidentified grasses, globose cyperus, and hog-peanut, with average relative frequencies of 36, 27, and 25, respectively.

The four oak forest stands vary in their value for wildlife. They all had relatively little green, seed-producing vegetation and lacked the cover required by small mammals for survival. Value of a forest type for wildlife was determined by species composition and stand density. Forest sampled by transects FT_3 and FT_4 were of low value due to the low number of plants in the understory. In the zero to 18-inch size class (vegetation utilized by white-tailed deer and cottontail), only 3,700 and 3,500 stems per acre were found. This lack of cover and food sources discourages mice, ground squirrels, and voles. Forest understory along FT_2 had a greater number of stems per acre than the two transects mentioned above; however, it was low in herbaceous plant diversity, with only five species present. Forest along FT_7 was high in value for wildlife; the understory was very dense, with 130,000 stems in the zero to 18-inch class. White-tailed deer, cottontail, small mammals and their predators would be favored by this last forest type.

Oak forests, besides producing seedlings and small grains for wildlife, also produce numerous acorns; these are favored by white-tailed deer, fox squirrel, gray squirrel, and "wild" turkey (Martin et al, 1961; Murphy and Crawford, 1970; Bent, 1963c; Smith and Follmer, 1972; Korschgen, 1954). Wildlife have been found to respond directly to the availability of acorns (Goodrum et al, 1971). Availability of acorns influences reproductive success, survival, population size, and condition of squirrel (Allen, 1943) and deer (Duvendeck, 1962).

Murphy and Crawford (1970) found that white oak forests produced a mean of 34 ± 6 pounds per acre of preferred deer foods during spring and summer and 24 ± 4 pounds per acre during fall and winter. White oak forests also produce 15 ± 3 pounds per acre of grasses and 19 ± 3 pounds per acre of forbs, foods preferred by turkey. A few of the preferred deer foods within the Intensive Study Area are sumacs, sugar maple, sassafras, red cedar, coral berry, grape, poison ivy, tick trefoil, goldenrod, and aster. Preferred turkey foods include foxtail, panic grass, sedge, avens, bedstraw, clover, goldenrod, wood sorrel, smartweed, and ragweed (Murphy and Crawford, 1970).

Basing their calculations on pounds of deer food available during each season, Murphy and Crawford (1970) estimated that 16 ± 3 deer per square mile could be supported within the white oak forest type during summer months and 4 ± 1 deer per square mile during winter months. The difference in carrying capacity between the two seasons is attributable to die-back of succulent green vegetation during winter.

Oak-Maple Forest

Two forest stands sampled (FT_5 and FT_6) were of the oak-maple type (Figure 3.2.3-1). Although both stands were dominated by oak and maple, they differed in species composition. In one stand, FT_5, sugar maple and red oak were the two most important species in the overstory, with Importance Values of 28 and 22, respectively (Table 3.3.1-3). Other trees of importance within this stand were white oak (IV=16) and hop-hornbeam (IV=9). The other oak-maple stand, FT_6, was dominated by a mixture of white oak (IV=14) and sugar maple (IV-23). Of less community importance in this second stand were white ash (IV=8) and bitternut hickory (IV=8).

Woody understory in oak-maple forest stands contained many sugar maple saplings (Table 3.3.1-3). Relative density of these maple saplings in both stands represented approximately 56 percent of the total number of stems counted. Green ash was also an important upper understory component in both stands, having

Importance Values of 14 and 26, respectively. Other important species were slippery elm (IV=14) and fragrant sumac (IV=9 and 12).

Woody ground layer in the two oak-maple stands was dominated by fragrant sumac and sugar maple, with Importance Values of 15.3 and 12.9, respectively (Table 3.3.1-3). Fragrant sumac was present in the sugar maple-red oak stand (IV=15) but was not present in the stand of sugar maple-white oak.

Herbaceous vegetation in oak-maple forest stands was sparse. Hog-peanut and Bowman's root were the most important species in the sugar maple-red oak stand, while grass was dominant in the other stand (Table 3.3.1-3). These two forest stands have been affected by logging, as indicated by numerous stumps, felled trees, and lack of a developed overstory. The two forests had 3,200 and 6,900 stems per acre in the zero to 18-inch class and six and four species, respectively, in the herbaceous layer. Forest along transect FT_5 has a higher value for wildlife than that along transect FT_1 because of its greater density of understory species.

Mast produced by oaks and sugar maple provides food for larger forest animals during fall, winter, and early spring, while thick and diverse undergrowth along FT_5 can maintain high populations of small mammals and birds during summer months.

Murphy and Crawford (1970) found that 62 ± 11 pounds per acre of preferred deer foods were produced during spring and summer in mixed hardwood forests and 32 ± 5 pounds per acre were produced in fall and winter. The same forest type produced preferrred turkey foods at the rate of 41 ± 6 pounds per acre of grasses and 45 ± 6 pounds per acre of forbs.

Oak-Hickory Forest

Only one forest transect (FT_1) was in an oak-hickory forest type (Figure 3.2.2-1). Black and white oak were the most important species, having Importance Values of 25 and 18, respectively (Table 3.3.1-4). However, shagbark hickory (IV=13) was also important within the community. Canopy closure in this forest was 50 to 80 percent, resulting in a sparse understory.

Woody understory was dominated by coral berry (IV=47). Species of less importance in the understory included shagbark hickory, hop-hornbeam, and white oak (IV's of 12, 7, and 9, respectively). Oak-hickory forest woody ground layer was dominated by white oak and coral berry seedlings (IV's of 28 and 23, respectively). Unlike the oak forest, the oak-hickory forest contained no fragrant sumac or Virginia creeper. The herbaceous vegetation in the oak-hickory forest was dominated by a grass with a 46 percent relative frequency. Globose cyperus was also present, as was pale plantain, Canada goldenrod, violets, rough bedstraw, and rough avens.

This climax forest has a relatively high value for white-tailed deer, gray and fox squirrel, and "wild" turkey because of the acorns and nuts produced by the dominant trees. Murphy and Crawford (1970) estimated a summer deer population density of 29 ± 5 deer per square mile and a winter population of 5 ± 1 deer per square mile for this forest type. Small mammals, however, are not favored in the oak-hickory forest because it has a relatively thin understory and lacks seed-producing plants.

Black Walnut-Red Cedar Forest

The black walnut-red cedar forested ravine bottom (FT_8) was found along a drainage (Figure 3.2.2-1). The most important overstory species in this forest were black walnut and red cedar, with IV's of 29 and 27, respectively (Table 3.3.1-5). Also present, but of lesser importance, were honeylocust (IV=8) and American elm (IV=9). The canopy closure was small, permitting high productivity in the lower layers.

The understory was dominated by coral berry (IV=42) but also contained diverse and high-density vegetation in the zero to 18-inch class. Two species not previously encountered in other forest types were found here: common persimmon (IV=16, a pioneer woody species) and black walnut (IV=11). The diverse herbaceous vegetation in the understory included grasses, elm-leaved goldenrod, daisy fleabane, hog-peanut, wild carrot, and mad-dog skullcap.

The black walnut-red cedar forest is suitable for a wide range of wildlife, including white-tailed deer, cottontail, coyote, cuckoo, and wood pewee. Black walnut and common persimmon are important food sources for white-tailed deer (Murphy and Crawford, 1970) and squirrels (Smith and Follmer, 1972). Murphy and Crawford estimated a deer population of 16 ± 3 deer per square mile during summer months and 73 ± 29 deer per square mile during winter. The increased carrying capacity in winter is directly related to the density and diversity of fruit and seed-producing vegetation.

Of the four forest types found in the direct impact zones on the Callaway Plant site, the black walnut-red cedar was ecologically the youngest in terms of succession. It also had the greatest percent of open canopy, the greatest variety and density of herbaceous vegetation, and the highest value for wildlife.

3.3.1.2 Pasture and Old Field

The site-area non-forest vegetation is classified primarily as agricultural cropland, pastures, and old fields. The two pastures sampled had different compositions. The pasture on the Menfro soil (Table 3.3.1-6) was dominated by buffalo clover (IV=64), Canada goldenrod (IV=59), and grass (IV=48). These plants are early seral species in disturbed areas and persist in pastures. The second pasture (Table 3.3.1-7) was on Mexico-Putnam soil and was dominated by inland rush, white clover, Canada goldenrod, and elm-leaved goldenrod.

Abandoned cropland is ecologically classified as an old field, a very early sere (stage) in plant suggession (see Section 3.2.2.2). Drew (1942), in his classic paper describing plant succession on abandoned cropland in Boone and Callaway counties, showed that a single pattern of plant succession occurs immediately following abandonment, regardless of the last crop grown. The year following abandonment, however, annual weeds do vary in composition and abundance according to the last crop grown. In old cornfields, fall panic grass, large crab grass, and common ragweed are the most abundant 1st-year weeds. In small-grain fields, the most important are common ragweed, fall panic grass, trailing wild bean, bracted plantain, and horseweed.

The 2nd year following abandonment produces a number of perennials. There is an increase in the two principal old-field dominants, gray goldenrod and white heath aster. The 3rd year after abandonment, the annual dominants of the first 2 years decrease, while the absolute number of species and perennials increases. After 5 or 6 years, the herbaceous vegetation remains relatively homogeneous, with only local changes, until approximately 20 years after abandonment. Chief old-field dominants then increase in importance until the old-field reaches 30 years.

Many abandoned fields 20 years old or more support a considerable woody vegetation. Development of woody vegetation begins with the establishment of shrubs and woody vines 5 to 6 years after cultivation ceases. Smooth and winged sumac are the most common shrubs invading cropland undergoing natural revegetation; they become established after perennial old-field dominants are established. Borders of abandoned fields are invaded by trees, where contiguous patches of forest exist. The establishment of woody vegetation in old fields is accelerated by the close proximity of a seed source. The old-field (Table 3.3.1-8) sampled during the present study, knotweed, white-oat grass, twice-toothed ragweed, roundseed paspalum, and yellow foxtail were important species, with IV's ranging from 17 to 55.

3.3.1.3 Miscellaneous Observations of Vegetation

Thirty-eight plant species not collected during regular sampling were collected for voucher specimens. Eastern white pine, loblolly pine, scrub pine, and scotch pine were found on the only pine plantation within the Intensive Study Area. Bullace plum, sassafras, poison ivy, and hawthorn were shrubby-woody species found along hedgerows created by local farmers, who allow fencelines and drainages to develop into weedy and/or woody vegetation. American ipecac, naked flowering scape trefoil, four-leaved milkweed, and hairy ruellia were found in forest herbaceous layers. The old-field habitat yielded clammy ground cherry, common milkweed, large-bracted tick-trefoil, and field garlic. A cumulative list of collected and/or identified plants appears in Appendix 3A.

TABLE 3.3.1-1

CHARACTERISTICS OF SOILS FOUND WITHIN THE INTENSIVE STUDY AREA, CALLAWAY COUNTY, MISSOURI

Series	Slope Gradient (percent)	Permeability[e] (in/hr)	Shrink/Swell Potential	Suitability as Topsoil	Potential Yield Corn (bu.)	Potential Yield Soybean (bu.)	Important Trees	Site Index
Mexico[a]	1 to 5	<0.05	Moderate	Fair	90	40	Upland Oak	54
Putnam[b]	0 to 2	<0.05	Low	Poor	80	30	Upland Oak	40
Menfro[c]	3 to 30	<0.80 to 2.50	Low-Moderate	Fair-Good	80-100	30-40	Upland Oak	60
Goss[d]	8 to 45	<0.80 to 2.50	Low	Poor	--	--	Upland Oak	60

a Soil Conservation Service, 1972b.

b Soil Conservation Service, 1972d.

c Soil Conservation Service, 1971.

d Soil Conservation Service, 1972a.

e Soil Survey Staff. 1951. Soil Survey mar[illegible] U.S. Dept. of Agriculture Handbook No. 18, p. 168.

TABLE 3.3.1-2

SUMMARY OF IMPORTANCE VALUES FOR VEGETATION IDENTIFIED WITHIN FOUR OAK FOREST TYPES

Species	Overstory[a] Sample Station FT2	FT3	FT4	FT7	AVG.	Upper Understory[b] Sample Station FT2	FT3	FT4	FT7	AVG.	Lower Understory[c] Sample Station FT2	FT3	FT4	FT7	AVG.	Herbaceous Layer[d] Sample Station FT2	FT3	FT4	FT7	AVG.
White oak	33.7	39.7	34.3	28.6	34.1	7.0	7.9		2.1	5.7	5.4	3.5	31.9	3.7	11.1					
Black oak	16.6	9.3	2.6	1.4	7.5	8.6	4.4			6.5										
Post-oak	11.2	11.5	7.6	1.6	8.0	4.7	3.3		3.1	3.7		4.3		1.8	3.1					
Flowering dogwood	10.3	6.4			8.4		8.9			8.9				1.8	1.8					
Shagbark hickory	7.0	6.6	1.4	5.5	5.1	8.1	10.8		2.5	7.1		3.5			3.5					
Sugar maple	3.1	1.1	7.6	14.1	12.7	1.5	2.0	36.6	10.6	12.7		3.5	18.1		10.8					
White ash	1.1	1.1	13.2	6.1	5.4									3.7	3.7					
Red oak		8.5	14.3	4.0	8.9		7.4	11.3		9.4		3.5	7.2	3.6	4.8					
Bitternut hickory		3.5	6.9		5.2	3.0	2.0	4.7		3.2	1.7		7.2		4.5					
Basket-oak		1.7		10.9	6.3				2.1	2.1				1.8	1.8					
Redbud				6.4	6.4	1.9			2.1	2.0										
Fragrant sumac						24.9	24.3	17.6	9.8	19.2	17.1	40.1	21.1	5.4	21.0					
Round-leaved dogwood						9.4				9.4		7.6			7.6					
Virginia creeper						3.0			4.2	3.6	30.9	4.3		52.5	29.2					
Green ash							6.8	20.5	9.1	12.1	3.3	15.0	7.2		8.5					
Bristly greenbrier									2.5	2.5				1.8	1.8					
Frost grape						2.2			9.1	5.7	4.8				4.8					
Rough-leaved dogwood											9.6				9.6					
Carolina rose											8.1	3.5		2.2	4.6					
Grass																66.0	14.6		27.1	35.9
Plantain-leaf everlasting																18.9	9.7		9.0	12.5
Hog-peanut																9.4	4.8	78.3	9.0	25.4
Globose cyperus																	53.4		1.8	27.6
Pale plantain																	9.7			9.7
Wild bergamot																		8.7	1.3	5.0
Florida lettuce																			7.2	7.2
White wild licorice																	2.9		7.2	5.1
Crown-beard																			7.2	7.2

[a] Woody vegetation greater than 1 inch d.b.h. Importance value based on the summation of the relative density, relative frequency and relative dominance divided by 3.

[b] Woody vegetation between 18 inches in height and 1 inch d.b.h. Importance value based on the summation of the relative density and relative frequency divided by 2.

[c] Woody vegetation less than 18 inches in height. Importance value based on the summation of the relative density and relative frequency divided by 2.

[d] Non-woody vegetation. Value based on relative frequency.

TABLE 3.3.1-3

IMPORTANT VEGETATION IDENTIFIED
IN TWO OAK-MAPLE FOREST TYPES

Species	Overstory[a] Sample Station FT5	Overstory[a] Sample Station FT6	Upper Understory[b] Sample Station FT5	Upper Understory[b] Sample Station FT6	Lower Understory[c] Sample Station FT5	Lower Understory[c] Sample Station FT6	Herbaceous Layer[d] Sample Station FT5	Herbaceous Layer[d] Sample Station FT6
Sugar maple	27.5	22.6	34.2	45.6	4.0	12.9		
Red oak	22.3	3.2	--	--	--	--		
White oak	15.5	41.3	--	--	6.6	9.1		
Hop-hornbeam	8.8	--	--	--	--	--		
Basket-oak	5.8	--	--	--	--	--		
Slippery elm	3.8	--	14.1	--	14.4	--		
Redbud	3.7	--	8.2	8.4	5.8	11.0		
Black oak	3.9	--	--	--	--	9.1		
White ash		7.9	--	--	--	--		
Bitternut hickory		7.8	--	--	--	--		
Red cedar		6.8	7.4	--	4.0	--		
Shagbark hickory		5.1	3.7	--	4.9	--		
Round-leaved dogwood		2.2	--	--	4.9	9.1		
Green ash			14.1	25.6	4.9	11.0		
Fragrant sumac			8.9	12.2	15.3	--		
Frost grape				8.4	4.9	--		
Hog-peanut							45.4	6.9
Bowman's root							22.7	
Rough bedstraw							15.9	
Broad-leaved panic-grass							6.8	
Grass							4.6	79.3
Common mullein								6.9
White avens							2.3	6.9

---

a Woody vegetation greater than 1 inch d.b.h. Importance Value is based on the summation of relative density, relative frequency and relative dominance divided by 3.

b Woody vegetation between 18 inches in height and 1 inch d.b.h. Importance Value is based on summation of relative density and relative frequency divided by 2.

c Woody vegetation less than 18 inches in height. Importance Value is based on summation of relative density and relative frequency divided by 2.

d Non-woody vegetation. Value is based on relative frequency.

TABLE 3.3.1-4

IMPORTANT VEGETATION IDENTIFIED IN AN OAK-HICKORY FOREST TYPE (FT_1)

Species	Overstory[a]	Upper Understory[b]	Lower Understory[c]	Herbaceous Layer[d]
Black oak	25.4	--	--	
White oak	17.7	9.0	27.7	
Shagbark hickory	13.1	12.0	9.0	
Red oak	10.4	2.7	4.6	
Red cedar	7.4	5.3	4.6	
Pignut hickory	6.3	--	--	
Hop-hornbeam	1.4	7.2	8.4	
Coral berry		47.4	23.1	
Black gum		2.7	12.7	
Grass				46.2
Globose cyperus				13.5
Pale plantain				5.8
Canada goldenrod				5.8
Violet				5.8

a Woody vegetation greater than 1 inch d.b.h. Importance Value is based on summation of relative density, relative frequency and relative dominance divided by 3.

b Woody vegetation between 18 inches in height and 1 inch d.b.h. Importance Value is based on summation of relative density and relative frequency divided by 2.

c Woody vegetation less than 18 inches in height. Importance Value is based on summation of relative density and relative frequency divided by 2.

d Non-woody vegetation. Value is based on relative frequency.

TABLE 3.3.1-5

IMPORTANT VEGETATION IDENTIFIED ALONG A WOODED RAVINE BOTTOM (FT_8)

Species	Overstory[a]	Understory[b]	Herbaceous[c] Layer
Black walnut	29.2	11.2	
Red cedar	27.2	7.1	
American elm	8.6		
Honey-locust	7.6	7.5	
Red oak	6.3		
Slippery elm	5.9		
Redbud	5.5		
Common persimmon	5.0	15.9	
Coral berry		41.7	
Round-leaved dogwood		5.7	
Grass			20.0
White oat-grass			10.1
Elm-leaved goldenrod			8.2
Broad-leaved spike grass			7.9
Daisy fleabane			7.6
Hog-peanut			7.3
Witchgrass			7.2
Wild carrot			5.1
Mad-dog skullcap			5.1

a Woody vegetation greater than 1 inch d.b.h. Importance Value is based on summation of relative density, relative frequency and relative dominance divided by 3.

b Woody vegetation between 24 inches in height and 1 inch d.b.h. Importance Value is based on summation of relative density, relative frequency and relative dominance divided by 3.

c All vegetation less than 24 inches in height. Importance Value is based on summation of relative density, relative frequency and relative dominance divided by 3.

TABLE 3.3.1-6

HERBACEOUS VEGETATION[a] ANALYSIS
OF A PASTURE, CALLAWAY COUNTY, MISSOURI

Species	Relative Frequency	Relative Density	Relative Dominance	Importance Value
Buffalo clover	10.00	12.15	41.44	63.59
Canada goldenrod	10.00	38.46	10.88	59.34
Grass	10.00	12.15	25.90	48.05
Yarrow	10.00	9.31	11.27	30.58
Twice-toothed ragweed	10.00	6.48	2.08	18.56
Baldwin's ironweed	5.00	6.07	1.04	12.11
Blue vervain	5.00	4.86	1.43	11.29
Pale plantain	5.00	2.02	1.94	8.96
Pilose Aster	5.00	2.02	.78	7.80
Common cinquefoil	5.00	1.21	1.55	7.76
Partridge pea	5.00	2.02	.26	7.28
Little bluestem	5.00	1.21	.39	6.60
Wild carrot	5.00	.81	.65	6.46
Hogwort	5.00	.81	.26	6.07
Smooth-seeded wild bean	5.00	.81	.13	5.94

a Sampled by quadrats along GQ_2, Figure 3.2.2-1.

TABLE 3.3.1-7

HERBACEOUS VEGETATION ANALYSIS IN A PASTURE TRANSECT $G_1 + G_2$, CALLAWAY COUNTY, MISSOURI

Species	Frequency of Occurrence[a]	Relative Frequency[b]
Inland rush	.96	30.1
White clover	.47	14.7
Canada goldenrod	.39	12.2
Elm-leaved goldenrod	.37	11.6
Clover	.30	9.4
Globose cyperus	.22	6.9
Red clover	.20	6.3
Low hop-clover	.08	2.5
Horse nettle	.07	2.2
Yellow wood sorrel	.04	1.3
Common ragweed	.03	.9
Tall ironweed	.03	.9
Yarrow	.02	.6
Hairy mountain-mint	.01	.3
Total	3.19	99.9

a Number of quarter-meter intervals within which a species occurred along two 15-meter tapes.

b Percent.

TABLE 3.3.1-8

HERBACEOUS VEGETATION[a] ANALYSIS
OF AN OLD FIELD, CALLAWAY COUNTY, MISSOURI

Species	Relative Frequency	Relative Density	Relative Dominance	Importance Value
Knotweed	6.56	12.31	36.25	55.12
White oat-grass	3.28	30.28	14.24	47.80
Twice-toothed ragweed	6.56	11.31	14.24	32.11
Roundseed paspalum	6.56	12.79	4.66	24.01
Yellow foxtail	4.92	8.35	3.88	17.15
Rough buttonweed	6.56	4.38	4.08	15.02
Hogwort	6.56	2.83	5.57	14.96
Western ironweed	3.28	2.69	4.14	10.11
Globose cyperus	6.56	1.08	1.36	9.00
Mad-dog skullcap	6.56	1.21	1.10	8.87
Spotted spurge	4.92	1.08	2.27	8.27
Florida lettuce	3.28	2.76	1.42	7.46
Crabgrass	3.28	2.02	.91	6.21
Horse nettle	4.92	.40	.91	6.23
Slender rush	3.28	2.08	.58	5.94
Pink wild bean	3.28	1.01	1.17	5.46
Witchgrass	3.28	1.41	.52	5.21
Little bluestem	3.28	1.08	.78	5.14
Pilose aster	3.28	.20	.71	4.19
Daisy fleabane	3.28	.13	.32	3.73
Three-sided mercury	1.64	.27	.65	2.56
Yarrow	1.64	.20	.13	1.97
Common cinquefoil	1.64	.20	.06	1.77
Yellow wood sorrel	1.64	.07	.06	1.77

a Sampled by quadrats along GQ_1, Figure 3.2.2-1.

3.3.2 MAMMALS

A list of all species identified on the site is presented in Table 3.3.2-1. Species are listed by ecological habitat, feeding habit, and number of identifications. The number and species of mammals trapped in the spring, early summer, and fall sampling periods are shown in Table 3.3.2-2.

The greatest number and diversity of captures occurred in early summer. Of eight species captured, the white-footed mouse and the opossum had the highest number of recaptures--eight and seven, respectively. Deer mice and opossum were captured during each of the three remaining sample periods. Raccoons were captured only during late summer and winter.

3.3.2.1 Small Mammals

A total of only seven white-footed and 17 deer mice were captured during 4,320 trap nights in four seasons. All captures of the white-footed mouse were along hedgerows (Traplines 4, 8, and 9). Four males, ranging in weight from 15.5 to 25.5 grams, were captured. The weight of the three females captured had a smaller range: 17.2 to 24.1 grams. Deer mice, captured in greater number than white-footed mice, were found in a variety of habitats. Four females and 13 males were trapped in hedgerows, old fields, and wheat fields. Female deer mice ranged in weight from 10.2 to 36.0 grams, with a mean of 19.5 grams; males had a range of 12 to 27 grams, with a mean of 19 grams.

In Missouri, north of the Missouri River, the pine vole, meadow jumping mouse, ground squirrel, and hispid cotton rat normally have low population levels (Elder, 1974); they were not captured in the Intensive Study Area during any of the four trapping periods.

Small mammal populations found in the Intensive Study Area are, compared to previous population studies, very low. During 4,320 trap-nights, a total of 25 individuals and two species were captured. These results are far below those found during a less intensive study conducted by Elder (1974) in the Tucker Prairie (Callaway County, Missouri) preceding the fall of 1972. Elder's conclusion, based on yearly trapping, indicates the existence of a highly significant, regional small mammal population decline. An increase in the affected mammal populations is expected in 1974-1975.

Cyclic fluctuations in small mammal populations have been attributed to changes in the variety and amounts of food

(Jameson, 1955), competition (Christian, 1971), habitat disturbance (LoBue and Darnell, 1959), and habitat changes through succession (Odum et al, 1962). Prairie voles (not captured, but expected to occur on the site), white-footed mice, and deer mice are subject to significant population declines about every 4 years (Godfrey, 1955; Elder, 1974; Christian, 1971).

3.3.2.2 Large Mammals

The opossum (Table 3.3.2-3) was the species most often captured during the large mammal sampling program. Twenty different individuals were captured at least once. Total population was estimated at 35 individuals during the late summer sampling period; however, the estimate at 95 percent confidence limits (Giles, 1971) was not statistically valid because the estimated population was between 5 and 201 animals. A lack of recaptures precluded a population size estimate during the remaining trapping periods.

One opossum (No. 1332/1333) was recaptured twice. During approximately 69 days between sampling periods, this individual, recaptured 1/2 mile and 1 mile from its origional point of capture, added 1.4 kg to its weight. Five other opossum were recaptured; each exibited increased weight and movement up to 1/2 mile from the initial capture point.

The opossum is a wandering solitary mammal whose susceptibility to extremely cold winter weather causes fluctuations in abundance throughout its range and within local populations (Schwartz and Schwartz, 1971). Jackson (1961) estimated a population density of one opossum per square mile in Wisconsin. Schwartz and Schwartz (1971) state that an individual opossum may move up to 2 miles during a night in search of food. Considering these two findings, it can be assumed that the population around the Callaway County site was very high during early summer, when 14 opossum were captured within a 1.5-square mile grid.

Opossum are omnivorous, feeding on insects, carrion, birds, eggs, fruit, and corn (Martin et al, 1961). Stomach analysis by Reynolds (1945) showed that in total volume and frequency of occurrence, insects are the most important food item.

Seven raccoons (Table 3.3.2-4) were captured during early summer, late summer, and winter sampling periods. Males ranged in weight from 4.5 to 5.9 kg and in total length from 580 to 770 mm. Two captured female raccoon weighed 4.9 and 4.5 kg and had a total length of 750 and 500 mm, respectively.

Seven different raccoon were captured during the 420 trap-nights; the greatest number captured during any one period was four. This occurred in both early and late summer sampling periods.

Raccoon population density in the Intensive Study Area could not be determined because of a lack of recaptures. The values obtained per period will be considered minimum densities. Urban (1970) estimated raccoon population density in Ohio at 45 raccoons per square mile. In a Michigan Study, Stuewer (1943) estimated 20 raccoons per square mile during spring. Compared to these estimates, our estimated minimum population densities are low even when natural variance by season is assumed.

Both plant and animal matter make up the raccoon's diet, including fruits (persimmon, grape, plum, osage orange, corn, acorns, blackberries), crayfish, fish, clams, eggs, and the young of various aquatic wildlife (Korschgen, 1952). Martin et al (1961) stated that oaks, corn, persimmon, pokeweed, and grape were common winter foods. These foods are scattered throughout the Intensive Study Area.

Four other mammals were trapped only once or twice during the 1973-74 baseline study period (Table 3.3.2-5). A woodchuck, two cottontail, and a long-tailed weasel were trapped once, and a striped skunk was captured twice. The low number of captures and recaptures for these species eliminated any attempt to estimate their population size.

The wildlife captured by trapping exhibit preferences for specific habitats. The raccoon preferred wooded drainageways located in the northeast and southern portions of the Intensive Study Area. The opossum sought interspersed habitat type, such as the flat prairie, where farming practices have produced a network of hedgerows, old fields and croplands traversed by drainageways, random scattered farm buildings, and ponds. The cottontail preferred an interface of brushy fields and forest edges (ecotones) where cover and food were readily available. The woodchuck, a burrowing animal, favored rocky or sandy sloping land for its burrow. It feeds almost entirely on vegetative matter. The long-tailed weasel, a rare species in Missouri, inhabited thickets, woodlands, and fencerows. A nearby source of drinking water is a prerequisite in its choice of habitat.

3.3.2.3 Evening Automobile Survey

Six mammals, the cottontail, coyote, opossum, raccoon, skunk, and white-tailed deer, were identified during the evening automobile survey (Table 3.3.2-6). Two species, the coyote and white-tailed deer, were not sampled by trapping. Cottontail were usually observed along roadways at dusk and had 3-day means of four, one, and two individuals during early summer, late summer, and winter sampling periods. Eleven, three, and five individuals per 19 miles of road were observed during the above mentioned sampling periods (an average of 0.6, 0.2, and 0.3 cottontail per mile.) A similar survey was conducted by the Missouri Department of Conservation (1973) along 6,406 miles of survey route. They estimated 1.01 rabbits per mile. Comparison of these two values indicates that the Intensive Study Area supported a smaller cottontail population than is average for the State of Missouri.

White-tailed deer were observed only during early summer and fall sampling periods. The number of deer (7) observed in the fall is lower than the densities expected for the forest types described in Section 3.3.1.1; white oak, mixed hardwood, and red cedar-hardwood forest types can support 16, 29, and 17 deer per square mile in the summer. It is therefore assumed that the upward trend in deer numbers described by Nagel (1970) will continue, and that the maximum Intensive Study Area carrying capacity for this species has not been reached.

3.3.2.4 Miscellaneous Observations of Wildlife

Species inhabiting the site but not observed during the more intensive mammal surveys include bat, eastern mole, fox squirrel, gray squirrel, and muskrat (Table 3.3.2.7). The bat was observed during the fall sampling period at a forest edge; its species could not be determined due to poor lighting. Eastern mole tunnels were observed at the interface between a hedgerow-drainageway and pasture.

Fox and gray squirrels were usually observed in hedgerows, along the forest edge, and within forests. Squirrel populations normally fluctuate from year to year. For example, during a 6-year period in Ohio, Nixon and McClain (1969) recorded squirrel populations of 47, 54, 85, 77, 128, and 22 individuals per 100 acres. Burkalow et al, (1970) found similar fluctuations within the gray squirrel population in North Carolina. Six continuous spring estimates for 100 acres were 34, 100, 36, 41, 26, and 60. The number of squirrels noted during the field work cannot be directly compared to these estimates -ecause of differences in sampling technique. Miscellaneous observation is a qualitative technique, whereas trapping is a quantitative one.

TABLE 3.3.2-1

SUMMARY OF MAMMALS IDENTIFIED DURING
THE FIVE SAMPLING PERIODS, CALLAWAY COUNTY, MISSOURI

	Community Type								
	Forest Types				Agricultural Types				
FEEDING HABIT Common Name	Forest	Creek Bottom	Forest Edge	Roadway	Pasture and Cropland	Old Field	Farmstead	Hedgerow	Pond
HERBIVORES-GRANIVORES									
White-footed mouse								7[b]	
Deer mouse	1[b]				5[b]	5[b]		8[b]	
Woodchuck								1[b]	
Muskrat									1[a]
Cottontail			3[a]	44[a]	4[ab]	7[a]	1[a]	4[ab]	
Fox squirrel	1[a]	1[a]	2[a]					5[a]	
Gray squirrel	4[a]							2[a]	
White-tailed deer	3[a]	2[a]	4[a]	8[a]		1[a]		3[a]	
INSECTIVORES									
Eastern mole					1[a]				
Bat			1[a]						

TABLE 3.3.2-1 (continued

FEEDING HABIT Common Name	Community Type: Forest Types: Forest	Creek Bottom	Forest Edge	Roadway	Agricultural Types: Pasture and Cropland	Old Field	Farmstead	Hedgerow	Pond
OMNIVORES									
Striped skunk	1[c]		1[c]	1[c]		2[b]			
Opossum	1[b]	4[b]		[illegible][a]	1[a]			[illegible][b]	
Raccoon	1[a]	3[bc]		[illegible]	1[a]	2[abc]		6[b]	
CARNIVORES									
Longtail weasel								1[b]	
Coyote	4[c]	1[c]		[illegible][a]		1[a]			

a Sighting, sign.

b Trapping.

c Call, odor.

TABLE 3.3.2-2

SMALL AND LARGE MAMMALS
TRAPPED IN CALLAWAY COUNTY, MISSOURI

Common Name	Number of Individuals/Period			
	Early Summer	Late Summer	Fall	Winter
White-footed mouse	7	-	-	-
Deer mouse	5	1	7	4
Longtail weasel	1	-	-	-
Woodchuck	1	-	-	-
Cottontail	2	-	-	-
Striped skunk	2	-	-	-
Opossum	7	17	3	2
Raccoon	4	4	-	1
TOTAL	29	22	10	7

TABLE 3.3.2-3

OPOSSUM (*Didelphis marsupialis*) TRAPPED
DURING FOUR SAMPLING PERIODS, CALLAWAY COUNTY, MISSOURI

Tag Number	Sex	Weight (kg)	Total Length (mm)	Date Trapped	Station	Habitat Description
1328/1329	M	3.5	720	6/21	36	Fencerow adjoining pasture
1332/1333	F	1.5	650	6/21	31	Hedgerow between pasture and soybean field
a		1.5	650	6/23	19	Hedgerow between an old field and hay field
a		2.9	670	8/31	35	Hedgerow between two old fields
1334/1335	F	2.6	690	6/21	35	Hedgerow between two old fields
a		3.9	720	11/9	28	Fencerow between pasture and drainage
1338/1339	F	2.1	610	6/22	19	Hedgerow between an old field and hayfield
a		2.5	610	3/30	30	Hedgerow between pasture and soybean field
1340/1341	M	2.6	720	6/22	14	Hedgerow between old field and hayfield
a		3.5	760	8/31	28	Fencerow between pasture and drainage

TABLE 3.3.2-3 (continued)

Tag Number	Sex	Weight (kg)	Total Length (mm)	Date Trapped	Station	Habitat Description
-- [b]	F.	3.0	820	6/22	35	Hedgerow between two old fields
1344/1345	F	2.1	740	6/23	3-C	Drainage within forest
1403/1404	F	2.1	590	8/30	8	Hedgerow between hayfields
1405/1406 [c]	F	2.2	700	8/30	7	Hedgerow between an old field, hayfield and pasture
1407/1408	M	1.6	580	8/30	25	Hedgerow between a hay-field and soybean field
1411/1412	M	2.9	690	8/30	12	Fencerow between pasture and hayfield
1413/1414	-	1.6	580	8/30	4	Drainage in forest
1415/1416 [c]	F	1.9	670	8/30	32	Fencerow between pasture and drainage
		1.9	670	9/1	31	Hedgerow between pasture and soybean field
1421/1422	M	2.2	690	8/31	21	Fencerow between hayfield, old field and roadway

TABLE 3.3.2-3 (continued)

Tag Number	Sex	Weight (kg)	Total Length (mm)	Date Trapped	Station	Habitat Description
1423/1424	F	2.9	730	8/31	15	Forest
a		2.9	730	9/1	18	Hedgerow between a hay-field and old field
1425/1426	M	4.2	800	8/31	32	Fencerow between pasture and drainage
1428/1429	F	2.8	710	9/1	2	Drainage in forest
1430/1431	F	3.0	740	9/1	13	Hedgerow between hayfield and old field
1432/1433[c]	F	2.9	730	9/1	5	Fencerow within pasture
1434/1435	M	1.9	690	9/1	25	Hedgerow between a hay-field and soybean field
1437/1438	F	1.9	600	11/8	7	Hedgerow between an old field, hayfield and pasture
1441/1442	F	2.4	710	11/10	33	Fencerow between hayfield and drainageway

TABLE 3.3.2-3 (continued)

Tag Number	Sex	Weight (kg)	Total Length (mm)	Date Trapped	Station	Habitat Description
--[bc]	M	3.7	760	2/15	19	Hedgerow between an old field and hayfield
--	M	1.9	500	2/15	4	Drainage in forest

a Recapture.

b Died in trap.

c Possible recapture (no tags present in ears; however, both ears showed signs of previous tagging).

TABLE 3.3.2-4

RACCOON (*Procyon lotor*) TRAPPED DURING FOUR SAMPLING PERIODS, CALLAWAY COUNTY, MISSOURI

Tag Number	Sex	Weight (Kg)	Total Length (mm)	Date Trapped	Station	Habitat Description
1326/1327	M	5.8	580	6/21	13	Hedgerow between hayfield and old field
1336/1337	M	4.5	700	6/21	26	Hedgerow between cornfield, hayfield and old field
1342/1343	M	5.4	770	6/23	13	Hedgerow between hayfield and old field
1401/1402	M	5.9	650	8/30	19	Hedgerow between an old field and hayfield
1409/1410	M	5.6	-	8/30	35	Hedgerow between two old fields
1417/1418	F	4.9	750	8/31	8	Hedgerow between hayfields
---	F	4.5	500	2/17	4	Drainage in forest

TABLE 3.3.2-5

MAMMALS (OTHER THAN OPOSSUM AND RACCOON)
TRAPPED DURING FOUR SAMPLING PERIODS, CALLAWAY COUNTY, MISSOURI

Species	Tag or Collection Number	Sex	Weight (Kg)	Total Length (mm)	Date Trapped	Trapline Station	Habitat Description
Woodchuck	1330/1331	F	.7	--	6/21	0-18	Hedgerow between an old field and hay-field
Striped skunk	--	-	--	--	6/21	0-16	Fencerow between pasture and hayfield
		-	--	--	6/22	0-16	
Cottontail	003	F	.3	200	6/21	5-10	Wheat field
	005	-	--	--	6/21	4-9	Hedgerow between hayfield, winter graze and soybean field
Long-tail weasel	004	M	--	--	6/21	4-13	Hedgerow between hayfield, winter graze, and soybean field

TABLE 3.3.2-6

MAMMALS IDENTIFIED DURING THE EVENING AUTOMOBILE SURVEY, CALLAWAY COUNTY, MISSOURI

Species	Sampling Period			
	Early Summer	Late Summer	Fall	Winter
Cottontail	12	3	--	5
Coyote	--	--	4	1
Opossum	--	--	--	1
Raccoon	4	--	--	2
Skunk	1	--	--	--
White-tailed deer	1	--	7	--
TOTAL	18	3	11	9

TABLE 3.3.2-7

MAMMALS IDENTIFIED
DURING FIVE SAMPLING PERIODS, CALLAWAY COUNTY, MISSOURI

Species	Sampling Period: Spring	Early Summer	Late Summer	Fall	Winter
Bat	--	--	--	1	--
Cottontail	3	24	2	6	6
Coyote	--	--	1	1	--
Eastern mole	--	--	--	--	1
Fox squirrel	4	--	4	1	--
Gray squirrel	1	--	--	2	3
Muskrat	--	1	--	--	--
Skunk	--	1	--	--	1
White-tailed deer	1	4	3	5	--
TOTAL	9	30	10	16	11

3.3.3 BIRDS

Avifauna was sampled to determine species utilizing the site. The total number of species and families identified during the five sampling periods is shown on Figure 3.3.3-1. The number of families was relatively constant (range of 8) compared to the number of species. These ranged from 34 in spring to 58 in early summer and 38 in winter.

Common and scientific names of all species identified are listed in Appendix 3C-2. A summary of findings of each sampling period follows. In the discussion of data, "1-day high" refers to the greatest number observed on any 1 day of the 3-day survey; "3-day mean" refers to the average number of individuals identified per day during the 3-day sampling period.

3.3.3.1 Avian Automobile Survey

Spring

Twenty-five species representing 17 families were observed during spring sampling period (Table 3.3.3-1). The red-winged blackbird, with a 1-day high of 317 individuals and a 3-day mean of 218 individuals was the most frequently observed (Table 3.3.3-2). Red-winged blackbirds were observed in agricultural habitats (agricultural stubble, farm dwelling, pasture-shrub and old field). Other 1-day highs were 238 and 90 for the common grackle and meadowlark, respectively. The common grackle had a 3-day mean of 128; 54 percent of these individuals were observed in agricultural habitats. The meadowlark had a 3-day mean of 67; 61 of these individuals were identified within agricultural habitats.

Early Summer

Forty-four species representing 22 families were observed during the early summer sampling period. The house sparrow was observed most frequently, with a 1-day high of 82 individuals (Table 3.3.3-1) and a 3-day mean of 55 individuals (Table 3.3.3-2) with 41 of these observed along the roadway. The red-winged blackbird and common grackle were again among the three most numerous birds, with 1-day highs of 50 and 71 individuals, respectively. An average of 42 red-winged blackbirds was observed during each day of this 3-day sampling period; an average of 28 birds was identified along the roadway. Twenty-two species not identified in the spring were observed during the early summer survey. Many of these new species, including woodpeckers, cuckoos, warblers, goatsuckers, and swifts, were insectivorous feeders.

Late Summer

Thirty-three species representing 18 families were observed during the late summer sampling period. The house sparrow was again most numerous, with a 1-day high of 60 individuals (Table 3.3.3-1) and a 3-day mean of 43 individuals (Table 3.3.3-2). The common grackle was the second most numerous species observed, with a 1-day high of 44 sightings and a 3-day mean of 16 individuals. Unlike the previous two sampling periods, no red-winged blackbirds were observed during this 3-day survey. Other species with relatively high 3-day means include the common crow (19), bluejay (13), and mourning dove (17).

Fall

Thirty-two species representing 18 families were observed during the fall sampling period. The slate-colored junco, with a 1-day high of 105 individuals, was the species most commonly observed (Table 3.3.3-1). Its 3-day mean for the fall period was 59 individuals (Table 3.3.3-2). The slate-colored junco was first sighted at the Callaway Plant site during this period. Other species with significant 1-day highs include bluejay (39), common crow (32), starling (74), red-winged blackbird (50), and American goldfinch (49). Their 3-day means for this period were 27, 23, 33, 17, and 30, respectively. Agricultural habitats again supported a larger percentage of identified birds. Species not previously observed include winter residents such as cedar waxwing, slate-colored junco, tufted titmouse, and white-crowned and white-throated sparrows.

Winter

Twenty-five species representing 13 families were observed during the winter sampling period. The starling was most commonly observed, with a 1-day high of 155 individuals (Table 3.3.3-1) and a 3-day mean of 74 individuals (Table 3.3.3-2). All but one of these individuals were observed in agricultural habitats. The slate-colored junco, bluejay, and common crow again were species with significant 1-day highs: 113, 63, and 50, respectively. The tree sparrow, common redpoll, and downy woodpecker were observed for the first time in this survey.

The results of the avian automobile survey are shown on Figures 3.3.3-2 and 3.3.3-3. Similar habitat types have been lumped together to depict more easily seasonal changes observed along the survey route. Birds have been categorized by feeding habit in order to facilitate discussion of energy flow (trophic levels) within the ecosystem. Major levels within the trophic structure are: herbivore-granivore (species feeding on plant food), omnivore (species feeding on plants and invertebrates in equal proportions), insectivore (species higher in the trophic level, feeding predominantly on invertebrates), and carnivore (the highest trophic level, consuming birds from any of the three previous levels). Some species do not fall in any of the groups listed above. Therefore, other categories are used: nectivore (hummingbirds feeding on nectar from flowering plants), aquatic omnivore (species feeding on aquatic plants, and invertebrates), and carrion feeder (turkey vulture, feeding on decaying animal matter).

On the Intensive Study Area, omnivorous feeders were the greatest number of species sighted during each of five sampling periods (Figure 3.3.3-2). In overall abundance (Table 3.3.3-2), omnivorous feeders were the dominant group found along the survey route. During spring, they composed 95 percent of total identified birds. During the four remaining sampling periods, omnivorous birds had relative abundance per season of 75, 68, 78, and 89 percent (Table 3.3.3-2). Omnivorous species were most abundant during spring, early summer, and winter, when other more specialized feeders would find climate and/or food sources limiting. Omnivores were least abundant during late summer and fall sampling periods, when an influx of insectivorous and gravivorous-herbivorous birds into the site area occurred. Omnivores showed a preference for agricultural habitats (Figure 3.3.3-3).

Granivorous-herbivorous birds were present on the site during each sampling period; however, they represented only 3, 16, 18, 16, and 4 percent of the total bird population during each successive season (Table 3.3.3-2). The number of granivorous-herbivorous species (Figure 3.3.3-2) was slightly higher during early summer, late summer, and fall because of the addition of summer residents such as the catbird, horned lark, and American goldfinch. Granivore-herbivores were observed in equal numbers among the four habitat types, except during winter, when only hedgerow and agricultural habitat types were utilized.

Insectivores observed along the avian automobile survey route reached their peak during the late summer sampling period (Table 3.3.3-2). They composed 11 percent of the total number of birds observed. The greatest number of insectivorous species, however, was observed during the early summer sampling period, when 11 species were identified in the forest habitat (Figure 3.3.3-2). Insectivores were least abundant during spring, fall, and winter (Figure 3.3.3-3), when many of the birds that feed on flying insects were further south. Species in this category are whip-poor-will, chimney swift, common nighthawk, and purple martin. Insectivorous species sighted during the winter sampling period were the downy, hairy, pileated and red-headed woodpeckers and the yellow-shafted flicker.

Five species of carnivores - the great-horned owl, loggerhead shrike, marsh hawk, red-tailed hawk and sparrow hawk - were identified along the avian automobile survey route (Table 3.3.3-2). Their numbers remained relatively constant throughout the study period, composing less than 3 percent of the total avian population (Figure 3.3.3-3). The highest number of carnivores was observed during fall and winter; favored habitats during those periods were hedgerows and agricultural fields (Figure 3.3.3-2). Carnivores are important in the ecosystem as regulators of small mammal populations, which may become pests or over abundant if not controlled. For example, a relationship has been established between increases or declines in rabbit populations and increases or decreases in the number of great horned owls (which were observed on the site) (Rusch et al, 1972). The food habits of an area's avian predators can be used to determine what small rodents are present (Korschgen and Stuart, 1972). Foods used by avian predators include cottontail, meadow mouse, white-footed mouse, songbirds, gray squirrel, fox squirrel, and mourning dove.

Aquatic omnivores observed along the avian automobile survey route were unidentified ducks, pied-billed grebe and ring-necked duck (Table 3.3.3-2). These species were most abundant during fall in the agricultural habitat (Figure 3.3.3-2). These feeders are not common to the Intensive Study Area because it lacks large bodies of water surrounded by vegetation.

Carrion feeders (Figure 3.3.3-2) sighted were the turkey vulture (Table 3.3.3-2). This species was observed during spring, early summer, and late summer sampling periods, but their numbers were relatively high only during the spring (Figure 3.3.3-3).

3.3.3.2 Avian Strip Survey

One preliminary avian strip survey was conducted during the spring sampling period; thereafter, two avian strip surveys were conducted during early summer, late summer, fall, and winter sampling periods. The following is a breakdown, by period, of the most numerous species identified during the avian strip survey.

Spring

SS_1: Twenty-one species representing 11 families were observed along survey strip 1 during the spring sampling period. Bob-whites were most numerous, with a 1-day high of 15 individuals and a 3-day mean of five individuals. These individuals were observed in a hedgerow. Other 1-day highs were field sparrows (11), red-winged blackbirds (10), and robins (10). Their 3-day means for this period were six, three, and three, respectively.

Early Summer

SS_2: Twenty-seven species representing 16 families were observed along survey strip 2 (Table 3.3.3-3). Common grackles and red-winged blackbirds were most numerous, with 1-day highs of 60 and 58 individuals, respectively. These species had 3-day means of 44 and 49, respectively (Table 3.3.3-4). Common grackles were observed most frequently in hedgerows, while red-winged black-birds were observed only in agricultural fields. Mourning doves (23), bobwhites (15), and common crows (14) also had significant 1-day highs. Three-day means for these species were 10, 8, and 6, respectively.

SS_3: Twenty-seven species representing 15 families were observed during early summer along survey strip 3. Red-winged blackbirds had a 1-day high of 65 individuals (Table 3.3.3-5) and a 3-day mean of 36 (Table 3.3.3-6). Bobwhites (21), field sparrows (16), and brown-headed cowbirds (12) were commonly observed. These species had 3-day means of 12, 8, and 6, respectively.

Late Summer

SS_2: Nineteen species representing 13 families were observed along strip survey 2 in the late summer. Bobwhites (17), bluejays (10), and field sparrows (9) had significant 1-day highs (Table 3.3.3-3). Bobwhites had a 3-day mean of 10, while bluejays and field sparrows had a 3-day mean of eight and five, respectively (Table 3.3.3-4). Bluejays were more numerous in the forest habitat type, while bobwhites and field sparrows were more numerous in agricultural fields. Four species not observed during the early summer sampling period along this route were observed: black-capped chickadee, blue grosbeak, robin, and catbird.

SS_3: Nineteen species representing 11 families were observed during the late summer sampling period. Rock doves (15), meadowlarks (14), barn swallows (11), and common crows (9) had significant 1-day highs (Table 3.3.3-5); these had 3-day means of five, six, seven, and four, respectively (Table 3.3.3-6).

Fall

SS_2: Twenty-six species representing 12 families were observed along strip survey 2 during the fall sampling period. The common grackle was the most numerous species along this survey route, with a 1-day high of 115 individuals (Table 3.3.3-3) and a 3-day mean of 62 (Table 3.3.3-4). American goldfinches, slate-colored juncos, and white-throated sparrows were less numerous, with 1-day highs of 48, 22, and 15, respectively. Bobwhites were less numerous than during the late summer sampling period, with a 1-day high of 12 and a 3-day mean of four. Of the 16 new species observed along this route, seven were winter residents.

SS_3: Twenty-nine species representing 16 families were observed during the fall along strip survey 3. Meadowlarks had a significant 1-day high of 76 individuals (Table 3.3.3-5) and a 3-day mean of 31 (Table 3.3.3-6). Common crows (47), bobwhites (30), snow geese (30), and blue geese (30) also had significant 1-day highs. Three-day means of 18, 17, 12, and 12, respectively, were recorded for these species.

Winter

SS_2: Sixteen species representing seven families were identified along this route during the winter sampling period. House sparrows (150), slate-colored juncos (58), and song sparrows (50) had significant 1-day highs (Table 3.3.3-3) and 3-day means of 55, 36, and 17, respectively (Table 3.3.3-4). House sparrows were generally observed in forests, while slate-colored juncos were identified in hedgerows and song sparrows in agricultural fields. Cardinals (22) and bluejays (14) also had significant 1-day highs. Many of the omnivorous and insectivorous species identified during previous periods were not observed during this period.

SS_3: Twenty species representing eight families were identified along strip survey 3 during the winter sampling period. The meadowlark was again commonly observed, with a 1-day high of 17 (Table 3.3.3-5) and a 3-day mean of six individuals (Table 3.3.3-6). Slate-colored juncos (11), bluejays (10), eastern bluebirds (10), and tree sparrows (10) also had high 3-day means of five, six, five, and seven, respectively.

The number of bird species identified during all periods along avian strip survey 2 and 3 is shown on Figures 3.3.3-4 and 3.3.3-5, respectively. Three general habitat types were found along SS_2: agricultural fields, hedgerows, and forests; only two --agricultural fields and hedgerows--were found along SS_3. During the early summer, agricultural fields held the greatest numbers of birds, while forest provided most species with food and cover during the late summer. Hedgerow was most heavily utilized during the fall and winter.

Omnivores were the most abundant species found along both SS_2 and SS_3, dominating SS_2 during the winter (Table 3.3.3-4) and SS_3 during the fall (Table 3.3.3-6). They comprised 82, 46, 70, and 96 percent by season of the total birds observed along SS_2 (Figure 3.3.3-6) and 71, 47, 61, and 80 percent along SS_3 (Figure 3.3.3-7). Species such as the bluejay, cardinal, and common crow were found along both survey routes during all four sampling periods. Other species, such as the slate-colored junco, song sparrow, and white-crowned and white-throated sparrow, were observed only during the fall and winter periods.

Granivorous-herbivorous species were usually the second most numerous species identified along both transects (Figures 3.3.3-6 and 3.3.3-7). They composed between zero and 32 percent of all birds observed along SS_2 and between 9 and 22 percent along SS_3. A total of nine granivorous-herbivorous species was identified along both transects (Tables 3.3.3-4 and 3.3.3-6). Peak abundance along SS_3 for granivore-herbivores came during the fall, when 23 birds of three species were observed. Fall was also the period of peak abundance along SS_2, when 20 individuals were observed in the hedgerow and 18 were observed in agricultural fields. The granivore-herbivores were least abundant in the winter: five individuals were observed along SS_3 and none were observed along SS_2. The granivore-herbivores contained two game species, the bobwhite and the mourning dove, and one "rare" species, the ruffed grouse.

Insectivores were less important along the two strip surveys than omnivores and granivore-herbivores. Relative abundance along SS_2 (Table 3.3.3-4) fluctuated from a low of 1.5 percent in the early summer to a high 21.6 percent in the late summer and back down to 4.5 percent in the fall and winter. Along SS_3 (Table 3.3.3-6) a greater fluctuation per season was noted; values (percent of total population) of 12.7, 28.8, 3.8, and 10.7 were recorded, respectively. In both strip surveys, it was during the late summer that insectivores were most abundant, with nine (Figure 3.3.3-6) and 13 (Figure 3.3.3-7) individuals sighted, respectively. Insectivore use of specific habitats also varied with season. Along SS_2, the favored habitat by season was hedgerow (early summer), agricultural fields (late summer), hedgerow (fall), and forest (winter). Along SS_3, the favored habitats were agricultural fields (early and late summer) and hedgerow (fall and winter). Only woodpeckers and the yellow-shafted flicker were permanent insectivorous residents of the Intensive Study Area. The remaining species were summer residents, migrating south in the fall in response to primary food die-off brought on by colder weather.

Carnivores along both survey routes composed only small percentages of the total population. Along SS_2, less than 1 percent of the total number of birds were carnivores; along SS_3, between 0.5 and 1.2 percent of the total were carnivores. Five species were observed along SS_2 during the four sampling periods (Table 3.3.3-4). Two interesting carnivore species were sighted: the belted kingfisher and the green heron, which feed on fish. Most of the other species are strictly meat-eaters, preying on small mammals and songbirds. The loggerhead shrike, sighted along SS_3, is a passerine (perching) bird that catches crickets, amphibians, and reptiles and attaches them to barb wire fences for later feeding.

One specialized feeder observed in early summer in the agricultural fields along SS_2 was the nectivorous ruby-throated hummingbird. A second group of specialized feeders was found along SS_3 (Table 3.3.3-6). The blue goose and snow goose were observed in the fall during their southward migration; they may use the site only sporadically during periods of migration. Since waterfowl feed either on submerged plants and/or invertebrates, they are limited in their choice of habitat. The mallard was sighted in the late summer; the mallard is common to many areas and nests in a variety of habitats unsuitable for other waterfowl. The small ponds in the Intensive Study Area would attract this less specific feeder.

3.3.3.3 Evening Automobile Survey

Five species of birds were noted during the four sampling periods (Table 3.3.3-7) along the evening automobile survey route. Two nocturnal insectivores, the common nighthawk and the whip-poor-will, were observed only during this survey. The whip-poor-will was seen or heard repeatedly during the early summer months. An avian predator, the great horned owl, was observed only a few times; the great horned owl is a nocturnal hunter. The pied-billed grebe, an aquatic omnivore, was observed at dusk on a farm pond. Twenty-five purple martins were observed only once along the route. Because this route was the same as the avian automobile survey route, and the surveys were generally run during the same 3 days, these data were combined with the avian automobile survey data and analyzed as such.

3.3.3.4 Miscellaneous Observations of Birds

Sixteen species of birds were classified as miscellaneous observations (Table 3.3.3-8). Among the 16 species, three were aquatic, two carnivorous, three upland gamebird, two specialized feeder, and six songbird.

Bobwhite, an upland game species, was observed during four of the five periods. The peak number was observed in fall, when 49 individual sightings were made. A flock of 100 common redpoll were observed during the winter. This is an unusual sighting because this species is a winter resident further north (Robbins et al, 1966). A golden eagle, which feeds on a variety of upland animals, was observed in an old field after an unsuccessful hunting attempt. The golden eagle is uncommon to Missouri; however, because it is near a major waterway and avian flight corridor, the site area is attractive to many wide-ranging species. Mourning dove, a second upland game species considered an interesting sighting, was observed during fall, when this species is migrating.

Among the remaining miscellaneously observed species, most were sighted only infrequently. Included in the above category are American bittern, common nighthawk, grasshoppper sparrow, turkey, white-breasted nuthatch, and ruby-throated hummingbird.

TABLE 3.3.3-1

SEASONAL ABUNDANCES[a] OF BIRDS IDENTIFIED ALONG THE AVIAN AUTOMOBILE SURVEY ROUTE

	Sampling Period				
Species	Spring	Early Summer	Late Summer	Fall	Winter
Ducks[a]			2	5	
Ring-necked duck				1	
Turkey vulture	19	1	1		
Red-tailed hawk	1			3	9
Marsh hawk				6	1
Sparrow hawk	3	2	1	1	3
Bobwhite	10	31	30	1	15
Turkey	5			1	
Killdeer	6		1		
Rock dove			1		
Mourning dove	10	40	20	23	
Yellow-billed cuckoo		1			
Black-billed cuckoo		1			
Great horned owl				1	
Chimney swift		2			
Yellow-shafted flicker		2	3	9	5
Pileated woodpecker	2	2			2
Red-bellied woodpecker	2	3	3	7	11
Red-headed woodpecker		6	8	2	8
Downy woodpecker					3
Eastern kingbird		4	8		
Great crested flycatcher		2			
Eastern phoebe			1		
Horned lark		1			8
Rough-winged swallow			23		
Barn swallow		17	16		
Blue jay	8	7	18	39	63
Common crow	13	13	24	32	50
Black-capped chickadee		2	4	4	2
Tufted titmouse				1	2
Mockingbird	5	4	5	3	4
Catbird		8	3	1	
Brown thrasher	2	8	2		
Robin	19	17	6	6	
Wood thrush		1			
Eastern bluebird	14	6	4	27	19
Cedar waxwing				12	
Loggerhead shrike		7	3	1	2
Starling	49	2	10	74	155
Red-eyed vireo		2			
Myrtle warbler	2				
Yellowthroat		5			

TABLE 3.3.3-1 (continued

Species	Sampling Period				
	Spring	Early Summer	Late Summer	Fall	Winter
Yellow-breasted chat		1			
House sparrow	13	82	60	7	11
Meadowlark	90	28	5	24	33
Red-winged blackbird	317	50		50	
Baltimore oriole		3			
Common grackle	238	71	44	7	16
Brown-headed cowbird	2	10	1		
Summer tanager	1	1			
Cardinal	24	14	10	25	47
Indigo bunting		23	3		
Dickcissel		13			
Common redpoll					1
American goldfinch		7	1	49	
Rufous-sided towhee		3	2		
Slate-colored junco				105	113
Chipping sparrow		1			
Field sparrow	62	12	4		
Tree sparrow					15
White-crowned sparrow				1	
White-throated sparrow				4	
Song sparrow	22	3		4	13
TOTAL	939	519	328	536	608

a Abundance based on one-day high per period.

TABLE 3.3.3-2

SEASONAL ABUNDANCE AND RELATIVE ABUNDANCE OF BIRDS IDENTIFIED ALONG THE AVIAN AUTOMOBILE AND EVENING AUTOMOBILE SURVEY ROUTE BY GENERAL HABITAT TYPE, CALLAWAY COUNTY, MISSOURI

FEEDING HABIT	Abundance[a]																				Relative Abundance[b]				
	Spring				Early Summer				Late Summer				Fall				Winter								
Species	F[c]	A[d]	R[e]	H[f]	F	A	R	H	F	A	R	H	F	A	R	H	F	A	R	H	Spring	Early Summer	Late Summer	Fall	Winter
OMNIVOROUS																									
Black-capped chickadee	-	-	-	-	-	-	-	-	-	-	-	-	2.3	-	.3	-	.3	-	-	.3	-	-	-	.8	.2
Blue jay	2	-	.7	1	3	-	.7	.7	9	.3	-	3.7	20.3	2.3	2	2.7	30	5	-	9.3	.7	1.2	6.9	8.8	12.6
Brown-headed cowbird	-	-	-	1	.3	1	6.3	-	-	.3	-	-	-	-	-	-	-	-	-	-	.2	2.1	.2	-	-
Brown thrasher	.3	.3	-	-	1	.7	3	.3	-	3	3	-	-	-	-	-	-	-	-	-	.1	1.4	2.1	-	-
Cardinal	8	.3	1.7	9.3	4	.7	3	1.7	4	-	2.3	-	2	4.7	7.7	1	4.7	4.3	-	6.3	3.4	2.6	3.4	5.0	4.4
Cedar waxwing	-	-	-	-	-	-	-	-	-	-	-	-	4.7	-	.3	-	-	-	-	-	-	-	-	1.6	-
Chipping sparrow	-	-	-	-	-	-	.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.2	-	-	-
Common crow	4.7	3.7	.7	1	4.3	2	.7	.7	10	1.3	7.3	.3	5	14.7	1.7	1.7	11	13	-	10	1.8	2.2	10.1	7.4	9.7
Common grackle	10.3	70.7	21.7	25.3	.7	16.7	35.7	-	-	15.7	.3	-	1	1.7	-	.7	-	5	-	.3	22.[illegible]	14.9	8.5	1.1	1.5
Dickcissel	-	-	-	-	.3	1.3	7.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.6	-	-	-

TABLE 3.3.3-2 (continued)

FEEDING HABIT	Abundance[a]																				Relative Abundance[b]				
	Spring				Early Summer				Late Summer				Fall				Winter				Spring	Early Summer	Late Summer	Fall	Winter
Species	F[c]	A[d]	R[e]	H[f]	F	A	R	H	F	A	R	H	F	A	R	H	F	A	R	H					
Eastern bluebird	-	4.7	-	3	-	1.3	2.3	.7	-	-	3	-	-	1.7	16.3	3	-	9.3	-	3	1.4	1.2	1.6	6.8	3.5
Field sparrow	3.3	2.7	7	17	3	1.7	1	-	1.3	1.7	-	-	-	-	-	-	-	-	-	-	5.3	1.6	1.6	-	-
House sparrow	-	4.3	-	1.3	.3	14	41	-	16.7	16.7	10	-	-	2.7	.3	.3	2.7	2.3	-	2	1.0	15.6	23.1	1.1	2.0
Indigo bunting	-	-	-	-	2.7	1	15.3	-	.7	.3	-	-	-	-	-	[illegible]	-	-	-	-	-	5.3	.5	-	-
Meadowlark	1	61	1.7	3	-	16.7	10	.7	-	2	1.3	-	-	12	[illegible]	[illegible]	-	17.7	-	.3	11.8	7.7	1.8	6.6	5.1
Mockingbird	-	1.3	-	1	.7	.7	2	-	.3	.3	2.3	-	-	-	.7	.3	.3	1.3	-	.7		1.0	1.5	.3	.7
Red-winged blackbird	30.7	154.7	8	25	1.3	12.3	27.7	.7	-	-	-	-	-	16.7	1	-	-	-	-	-	38.6	11.8	-	5.7	-
Robin	.3	4	2	7	1.7	4.3	3.3	1	-	1.3	3	1	2	.3	.3	1.3	-	-	-	-	2.3	2.9	2.8	1.2	-
Rufous-sided towhee	-	-	-	-	.7	.3	-	-	.3	-	.7	.3	-	-	-	-	-	-	-	-	-	.3	.7	-	-
Slate-colored junco	-	-	-	-	-	-	-	-	-	-	-	-	6	4	15.3	33.7	3	23.3	-	56.3	-	-	-	19.0	23.6
Song sparrow	4	-	1.3	6.7	-	.7	.3	-	-	-	-	-	-	1.7	-	1	-	1	-	4.7	2.1	.3	-	.9	1.6

TABLE 3.3.3-2 (continued)

FEEDING HABIT Species	Abundance[a] Spring F[c]	A[d]	R[e]	H[f]	Early Summer F	A	R	H	Late Summer F	A	R	H	Fall F	A	R	H	Winter F	A	R	H	Relative Abundance[b] Spring	Early Summer	Late Summer	Fall	Winter
Starling	-	15	-	1.3	-	1	.3	-	-	-	3	3.3	-	30.7	2.3	-	-	73.7	-	.3	2.9	.4	3.4	10.6	21.1
Tree sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	2.8
Tufted titmouse	-	-	-	-		-	-	-	-	-	-		.3	-	-	-	.7	-	-	-	-	-	-	.1	.2
White-crowned sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.3	-	-	-	-	-	-	-	.1	-
White-throated sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	.3	-	2	-	-	-	-	-	-	-	.7	-
Wood thrush	-	-	-	-	.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-
Group total	64.6	322.7	44.8	102.9	24.3	76.4	161	6.5	42.3	42.9	34.2	8.6	43.6	93.5	53.9	50.7	52.7	155.9	0	103.5	94.6	75.4	68.2	77.8	89.1
GRANIVOROUS - HERBIVOROUS																									
American goldfinch	-	-	-	-	-	-	2.3	.7	.3	-	-	-	16.7	3.3	4.3	5.7	-	-	-	-	-	.8	.2	9.6	-
Bobwhite	1	3.3	-	2.7	2	14.7	6.7	1	.3	4	11	-	-	.3	-	-	-	5	-	-	1.2	6.9	8.2	.1	1.4
Catbird	-	-	-	-	1	.7	2.3	.7	1	-	-	-	.3	-	-	-	-	-	-	-	-	1.3	.5	.1	-
Common redpoll	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	.9
Horned lark	-	-	-	-	-	-	.3	-	-	-	-	-	-	-	-	-	-	4.3	-	.3	-	.1	-	-	1.3
Mourning dove	-	3.3	2.7	.7	1.3	5.3	16.3	.7	1.3	4	12	-	.3	2.3	14	2	-	-	-	-	1.2	6.6	9.2	6.0	-
Rock dove	-	-	-	-	-	-	-	-	-	.3	-	-	-	-	-	-	-	-	-	-	-	-	.2	-	-

TABLE 3.3.3-2 (continued)

FEEDING HABIT	Abundance[a]																				Relative Abundance[b]				
	Spring				Early Summer				Late Summer				Fall				Winter								
Species	F[c]	A[d]	R[e]	H[f]	F	A	R	H	F	A	R	H	F	A	R	H	F	A	R	H	Spring	Early Summer	Late Summer	Fall	Winter
Turkey	.7	-	1	-	-	-	-	-	-	-	-	-	.3	-	-	-	-	-	-	-	.3	-	-	.1	-
Group total	1.7	6.6	3.7	3.4	4.3	20.7	27.9	3.1	2.9	8.3	23	0	17.6	5.9	18.3	7.7	0	9.3	0	3.3	2.7	15.7	18.3	15.9	3.6
INSECTIVOROUS																									
Baltimore oriole	-	-	-	-	.3	.3	1	.3	-	-	-	-	-	-	-	-	-	-	-	-	-	.5	-	-	-
Black-billed cuckoo	-	-	-	-	.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-
Chimney swift	-	-	-	-	-	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.5	-	-	-
Common nighthawk	-	-	-	-	-	-	.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-
Downy woodpecker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.7	-	.7	-	-	-	-	.4
Eastern kingbird	-	-	-	-	-	.7	1	-	1	.3	2	1	-	-	-	-	-	-	-	-	-	.5	2.3	-	-
Eastern phoebe	-	-	-	-	-	-	-	-	.3	.3	-	-	-	-	-	-	-	-	-	-	-	-	.3	-	-
Great crested flycatcher	-	-	-	-	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.4	-	-	-
Killdeer	-	2	1.7	-	-	-	-	-	-	.3	-	-	-	.7	-	-	-	-	-	-	.7	-	.2	.2	-
Myrtle warbler	-	-	.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-	-

TABLE 3.3.3-2 (continued

FEEDING HABIT	Abundance[a]																				Relative Abundance[b]				
	Spring				Early Summer				Late Summer				Fall				Winter								
Species	F[c]	A[d]	R[e]	H[f]	F	A	R	H	F	A	R	H	F	A	R	H	F	A	R	H	Spring	Early Summer	Late Summer	Fall	Winter
Pileated wood-pecker	.7	-	-	-	.3	-	.7	-	-	-	-	-	-	-	-	-	.7	-	-	-	.1	.3	-	-	.2
Purple martin	-	-	-	-	-	-	-	-	-	-	8.3	-	-	-	-	-	-	-	-	-	- -	-	4.4	-	-
Red-bellied woodpecker	.7	-	-	.3	1	-	-	.7	.7	3	.3	.3	2	.3	2.7	-	1.3	1	-	4	.2	.5	.8	1.6	1.8
Red-eyed vireo	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.3	-	-	-
Red-headed woodpecker	-	-	-	-	1.3	2.3	1.3	.7	1.7	1.7	-	2.3	1	-	-	.3	2.3	.3	-	2	-	1.6	3.0	.4	1.3
Summer tanager	-	-	-	.3	.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	.1	-	-	-
Whip-poor-will	-	-	-	-	-	-	3	-	-	-	.3	-	-	-	-	-	-	-	-	-	-	.8	.2	-	-
Yellow-billed cuckoo	-	-	-	-	.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-
Yellow-breasted chat	-	-	-	-	-	-	.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.1	-	-	-
Yellow-shafted flicker	-	-	-	-	1	-	.3	-	-	.3	.3	-	2	.3	2	-	1.7	1	-	.7	-	.4	.3	1.4	1.0
Yellowthroat	-	-	-	-	.7	.7	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.9	-	-	-
Group total	1.4	2	2.4	.9	7.8	5.7	18.6	1.7	3.7	3.2	11.2	3.6	5	1.3	4.7	.3	6.0	3	0	7.4	1.2	7.1	11.5	3.6	4.7

TABLE 3.3.3-2 (continued)

FEEDING HABIT Species	Abundance[a] Spring F[c]	A[d]	R[e]	H[f]	Early Summer F	A	R	H	Late Summer F	A	R	H	Fall F	A	R	H	Winter F	A	R	H	Relative Abundance[b] Spring	Early Summer	Late Summer	Fall	Winter
CARNIVOROUS																									
Great horned owl	-	-	-	-	-	-	.3	-	-	-	-	-	-	.3	-	-	-	-	-	-	-	-	-	.1	-
Loggerhead shrike	-	-	-	-	-	-	4.7	-	-	.3	1.3	.3	-	-	.7	.3	-	1.3	-	.7	-	1.3	1.0	.3	.6
Marsh hawk	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	.3	-	.3	-	-	-	-	-	.7	.1
Red-tailed hawk	-	.3	-	.3	-	-	-	-	-	-	-	-	.7	.7	-	.7	.7	2.7	-	1.7	.1	-	-	.7	1.5
Sparrow hawk	-	1	-	-	-	.3	.7	.3	-	.3	-	-	-	.3	-	.3	.3	1.3	-	-	.2	.4	.2	.2	.4
Group total	0	1.3	0	.3	0	.3	5.7	.3	0	.6	1.3	.3	.7	1.6	.7	1.6	1.0	5.6	0	2.4	.3	1.7	1.2	2.0	2.6
AQUATIC OMNIVOROUS																									
Ducks[g]	-	-	-	-	-	-	-	-	-	.7	-	-	-	1.7	-	-	-	-	-	-	-	-	.4	.5 .1	-
Pied-billed grebe	-	-	-	-	-	-	-	-	-	-	-	-	-	.3	-	-	-	-	-	-	-	-	-	.1	-
Ring-necked duck	-	-	-	-	-	-	-	-	-	-	-	-	-	.3	-	-	-	-	-	-	-	-	-	-	-
Group total	0	0	0	0	0	0	0	0	0	.7	0	0	0	2.3	0	0	0	0	0	0	0	0	.4	.7	-

TABLE 3.3.3-2 (continued)

FEEDING HABIT	Abundance[a]																				Relative Abundance[b]				
	Spring				Early Summer				Late Summer				Fall				Winter								
Species	F[c]	A[d]	R[e]	H[f]	F	A	R	H	F	A	R	H	F	A	R	H	F	A	R	H	Spring	Early Summer	Late Summer	Fall	Winter
CARRION-Feeder																									
Turkey vulture	7.3	-	-	-	.3	.3	-	-	-	.7	-	-	-	-	-	-	-	-	-	-	1.3	.2	.4	-	-
Group total	7.3	-	-	-	.3	.3	-	-	-	.7	-	-	-	-	-	-	-	-	-	-	1.3	.2	.4	-	-
Total for all Groups	75.0	332.6	50.9	107.5	36.7	103.4	213.2	11.6	48.9	56.4	69.7	12.5	66.9	106.3	77.6	60.3	59.7	173.8	0	116.6					
Total/Period	566.0				364.9				187.5				311.1				350.1								

a Based on a three-day mean per period.

b Percent.

c Forest.

d Agricultural fields.

e Roadway.

f Hedgerow.

g Unidentified to species.

TABLE 3.3.3-3

SEASONAL ABUNDANCES[a] OF BIRDS
IDENTIFIED ALONG THE AVIAN SURVEY ROUTE (SS_2)

Species	Sampling Period: Early Summer	Late Summer	Fall	Winter
Green heron	2			
Sparrow hawk				1
Marsh hawk			2	
Red-tailed hawk	1	1		
Ruffed grouse			1	
Bobwhite	15	17	12	
Rock dove	3			
Mourning dove	23	2	3	
Ruby-throated hummingbird	1			
Belted kingfisher	1			
Chimney swift		2		
Yellow-shafted flicker			6	5
Red-bellied woodpecker	3	3	3	3
Red-headed woodpecker		4	2	
Hairy woodpecker			2	
Downy woodpecker			3	4
Horned lark	2			
Barn swallow	1	9		
Blue jay	3	10	13	14
Common crow	14	1	7	2
Black-capped chickadee		1	7	4
Tufted titmouse			1	
White-breasted nuthatch			1	
Mockingbird	2			
Catbird		4		
Brown thrasher	1	2		
Robin		1	2	1
Wood thrush	2			
Eastern bluebird	5			3
Yellowthroat	1			
Starling		2	5	
Meadowlark	10	2		
Red-winged blackbird	58		1	
Common grackle	60		115	
Brown-headed cowbird	2			
Summer tanager	1			
House sparrow				150
Cardinal	1	3	3	22
Blue grosbeak		1		
Indigo bunting	2	2		
Dickcissel	2			

TABLE 3.3.3-3 (continued)

Species	Sampling Period Early Summer	Late Summer	Fall	Winter
Common redpoll			1	
American goldfinch			48	
Slate-colored junco			22	58
Tree sparrow				7
Field sparrow	4	9		
White-crowned sparrow			4	
White-throated sparrow			15	
Fox sparrow			4	
Song sparrow			6	50
TOTAL	220	76	289	324

a Abundances based on one-day high per period.

TABLE 3.3.3-4

SEASONAL ABUNDANCE AND RELATIVE ABUNDANCE OF BIRDS
IDENTIFIED ALONG AVIAN STRIP SURVEY ROUTE SS_2 BY GENERAL HABITAT TYPE, CALLAWAY COUNTY, MISSOURI

FEEDING HABIT	Abundance[a]												Relative Abundance[b]			
	Early Summer			Late Summer			Fall			Winter			Early Summer	Late Summer	Fall	Winter
Species	A[c]	H[d]	F[e]	A	H	F	A	L	[illegible]	A	H	F				
C[illegible]IVOROUS																
Black-capped chickadee	-	-	-	-	-	0.7	0.3	2.3	1.7	-	0.3	2.3	-	1.6	2.8	1.6
Blue grosbeak	-	-	-	-	0.3	-	-	-	-	-	-	-	-	.7	-	-
Blue jay	0.3	0.7	1.0	-	2.0	6.3	0.7	2.0	6.3	-	9.3	3.0	1.4	19.2	5.8	7.8
Brown-headed cowbird	0.7	-	-	-	-	-	-	-	-	-	-	-	.5	-	-	-
Brown thrasher	0.3	-	-	0.7	0.3	-	-	-	-	-	-	-	.2	2.3	-	-
Cardinal	-	-	0.[illegible]	-	-	2.0	0.7	0.3	1.0	-	14.7	8.7	.2	4.6	1.3	14.8
Common crow	.2	.7	5.3	-	-		1.7	1	2.7	-	3	1	4.6	.7	3.5	0.8
Common grackle	16.7	27.3	0.[illegible]	-	-	-	17.7	44.0	-	-	-	-	32.[illegible]	-	39.9	-
Dickcissel	1.0	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Eastern bluebird	1.7	-	-	-	-	-	-	-	-	0.3	1.0	-	1.2	-	-	0.8
Field sparrow	1.0	-	1.3	3.0	1.0	1.0	-	-	-	-	-	-	1.7	11.5	-	-
House sparrow	-	-	-	-	-	-	-	-	-	-	5.3	50.0	-	-	-	34.9
Indigo bunting	0.3	-	0.3	0.3	0.3	0.3	-	-	-	-	-	-	0.4	2.1	-	-
Meadowlark	4.0	-	-	1.0	-	-	-	-	-	-	-	-	2.9	2.3	-	-
Mockingbird	-	-	0.7	-	-	-	-	-	-	-	-	-	0.5	-	-	-
Red-winged blackbird	42.3	7.0	-	-	-	-	.3	-	-	-	-	-	35.6	-	0.2	-
Robin	-	-	-	-	-	0.3	-	0.7	0.3	-	-	0.3	-	0.7	0.6	0.2
Slate-colored junco	-	-	-	-	-	-	0.7	8.3	0.3	2.3	31.7	2.0	-	-	6.0	22.7
Song sparrow	-	-	-	-	-	-	-	4.3	0.3	16.7	-	-	-	-	3.0	10.5
Starling	-	-	-	-	-	-	3.0	-	-	-	-	-	-	-	1.9	-
Tree sparrow	-	-	-	-	-	-	-	-	-	-	2.3	-	-	-	-	1.5
Tufted titmouse	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	0.2	-
White-breasted nuthatch	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	[illegible]	-
White-crowned sparrow	-	-	-	-	-	-	1.3	-	-	-	-	-	-	-	0.8	-
White-throated sparrow	-	-	-	-	-		4.0	2.3	-	-	-	-	-	-	4.1	-
Wood thrush	-	-	0.7	-	-	-	-	-	-	-	-	-	.5	-	-	-
Group Total	68.6	35.7	9.9	5.0	3.9	10.9	30.1	65.8	12.6	19.3	64.9	57.3	82.4	45.7	70.3	95.6
GRANIVOROUS-HERBIVOROUS																
American goldfinch	-	-	-	-	-	-	17.3	13.3	-	-	-	-	-	-	19.8	-

Sheet .

TABLE 3.3.3-4 (continued)

FEEDING HABIT Species	Abundance[a]												Relative Abundance[b]			
	Early Summer			Late Summer			Fall			Winter			Early Summer	Late Summer	Fall	Winter
	A[c]	H[d]	F[e]	A	H	F	A	H	F	A	H	F				
Bobwhite	2.0	3.7	2.0	7.0	0.3	2.7	-	4.0	-	-	-	-	5.6	23.1	2.6	-
Catbird	-	-	-	-	0.7	1.0	-	-	-	-	-	-	-	3.9	-	-
Common redpoll	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	0.2	-
Fox sparrow	-	-	-	-	-	-	0.3	1.0	-	-	-	-	-	-	0.8	-
Horned lark	0.7	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-
Mourning dove	9.3	-	0.7	0.7	0.7	0.7	-	1.0	0.3	-	-	-	6.7	4.8	0.8	-
Rock dove	1.0	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Ruffed grouse	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	0.2	-
Group Total	13.0	3.7	2.7	7.7	1.7	4.4	17.6	19.9	.3	-	-	-	13.5	31.8	24.4	-
INSECTIVOROUS																
Barn swallow	0.3	-	-	[illegible].7	-	-	-	-	-	-		-	.2	8.5	-	-
Chimney swift	-	-	-	0.7	-	-	-	-	-			-	-	1.6	-	-
Downy woodpecker	-	-	-	-	-	-	-	1.0	-	0.[illegible]	1.0	0.3	-	-	0.6	1.0
Hairy woodpecker	-	-	-	-	-	-	-	0.7	-	-	0.3	-	-	-	0.5	.2
Red-bellied woodpecker	0.3	0.7	-	-	-	2.3	-	1.0	0.7	-	1.3	1.3	.7	5.3	1.1	1.6
Red-headed woodpecker	0.3	-	-	1.0	1.7	-	-	-	0.7	-	0.3	-	.2	6.2	0.5	.2
Summer tanager	-	0.3	-	-	-	-	-	-	-	-	-	-	.2	-	-	-
Yellow-shafted flicker	-	-	-	-	-	-	0.3	2.7	-	-	-	2.0	-	-	1.9	1.3
Yellow throat	-	-	0.3	-	-	-	-	-	-	-	-	-	.2	-	-	-
Group Total	0.9	1.0	.3	5.4	1.7	2.3	0.3	5.4	1.4	0.3	2.9	3.6	1.5	21.6	[illegible].6	4.3
CARNIVOROUS																
Belted kingfisher	-	-	0.3	-	-	-	-	-	-	-	-	-	0.2	-	-	-
Green heron	0.7	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-
Marsh hawk	-	-	-	-	-	-	1.0	-	-	-	-	-	-	-	0.6	-
Red-tailed hawk	0.3	-	-	-	0.3	-	-	-	-	-	-	-	0.2	0.7	-	-
Sparrow hawk	-	-	-	-	-	-	-	-		0.3	-	-	-	-	-	0.2
Group Total	1.0	-	0.3	-	0.3	-	1.0	-	-	0.3	-	-	0.4	0.7	0.6	0.2

Sheet 2

TABLE 3.3.3-4 (continued)

FEEDING HABIT Species	Abundance[a] Early Summer A[c]	H[d]	F[e]	Late Summer A	H	F	Fall A	H	F	Winter A	H	F	Relative Abundance[b] Early Summer	Late Summer	Fall	Winter
NECTIVOROUS																
Ruby-throated hummingbird	0.3	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-	-
Group Total	.3	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-	-
Total for all Groups	83.8	40.4	13.2	18.1	7.6	17.6	49.0	91.1	14.3	19.9	67.8	70.9				
Total/Period	137.4			43.3			154.4			158.6						

a Based on a three-day mean per period

b Percent

c Agricultural fields

d Hedgerow

e Forest

TABLE 3.3.3-5

SEASONAL ABUNDANCES[a] OF BIRDS IDENTIFIED ALONG THE AVIAN SURVEY ROUTE (SS_3)

Species	Sampling Period: Early Summer	Late Summer	Fall	Winter
Snow goose			30	
Blue goose			30	
Mallard		2		
Rough-legged hawk			1	
Sparrow hawk			3	
Bobwhite	21	3	30	
Rock dove		15		
Mourning dove	4	5	4	
Yellow-shafted flicker	2		8	7
Red-bellied woodpecker		1	1	3
Red-headed woodpecker	2	8		2
Downy woodpecker				1
Eastern kingbird	2	2		
Acadian flycatcher	1			
Eastern wood pewee			1	
Horned lark				2
Rough-winged swallow		1		
Barn swallow	9	11		
Purple martin		1		
Blue jay	1	8	14	10
Common crow	5	9	47	6
Black-capped chickadee			5	4
White-breasted nuthatch			1	
Mockingbird	1	1	1	2
Catbird	3	3		3
Brown thrasher	7	1		
Robin			1	
Eastern bluebird	2		4	14
Loggerhead shrike	2		2	1
Starling	1	1	11	9
Yellowthroat	3			
House sparrow	2			
Meadowlark	7	14	76	17
Red-winged blackbird	65	7		
Common grackle	7		3	
Brown-headed cowbird	12			
Summer tanager	3			
Cardinal	1	4	14	5
Indigo bunting	4			
Dickcissel	4			
Common redpoll				7

TABLE 3.3.3-5 (continued)

Species	Sampling Period Early Summer	Late Summer	Fall	Winter
American goldfinch	1		19	
Slate-colored junco			19	11
Tree sparrow				10
Field sparrow	16			
Harris' sparrow			2	1
White-crowned sparrow			1	
White-throated sparrow			10	
Fox sparrow			10	
Swamp sparrow			1	
Song sparrow			19	7
TOTAL	188	97	368	122

a Abundance based on one-day high per period.

TABLE 3.3.3-6

SEASONAL ABUNDANCE AND RELATIVE ABUNDANCE OF BIRDS IDENTIFIED ALONG THE AVIAN STRIP SURVEY ROUTE SS_3 BY GENERAL HABITAT TYPE, CALLAWAY COUNTY, MISSOURI

FEEDING HABIT Species	Abundance[a] Early Summer A[c]	H[d]	Late Summer A	H	Fall A	H	Winter A	H	Relative Abundance[b] Early Summer	Late Summer	Fall	Winter
OMNIVOROUS												
Black-capped chickadee	-	-	-	-	-	2.3	1.3	1.7	-	-	1.4	5.1
Blue jay	0.3	-	-	4.0	[illegible]	7.3	0.3	5.7	0.3	9.2	5.4	10.2
Brown-headed cowbird	3.3	2.7	-	-	-	-	-	-	6.0	-	-	-
Brown thrasher	-	4.0	0.3	0.3	-	-	-	-	4.0	1.6	-	-
Cardinal	-	0.7	-	2.3	1.3	4.7	0.3	3.0	0.3	5.3	3.6	5.6
Common crow	0.7	2.7	0.3	4.0	2.0	16.	2.3	1.7	3.3	9.9	11.5	6.8
Common grackle	3.0	2.3	-	-	1.3	-	-	-	5.3	-	0.8	-
Dickcissel	-	1.7	-	-	-	-	-	-	1.7	-	-	-
Eastern bluebird	-	0.7	-	-	1.0	1.0	1.3	3.3	0.7	-	1.2	8.0
Field sparrow	5.0	2.7	-	-	-	-	-	-	7.6	-	-	-
House sparrow	-	0.7	-	-	-	-	-	-	0.7	-	-	-
Indigo bunting	1.3	[illegible]	-	-	-	-	-	-	1.7	-	-	-
Meadowlark	3.3	0.3	6.3	-	30.3	0.3	5.0	1.3	3.7	14.5	18.5	10.7
Mockingbird	-	0.3	-	0.3	-	0.3	-	0.7	0.3	0.7	0.2	1.2
Red-winged blackbird	19.0	16.7	2.3	-	-	-	-	-	35.4	5.3	-	-
Robin	-	-	-	-	0.3	-	-	-	-	-	0.2	-
Slate-colored junco	-	-	-	-	-	9.0	1.0	3.7	-	-	5.4	8.0
Song sparrow	-	-	-	-	0.3	9.0	1.0	2.7	-	-	5.6	6.3
Starling	-	0.3	0.3	-	6.0	-	3.3	-	0.3	0.7	3.6	5.6
Swamp sparrow	-	-	-	-	-	0.3	-	-	-	-	0.2	-
Tree sparrow	-	-	-	-	-	-	-	7.3	-	-	-	12.4
White-breasted nuthatch	-	-	-	-	-	0.3	-	-	-	-	0.2	-
White-crowned sparrow	-	-	-	-	0.3	-	-	0.3	-	-	0.2	0.5
White-throated sparrow	-	-	-	-	-	4.7	-	-	-	-	2.8	-
Group Total	35.9	36.1	9.5	10.9	44.5	55.2	[illegible]	31.4	71.3	47.2	60.8	80.4

TABLE 3.3.3-6 (continued)

FEEDING HABIT Species	Abundance[a] Summer A[c]	H[d]	Late Summer A	H	Fall A	H	Winter A	H	Relative Abundance[b] Summer	Late Summer	Fall	Winter
GRANIVOROUS-HERBIVOROUS												
American goldfinch	-	0.3	-	-	4.7	4.7	-	-	0.3	-	5.6	-
Bobwhite	8.0	3.7	1.0	0.7	16.7	-	-	-	11.6	3.9	10.1	-
Catbird	-	1.0	-	1.3	-	-	-	1.0	1.0	3.0	-	1.7
Common redpoll	-	-	-	-	-	-	-	2.3	-	-	-	3.9
Fox sparrow	-	-	-	-	-	4.0	-	-	-	-	2.4	-
Harris' sparrow	-	-	-	-	-	0.7	-	-	-	-	0.4	-
Horned lark	-	-	-	-	-	-	1.7	-	-	-	-	2.9
Mourning dove	2.0	0.7	1.3	0.3	1.3	0.7	-	-	2.7	3.9	1.2	-
Rock dove	-	-	5.0	-	-	-	-	-	-	11.5	-	-
Group Total	10.0	5.7	7.3	2.3	22.7	10.1	1.7	3.3	15.6	22.3	19.7	8.5
INSECTIVOROUS												
Acadian flycatcher	-	0.3	-	-	-	-	-	-	0.3	-	-	-
Barn swallow	6.3	0.7	7.0	-	-	-	-	-	7.0	16.1	-	-
Downy woodpecker	-	-	-	-	-	-	-	0.7	-	-	-	-
Eastern kingbird	0.3	0.7	0.3	1.0	-	-	-	-	1.0	3.0	-	-
Eastern wood pewee	-	-	-	-	-	0.3	-	-	-	-	0.2	-
Purple martin	-	-	0.3	-	-	-	-	-	-	0.7	-	-
Red-bellied woodpecker	-	-	-	0.7	-	0.7	-	1.3	-	0.7	0.4	2.2
Red-headed woodpecker	-	1.7	0.7	2.7	-	-	-	1.3	1.7	7.6	-	2.2
Rough-winged swallow	-	-	0.3	-	-	-	-	-	-	0.7	-	-
Summer tanager	-	1.0	-	-	-	-	-	-	1.0	-	-	-
Yellow-shafted flicker	-	0.7	-	-	2.3	3.0	-	3.0	0.7	-	3.2	5.1
Yellowthroat	-	1.0	-	-	-	-	-	-	1.0	-	-	-
Group Total	6.6	6.1	8.6	4.4	2.3	4.0	-	6.3	12.7	28.8	3.8	10.7
CARNIVOROUS												
Loggerhead shrike	-	0.7	-	-	0.7	-	0.3	-	0.7	-	0.4	0.5

TABLE 3.3.3-6 (continued)

FEEDING HABIT Species	Abundance[a] Early Summer A[c]	H[d]	Late Summer A	H	Fall A	H	Winter A	H	Relative Abundance[b] Early Summer	Late Summer	Fall	Winter
Rough-legged hawk	-	-	-	-	0.3	-	-	-	-	-	0.2	-
Sparrow hawk	-	-	-	-	1.0	-	-	-	-	-	0.6	-
Group Total	-	0.7	-	-	2.0	-	0.3	-	0.7	-	1.2	0.5
AQUATIC OMNIVOROUS												
Blue goose	-	-	-	-	11.7	-	-	-	-	-	7.1	-
Mallard	-	-	-	0.7	-	-	-	-	-	1.6	-	-
Snow goose	-	-	-	-	12.0	-	-	-	-	-	7.3	-
Group Total	-	-	-	0.7	23.7	-	-	-	-	1.6	14.4	-
TOTAL FOR ALL GROUPS	52.5	48.6	2[illegible].4	18.3	95.2	69.3	22.8	41.0				
TOTAL/PERIOD	101.1		43.7		164.5		63.8					

a Based on a three-day mean per period.

b Percent.

c Agricultural fields.

d Hedgerow.

TABLE 3.3.3-7

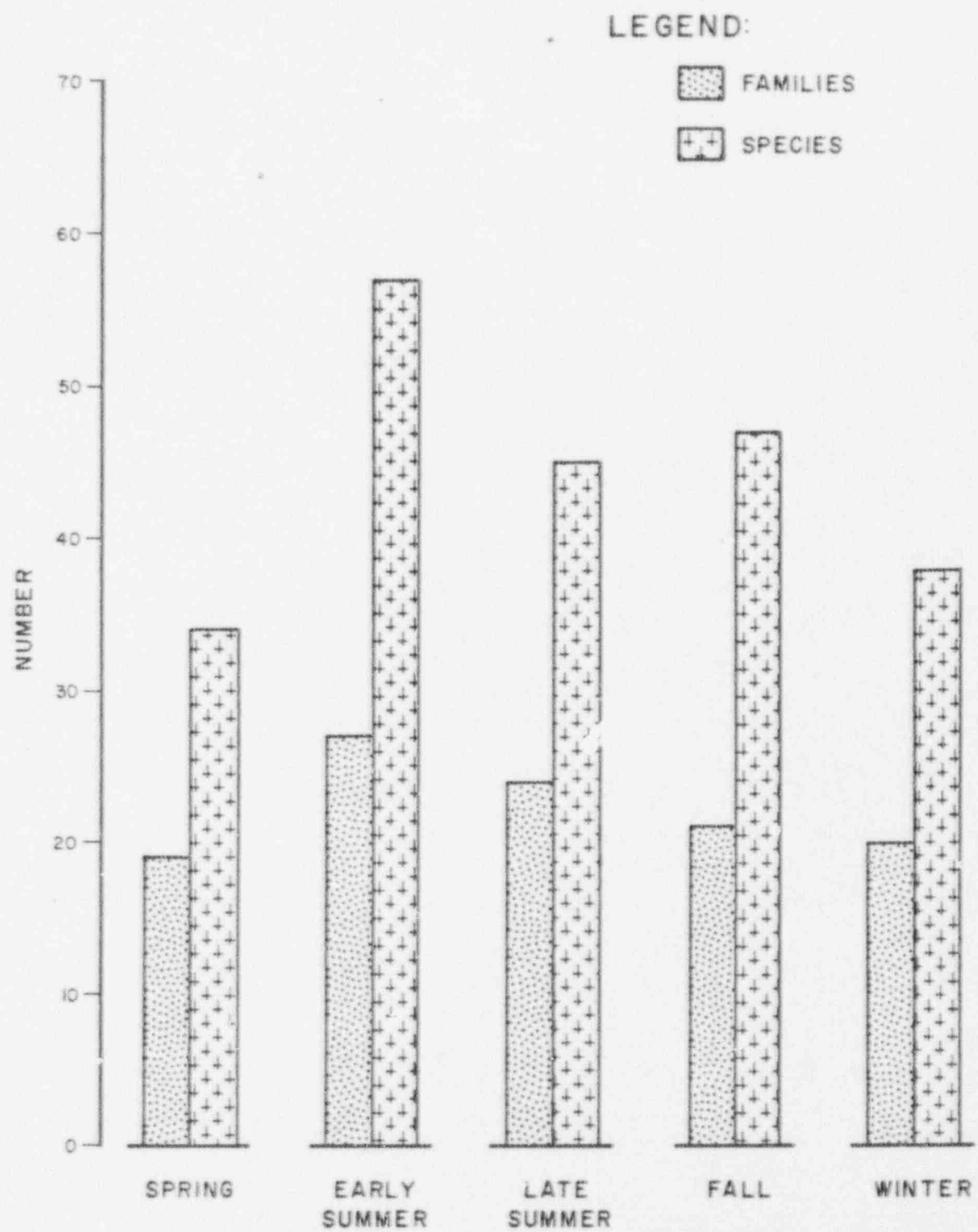
BIRDS IDENTIFIED DURING THE EVENING AUTOMOBILE SURVEY, CALLAWAY COUNTY, MISSOURI

Species	Sampling Period			
	Early Summer	Late Summer	Fall	Winter
Common nighthawk	1	-	-	-
Great horned owl	1	-	1	1
Pied-billed grebe	-	-	1	-
Purple martin	-	25	-	-
Whip-poor-will	27	1	-	-

TABLE 3.3.3-8

MISCELLANEOUS OBSERVATIONS OF BIRDS
DURING FIVE SAMPLING PERIODS, CALLAWAY COUNTY, MISSOURI

	Sampling Period				
Species	Spring	Early Summer	Late Summer	Fall	Winter
American bittern	1	-	-	-	-
Blue-winged teal	-	-	4	-	-
Bobwhite	12	7	31	49	-
Cedar waxwing	-	-	-	25	-
Common nighthawk	-	-	1	-	-
Common redpoll	-	-	-	-	100
Ducks	-	-	-	9	-
Golden eagle	-	-	-	-	1
Grasshopper sparrow	-	1	-	-	-
House wren	-	1	-	-	-
Marsh hawk	-	-	-	3	-
Mourning dove	-	-	-	25	5
Ruby-throated hummingbird	-	-	1	-	-
Turkey	1	-	-	-	-
Turkey vulture	-	-	2	-	-
White-breasted nuthatch	-	-	-	-	1



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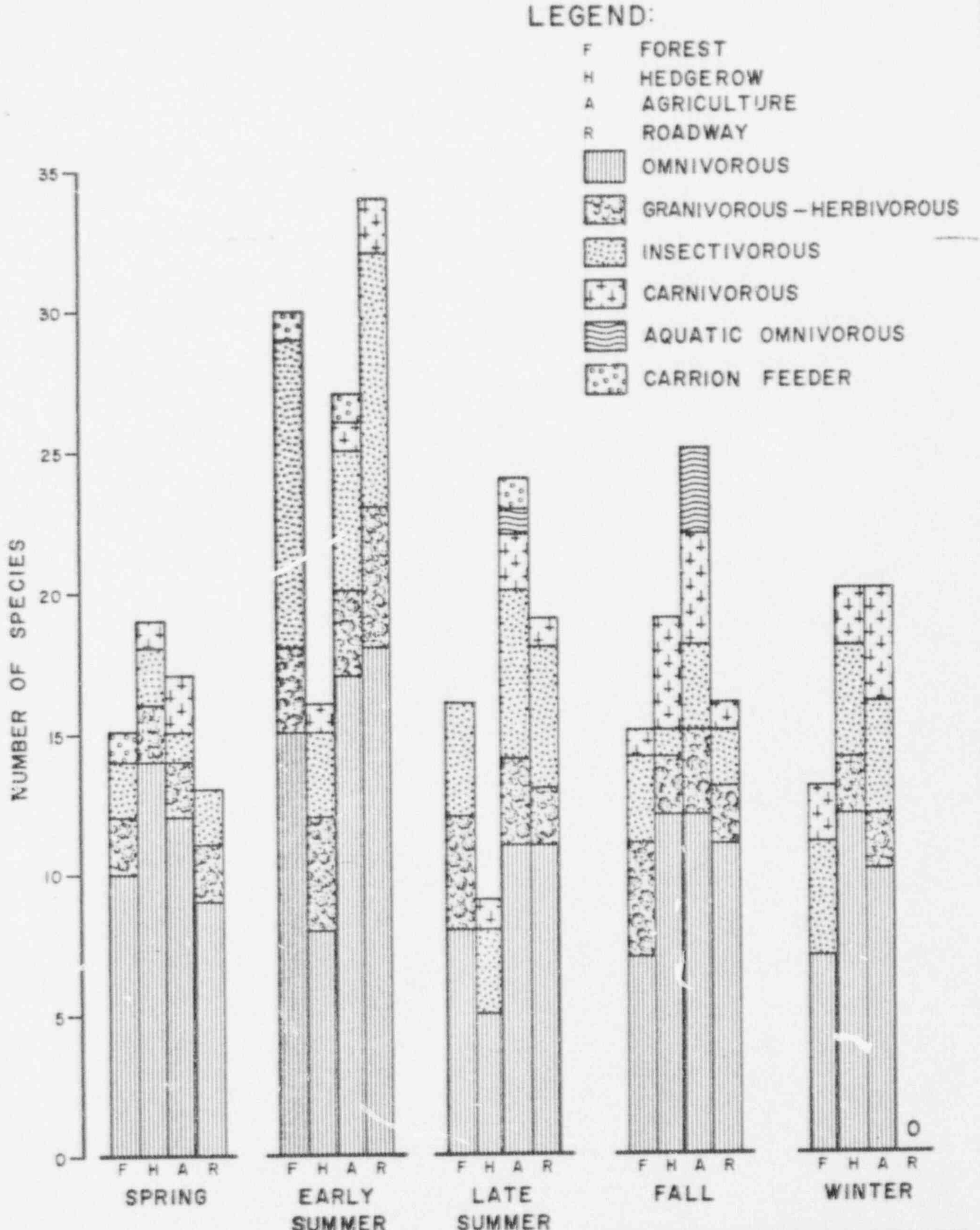
TOTAL NUMBER OF SPECIES AND FAMILIES OF BIRDS FOR THE FIVE SAMPLING PERIODS, CALLAWAY COUNTY, MISSOURI

Figure 3.3.3-1



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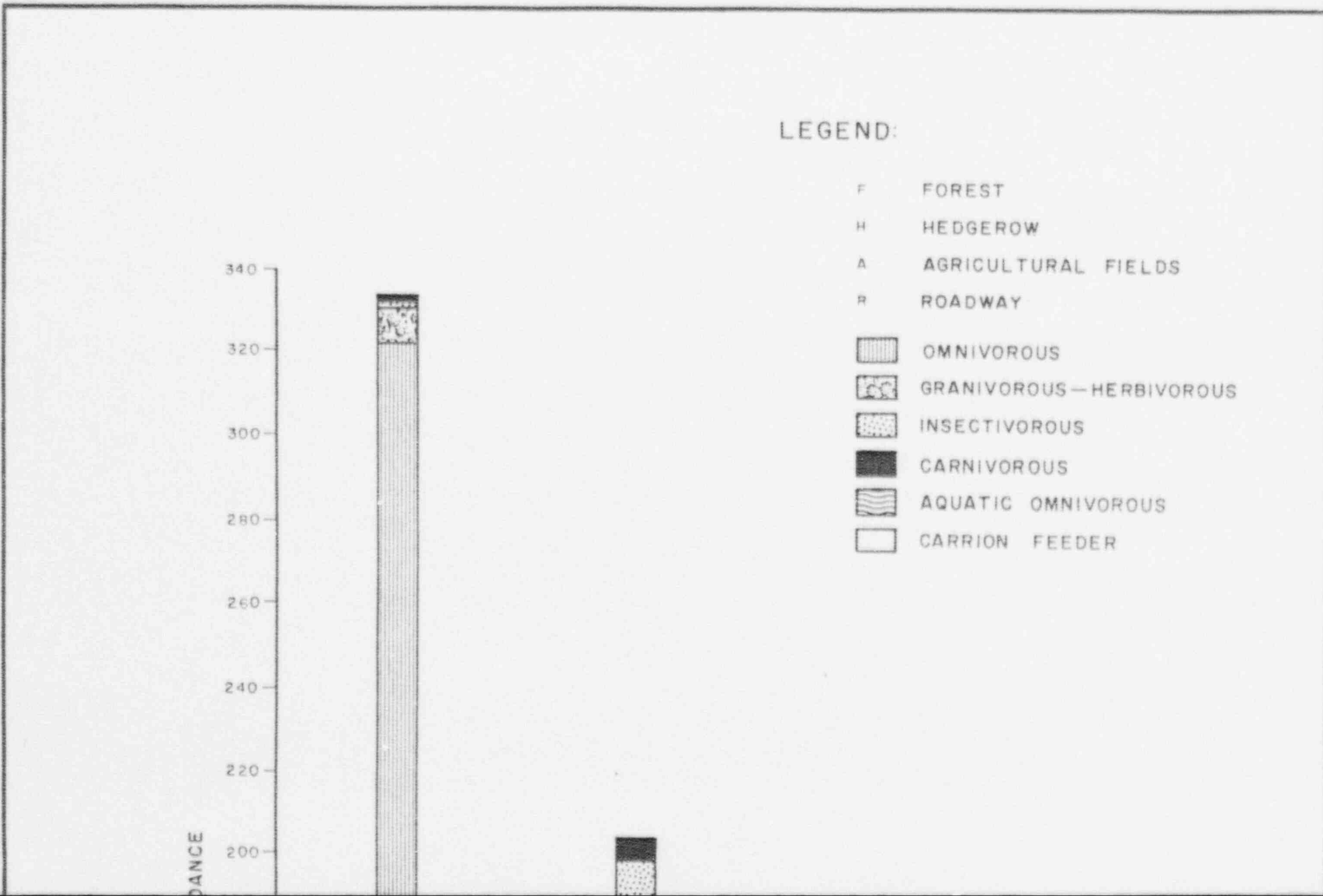
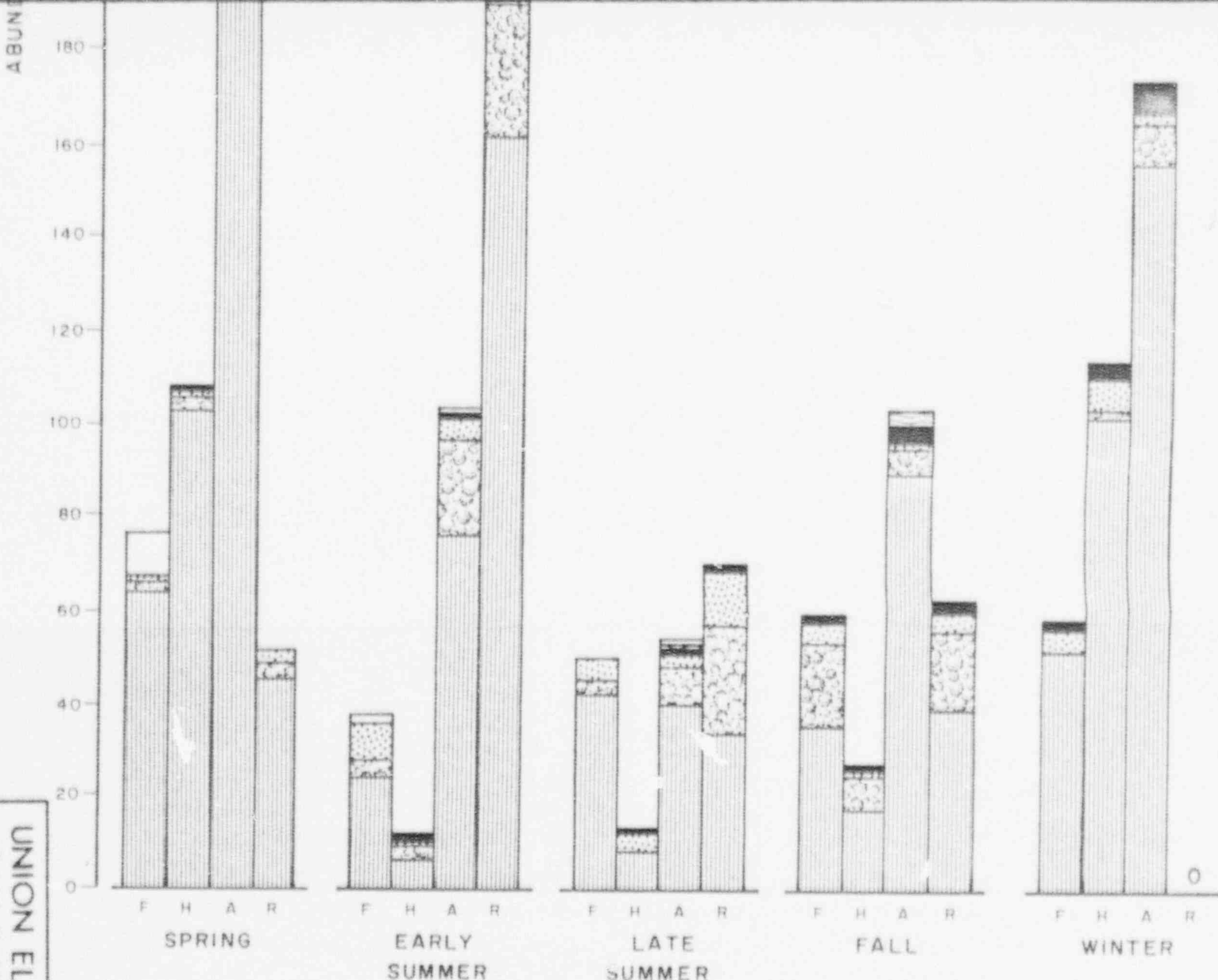
BIRD SPECIES ALONG AVIAN AUTOMOBILE AND EVENING SURVEY ROUTES BY SAMPLING PERIOD, HABITAT TYPE AND FEEDING HABIT

Figure 3.3.3-2


LEGEND:
F FOREST
H HEDGEROW
A AGRICULTURAL FIELDS
R ROADWAY
OMNIVOROUS
GRANIVOROUS—HERBIVOROUS
INSECTIVOROUS
CARNIVOROUS
AQUATIC OMNIVOROUS
CARRION FEEDER
340
320
300
280
260
240
220
200
DANCE



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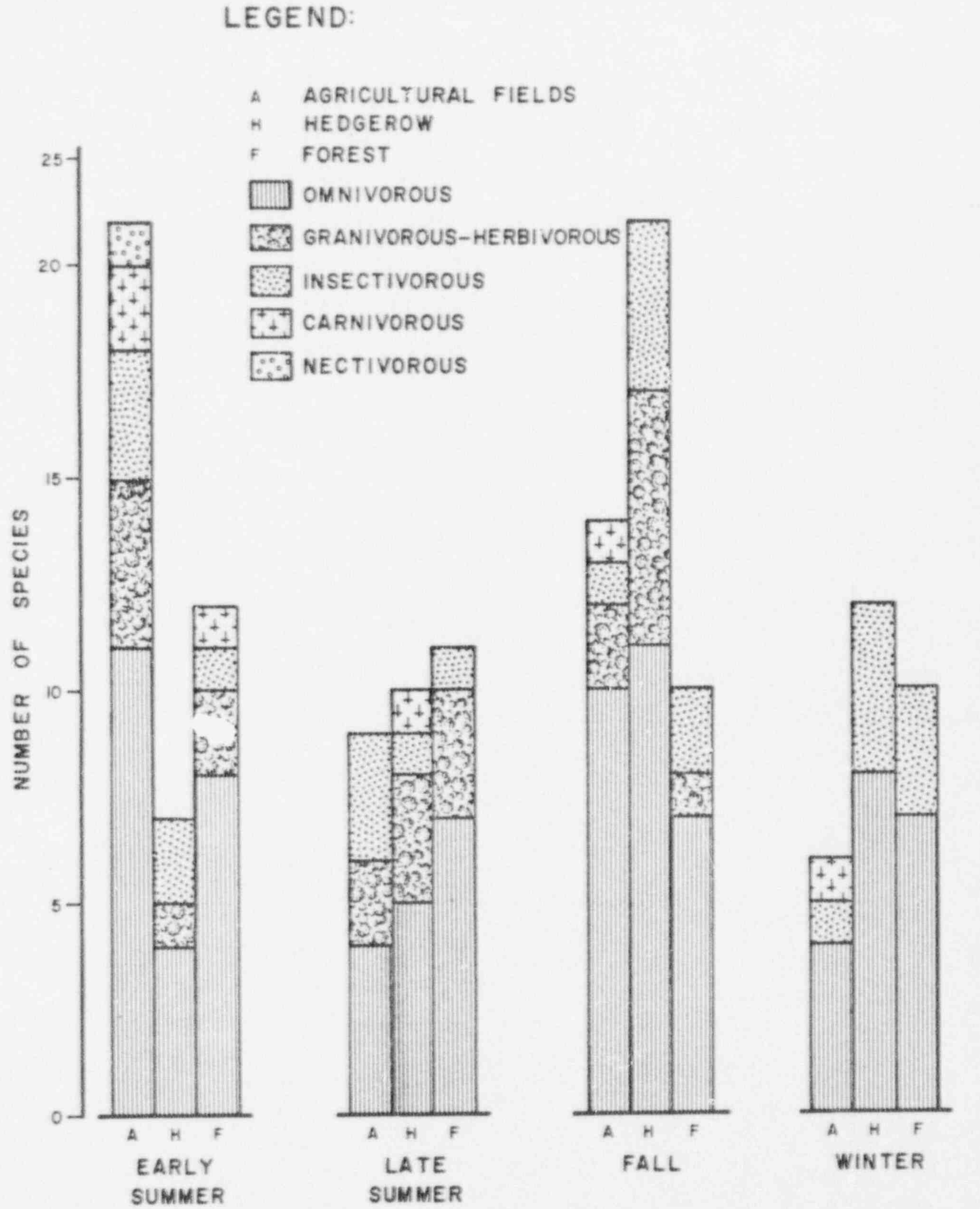
SEASONAL ABUNDANCE (3-DAY MEANS) OF BIRD SPECIES ALONG AVIAN AUTOMOBILE AND EVENING SURVEY ROUTE BY HABITAT TYPE AND FEEDING HABIT

Figure 3.3.3-3



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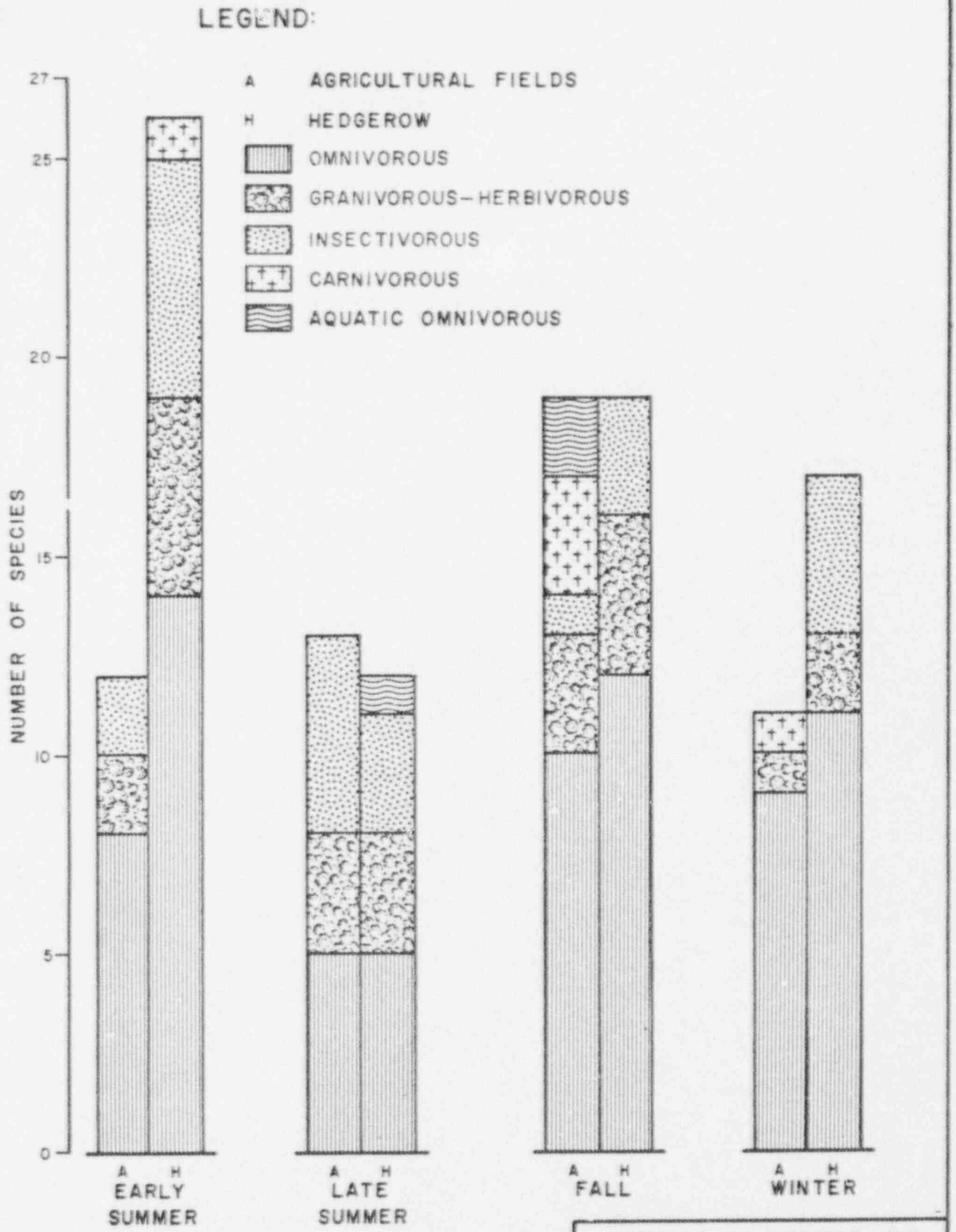
BIRD SPECIES ALONG AVIAN STRIP SURVEY SS_2 BY SAMPLING PERIOD, HABITAT TYPE AND FEEDING HABIT

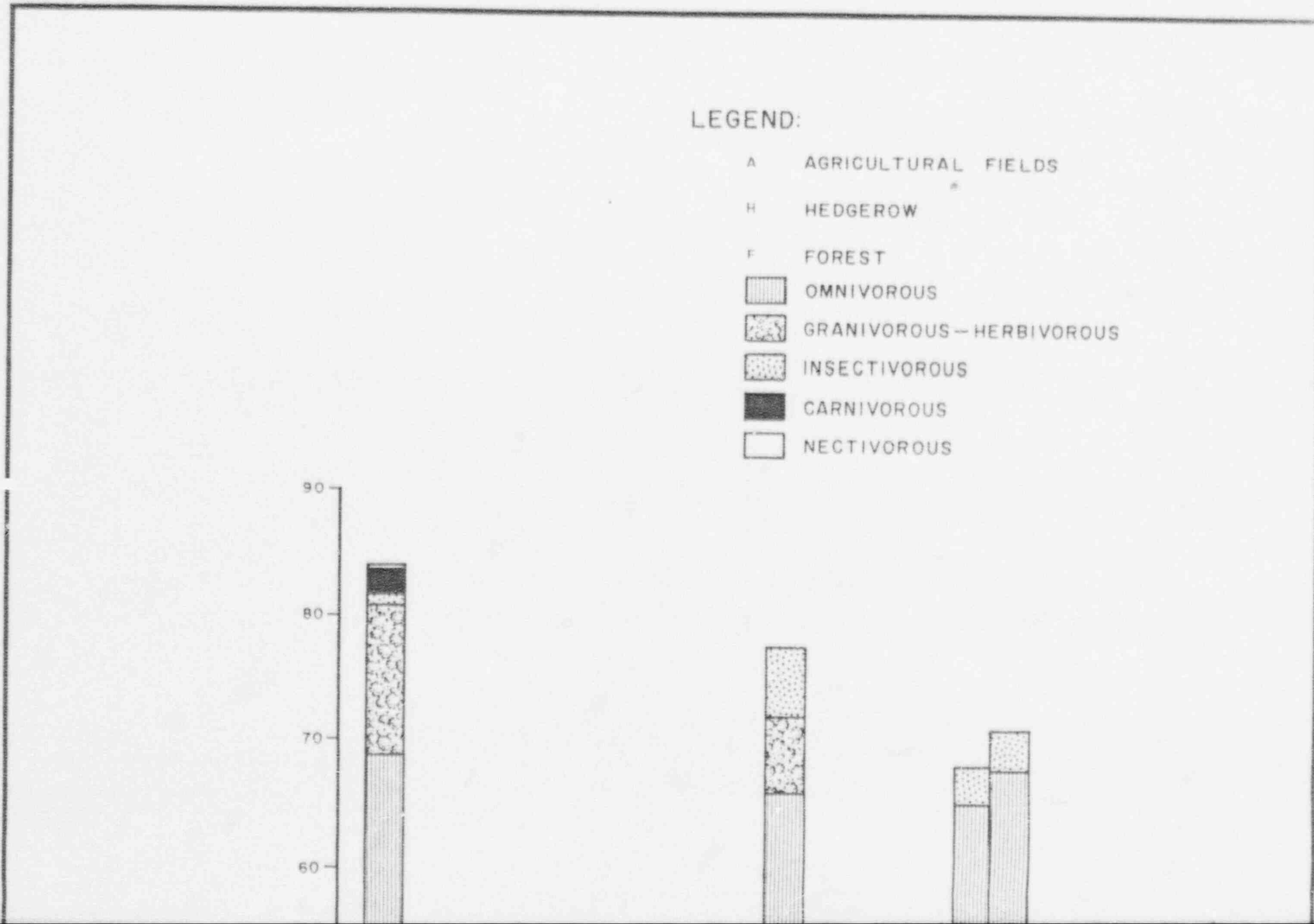
Figure 3.3.3-4



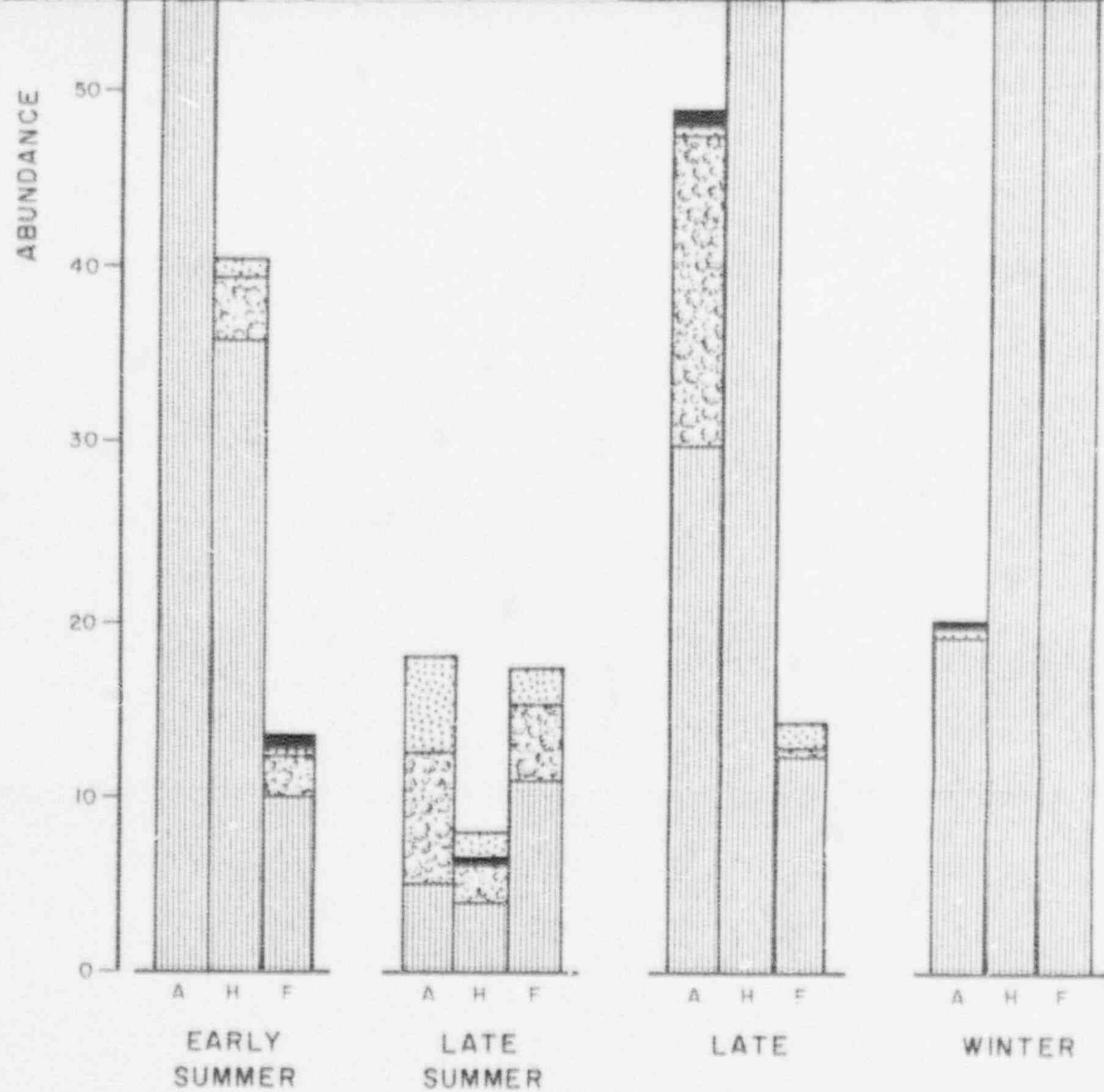
UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

NUMBER OF BIRD SPECIES ALONG STRIP SURVEY SS_3 BY SAMPLING PERIOD, GENERAL HABITAT TYPE AND FEEDING HABIT

Figure 3.3.3-5



LEGEND:
A AGRICULTURAL FIELDS
H HEDGEROW
F FOREST
OMNIVOROUS
GRANIVOROUS-HERBIVOROUS
INSECTIVOROUS
CARNIVOROUS
NECTIVOROUS
90
80
70
60



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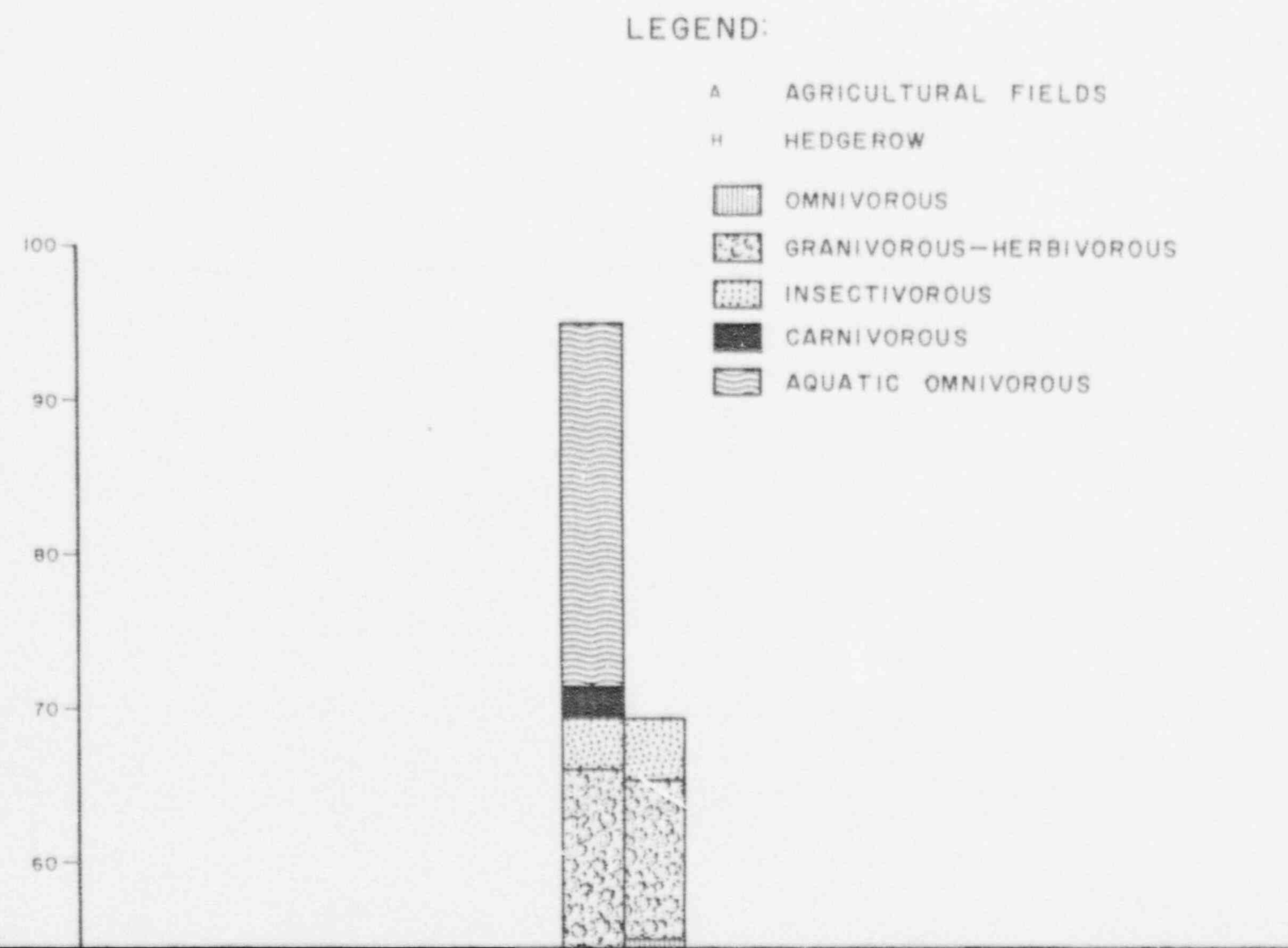
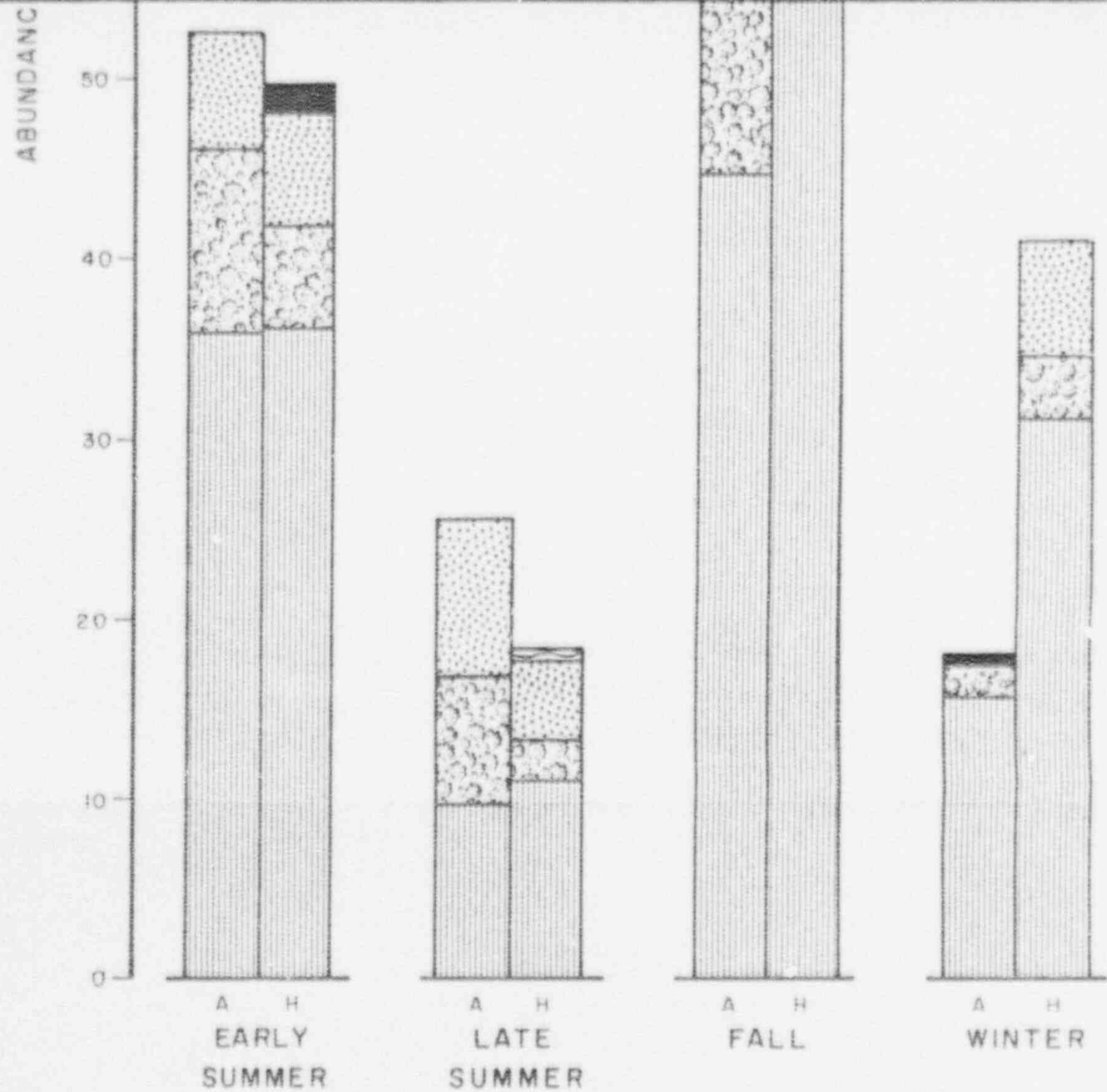
CALLAWAY PLANT
UNITS 1&2

SEASONAL ABUNDANCE (3-DAY MEAN PER HABITAT) OF BIRD SPECIES ALONG AVIAN STRIP SURVEY SS, BY HABITAT TYPE AND FEEDING HABIT

Figure 3.3.3-6


LEGEND:
A AGRICULTURAL FIELDS
H HEDGEROW
OMNIVOROUS
GRANIVOROUS-HERBIVOROUS
INSECTIVOROUS
CARNIVOROUS
AQUATIC OMNIVOROUS
100
90
80
70
60



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CALLAWAY PLANT
UNITS 1&2

SEASONAL ABUNDANCE (3-DAY MEAN) OF BIRD SPECIES ALONG AVIAN STRIP SURVEY SS_5 BY HABITAT TYPE AND FEEDING HABIT

Figure 3.3.3-7

3.3.4 AMPHIBIANS AND REPTILES

3.3.4.1 Evening Automobile Survey

Although the survey was conducted during four of five sampling periods, only the early summer sampling period yielded results, primarily because this sampling period coincided with peak breeding activity of amphibians.

Treefrogs (Table 3.3.4-1) were the most common sightings along the survey route, while the chorus frog, bullfrog, cricket frog, and American toad were less common. These amphibians were noted along stretches of roadway near Logan Creek and farm ponds used for mating and egg laying.

Four of the amphibian species observed are predominantly aquatic, while the remaining species is aquatic only during part of their life cycle. Leopard frogs are usually found in marshes or ponds; bullfrogs can be found in almost any water, while green frogs prefer ditches and creeks. The American toad is usually observed in shallow bodies of water or on land; the treefrogs breed in water, but then move to a terrestrial environment.

No reptiles were sighted in the Intensive Study Area during the evening automobile survey. They are generally not easily observed. However, based on lists of reptiles whose range includes the site, the following are assumed to be present: common snapping turtle, stinkpot, map turtles, western painted turtle, red-eared turtle, and soft-shell turtles, Graham's, blotched, northern,and diamond-backed water snakes, eastern and red-sided garter snakes; these species all would be found in an aquatic habitat. Also likely to be present are the ornate box turtle, western slender glass lizard, and the six-lined racerunner. These would be found in agricultural habitats.

3.3.4.2 Miscellaneous Observations of Amphibians and Reptiles

Six species (Table 3.3.4-2) not identified during the evening automobile survey were sighted in miscellaneous observations. Three of these species were reptiles. During four of the sampling periods, the three-toed box turtle was observed crossing roadways, within forests, and in old fields. A garter snake was observed in a ditch during early summer, and a snapping turtle was found in an old field. The remaining three species (central newt, green frog, and leopard frog) were amphibians. The green frog and the leopard frog were observed in a ditch; the newt was found impaled on a barb-wire fence, presumable the prey of a loggerhead shrike observed in the area.

TABLE 3.3.4-1

AMPHIBIANS IDENTIFIED DURING THE EARLY SUMMER EVENING AUTOMOBILE SURVEY, CALLAWAY COUNTY, MISSOURI

Species	Number Identified
American toad	3
Bullfrog	2
Chorus frog	5
Cricket frog	1
Gray treefrog	2
Treefrog	12
TOTAL	25

TABLE 3.3.4-2

MISCELLANEOUS OBSERVATIONS OF AMPHIBIANS AND REPTILES
DURING FIVE SAMPLING PERIODS, CALLAWAY COUNTY, MISSOURI

Species	Sampling Period				
	Spring	Early Summer	Late Summer	Fall	Winter
Bullfrog	--	1	--	--	--
Central newt	--	--	--	--	1
Garter snake	--	1	--	--	--
Green frog	--	1	--	--	--
Leopard frog	--	1	--	--	--
Snapping turtle	--	1	--	--	--
Three-toed box turtle	1	3	3	--	1
TOTAL	1	8	3	--	2

3.3.5 RARE AND ENDANGERED SPECIES

Among plants and wildlife with natural ranges encompassing the Callaway Plant site, 10 are considered "endangered" and 12 "rare" by the Missouri Department of Conservation (Gale, 1973). Indiana Myotis, classified as "endangered" by the State of Missouri, is also classified as "threatened" by the USDI (1973).

Within the "endangered" category, there are two mammals (Appendix 3B-3), five birds (Appendix 3C-2), and one plant (Appendix 3A-1) with ranges encompassing the site. Of these, only the plant (elm) was observed directly on the site, where it was found along forested ravine bottoms. Elms are considered "endangered" because of their extreme susceptibility to the Dutch Elm disease.

The "rare" category contains two mammals, nine birds, and one reptile with ranges encompassing the site. Of the two "rare" mammals, only the long-tailed weasel was observed. The classification of the long-tailed weasel as "rare" is paradoxical, since it is still part of the annual state fur harvest. Apparently the State of Missouri is aware of this mammal's population decline but has not passed legislation to protect it. Of the nine birds classified as "rare," only the bald eagle and the ruffed grouse have been observed near or on the site. Bald eagles, which feed predominantly on fish, are usually found along the nation's waterways. They have been observed south of the site along the bluffs of the Missouri River flood plain. Because of their habitat requirements, bald eagles are not expected to be frequent visitors to the site. The ruffed grouse has been observed on the site, which lies within an area selected by the Missouri Department of Conservation for planting a ruffed grouse breeding population (Nagel, 1970). The large, ungrazed forest south, east, and northeast of the site provides this species' habitat requirements. The ruffed grouse is in the process of expanding its range to suitable habitats in adjacent areas.

3.3.6 ECOLOGICAL SUMMARY

The Callaway Plant site is located within the ecotone between two historic climax vegetation types, tall grass prairie and oak-hickory forest. Situated on the northern border of the Missouri River, the site lies within an area that has been influenced by glacial activity.

The soils of the site - Mexico and Putnam series in the Flat Prairie resource area and Goss series in the Rough Stony Land and River Hills resource areas - were formed from glacier-deposited parent material. These soils have been a major influence on native vegetation types. Likewise, the vegetation types have influenced soil genesis.

Presently, forests are found on approximately 50 percent of the site area, occupying terrain generally too steep for cultivation. About 70 percent of this forested area is pasture. The original prairie that occurred on the plateau above the forested slopes is now nearly all used for cultivated crops, although some areas are used for pasture.

A total of 175 plant species were identified on the site. The majority of these were found in the Oak-Hickory Forest Association and along hedgerows between cultivated fields on the plateau. The Oak-Hickory Association is comprised of four major types: 1) oak forest, which occupies about 20 percent of the forested area, 2) oak-hickory forest, 3) oak-maple forest, and 4) black walnut-red cedar forest. Ecologically, the black walnut-red cedar type is the youngest forest in terms of plant succession. The oak-hickory forest is the most mature.

Non-forest areas on the site are the old fields and pastures. Both types are relatively small in area and support plant species typical of disturbed areas. Forty-one plant species were identified in these areas.

Wildlife populations on the site are typical of forested areas broken by agricultural land and grassland. Fifteen of the 47 mammal species with range and habitat requirements including the site area were identified. The majority of the species identified were game and fur-bearing mammals such as the cottontail, raccoon, and white-tailed deer. Two small mammals, the white-footed mouse and deer mouse, were trapped on the site, and their population levels were found to be extremely low. These levels apparently reflect existing normal population patterns, since small mammal populations are currently at low levels in eastern Missouri. Population levels for the white-tailed deer, cottontail, and raccoon are estimated to be below average. The density of opossum is above average.

Approximately 208 bird species are expected to inhabit the region as either permanent residents, winter residents, summer residents, or summer visitors (does not breed locally). Ninety-one of these species were identified on the site. The number of species observed each season varied considerably, with a low of 34 in spring and a maximum of 58 in early summer. On the basis of feeding groups, the omnivorous feeders were largest in number of species and individuals during each season in all surveys. In spring, for example, they comprised 95 percent of all birds identified in one survey. The other feeding groups, granivore-herbivores, insectivores, carnivores, aquatic-omnivores, and carrion feeders, normally display lower densities wherever a mix of agricultural land and forest occurs. The total number of birds observed each season varied only moderately. The average number of birds observed was 920 for all seasons, with a range of 500 to 1,190.

In general, wildlife habitats occurring on the site are those commonly found in central Missouri. These habitats are relatively diverse, supporting a large, intermixed number of plant species throughout the study area. The most favorable areas for wildlife are those where two or more habitats, including agricultural land, are intermixed. The most favorable habitats are those adjacent to ravines and drainages, the old fields, the young forest (black walnut-red cedar), and forests with a moderate to dense understory. Agriculture practices conducted in the site area also create favorable conditions for some species of wildlife. Much of the area is pastured and cut for hay, and these practices favor species such as the bobwhite and cottontail by providing them with adequate cover as well as food.

Twenty-two species of "endangered" or "rare" plants and wildlife are known to have natural ranges encompassing the site. Three of these wildlife species (long-tailed weasel, bald eagle, and ruffed grouse), and one plant (elm) were observed.

3.4 CONCLUSION AND RECOMMENDATION

The ecology of the Callaway Plant site is not unique, and its particular ecological balance re-occurs many times throughout central and eastern Missouri. Intensive farming has produced favorable habitat for wildlife populations, but these conditions can be found in areas adjacent to the site. Since construction of the facility will remove only a small portion of the total acreage from production and since the ecology of the Callaway County Plant site is not unique, no significant impact from plant construction on the resident wildlife population is anticipated.

Rare and endangered or extremely important economic species occurring near or on the site will be affected little by development of the facility. The turkey, white-tailed deer, and ruffed grouse require forested habitats broken by small fields or openings and a relatively large home range. Only a few acres of forest will be disrupted during construction, and the access road, pipelines, and railroad spur should not affect movement of these species. Other species, such as the bald eagle, are extremely mobile and are not expected to be found near or on the site very often.

Although the terrestrial ecology of the plant site area is not expected to be significantly affected by plant construction or operation, the recommended monitoring program (authorized by Union Electric Company to begin in spring, 1974) is necessary to test the validity of this conclusion. Data obtained during the present study, when combined with that gathered during pre-construction monitoring, will satisfactorily document plant site biotic and abiotic elements, and can then be used as a standard with which to compare data obtained during construction and operation impact monitoring.

3.5 REFERENCES

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APPENDIX TABLE 2A-1

MISSOURI RIVER WATER QUALITY DATA (TRANSECTS F AND G)

Parameter	Sample Date	Transect F F-1	F-2	Transect G G-1	G-2	Average
Temperature	Sept. '73	24.6	24.6	24.8	24.8	24.7
°C	Dec. '73	3.5	2.9	2.8	3.0	3.1
	Feb. '74	4.0	4.0	4.0	4.5	4.1
pH	Sept. '73	7.8	7.9	7.9	8.0	7.9
Standard Units	Dec. '73	7.9	7.9	7.9	7.9	7.9
	Feb. '74	7.2	7.4	7.3	7.1	7.3
Conductivity	Sept. '73	700	625	710	710	686
μmhos/cm	Dec. '73	390	380	490	500	440
	Feb. '74	210	370	340	350	318
Turbidity	Sept. '73	16	20	26	16	20
FTU	Dec. '73	40	40	42	42	41
	Feb. '74	140	100	170	140	138
Chloride	Sept. '73	21	25	26	26	25
mg/l	Dec. '73	25	26	26	27	26
	Feb. '74	10	26	22	23	20
Nitrate	Sept. '73	0.5	0.4	0.7	0.7	0.6
mg/l N	Dec. '73	1.3	1.5	1.4	1.5	1.4
	Feb. '74	1.4	2.0	1.7	1.6	1.7
Organic Nitrogen	Sept. '73	0.6	0.6	0.5	0.5	0.6
mg/l	Dec. '73	0.9	1.0	1.1	1.2	1.1
	Feb. '74	1.2	1.7	1.6	1.7	1.6

APPENDIX TABLE 2A-1

Parameter	Sample Date	Transect F F-1	Transect F F-2	Transect G G-1	Transect G G-2	Average
Orthophosphate mg/l P	Sept. '73	0.18	0.21	0.21	0.22	0.21
	Dec. '73	0.16	0.18	0.16	0.18	0.17
	Feb. '74	0.07	0.11	0.13	0.14	0.11
Total Phosphorus mg/l P	Sept. '73	0.19	0.22	0.21	0.22	0.21
	Dec. '73	0.24	0.27	0.25	0.27	0.26
	Feb. '74	0.12	0.24	0.22	0.24	0.21
Dissolved Oxygen mg/l	Sept. '73	7.4	7.3	7.3	7.3	7.3
	Dec. '73	12.8	13.1	13.1	12.8	13.0
	Feb. '74	13.1	13.0	11.2	11.2	12.1
Chemical Oxygen Demand mg/l	Sept. '73	12	16	12	16	14
	Dec. '73	15	15	15	16	15
	Feb. '74	13	18	18	107	39
Total Suspended Solids mg/l	Sept. '73	112	102	36	102	88
	Dec. '73	113	133	123	121	123
	Feb. '74	92	184	138	332	187
Total Dissolved Solids mg/l	Sept. '73	446	518	508	506	495
	Dec. '73	452	458	432	460	451
	Feb. '74	314	466	456	448	421
Hardness mg/l $CaCO_3$	Sept. '73	208	231	225	231	224
	Dec. '73	232	246	245	244	242
	Feb. '74	148	232	203	206	197
Arsenic mg/l	Sept. '73	0.004	0.004	0.004	0.006	0.005
	Dec. '73	0.003	0.003	0.003	0.004	0.003
	Feb. '74	0.002	0.003	0.003	0.003	0.003
Cadmium mg/l	Sept. '73	0.008	<0.001	0.006	0.001	<0.004
	Dec. '73	0.005	0.007	0.006	0.007	0.006
	Feb. '74	0.012	0.024	0.010	0.025	0.018

APPENDIX TABLE 2A-1

Parameter	Sample Date	Transect F F-1	F-2	Transect G G-1	G-2	Average
Iron (total) mg/l	Sept. '73	1.4	1.4	1.4	1.3	1.4
	Dec. '73	2.5	2.4	2.3	2.4	2.4
	Feb. '74	1.2	2.5	2.9	2.0	2.2
Copper mg/l	Sept. '73	0.011	0.009	0.016	0.010	0.012
	Dec. '73	0.002	0.007	0.005	0.007	0.005
	Feb. '74	0.017	0.022	0.018	0.016	0.018
Lead mg/l	Sept. '73	<0.02	<0.02	<0.02	<0.02	<0.02
	Dec. '73	0.05	0.05	0.01	0.01	0.03
	Feb. '74	<0.02	<0.02	0.03	0.03	<0.03
Mercury µg/l	Sept. '73	<0.1	<0.1	0.1	0.1	<0.1
	Dec. '73	0.4	0.3	0.0	0.1	0.2
	Feb. '74	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium mg/l	Sept. '73	0.015	0.007	0.013	0.005	0.010
	Dec. '73	0.003	0.003	0.003	0.003	0.003
	Feb. '74	0.011	0.004	0.006	0.004	0.006
Selenium mg/l	Sept. '73	<0.001	<0.001	<0.001	0.001	<0.001
	Dec. '73	<0.001	<0.001	<0.001	<0.001	<0.001
	Feb. '74	<0.001	<0.001	<0.001	<0.001	<0.001
Sulfate mg/l	Sept. '73	151	206	202	151	178
	Dec. '73	82	100	97	102	95
	Feb. '74	45	106	86	95	83
Hexane Solubles mg/l	Sept. '73	2	1	3	2	2
	Dec. '73	8	9	7	10	9
	Feb. '74	6	3	2	2	3
Fecal Coliforms number/100 ml	Sept. '73	740	1500	1300	1200	1185
	Dec. '73	1800	2100	3900	3400	2800
	Feb. '74	680	970	880	1000	883

APPENDIX TABLE 2A-1

Parameter	Sample Date	Transect F F-1	F-2	Transect G G-1	G-2	Average
Total Coliforms number/100 ml	Sept. '73	3700	12,000	12,000	16,000	10,925
	Dec. '73	3100	4600	3900	4600	4050
	Feb. '74	1900	1700	1400	1600	1650

APPENDIX TABLE 2A-2

AVERAGE DENSITIES OF PLANKTON COLLECTED IN THE MISSOURI RIVER AT TRANSECTS F AND G IN SEPTEMBER, 1973[a]

PHYTOPLANKTON (cells per liter)

Stations	Greens	Diatoms	Blue-greens	Others	Total
F-1	89	153	12	34	288
F-2	149.5	212.5	27	32.5	421.5
G-1	86	207.5	16	25	334.5
G-2	85	108	14	13	220

ZOOPLANKTON (organisms per liter)

Stations	Rotifers	Cladocerans	Copepods	Total
F-1	44.1	0	5.3	49.4
F-2	42.5	0.2	3.0	45.7
G-1	49.4	0.2	1.8	51.4
G-2	16.2	0	1.6	17.8

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[a] Plankton was also collected from Transects F and G in December, 1973, and February, 1974, but these samples were not analyzed.

APPENDIX TABLE 2A-3

MACROINVERTEBRATES COLLECTED FROM THE MISSOURI RIVER - STATIONS F AND G

Date	Station	Organism	No./m^2
September 1973	F-1	Diptera	
		Tendipedini sp. C	14
		Unidentified	7
	G-1	Diptera	
		Tendipedini sp. C	21
		Crustacea	
		Hyalella azteca	7
	G-2	Diptera	
		Tendipedini sp. C	14
		Tendipedini sp. C-1	42
		Trichocladius sp.	21
December 1973	F-2	Diptera	
		Ceratopogonidae (unidentified)	7
		Odonata	
		Argia sp.	7
		Trichoptera	
		Hydropsyche orris	7
	G-2	Diptera	
		Ceratopogonidae (unidentified)	98
		Annelida	
		Oligochaeta (unidentified)	7

APPENDIX TABLE 2A-4

ITEM ANALYSIS OF STOMACH CONTENTS OF FISH FROM TRANSECTS F AND G, MISSOURI RIVER
COLLECTED DURING SEPTEMBER, 1973 (NUMBERS REPRESENT PERCENT OF WEIGHT)

Fish Species	Number of Stomachs Examined	Number of Empty Stomachs	FOOD ITEMS Green Algae	Diptera	Other Insecta	Pelecypoda	Fish	Unidentified Organic Material	Mean Weight/ Stomach	Total Weight
Gizzard Shad	1	0						100	0.59	0.59
Carp	11	0	1	45	10	4		40	1.01	11.14
River Carpsucker	8	1			10			90	0.43	2.99
Goldeye	1	0			100				0.36	0.36
Blue Catfish	1	0						100	0.20	0.20
Largemouth Bass	2	0			1		98	1	16.21	32.43
White Crappie	4	0		26	62			12	0.10	0.39
Bluegill	1	0		71	29				0.11	0.11
Freshwater Drum	1	0			5			95	0.25	0.25
TOTALS	30	1								

APPENDIX TABLE 2A-5

ITEM ANALYSIS OF STOMACH CONTENTS OF FISH FROM TRANSECTS F AND G MISSOURI RIVER COLLECTED DURING DECEMBER, 1973

Fish Species	Number of Stomachs Examined	Number of Empty Stomachs
Gizzard shad	21	21
Carp	5	5
Smallmouth buffalo	1	1
Skipjack herring	2	2
White crappie	1	1
Freshwater drum	2	2
TOTALS	32	32

APPENDIX 3A-1

SPECIES LIST OF PLANTS IDENTIFIED IN AN INTENSIVE STUDY AREA, CALLAWAY COUNTY, MISSOURI

Common Name	Scientific Name[a]
American elm[b]	Ulmus americana
American hornbeam	Carpinus caroliniana
American ipecac[c]	Gillenia stipulata
Anomalous aster	Aster anomalous
Baldwin's ironweed	Vernonia baldwini
Basket-oak	Quercus michauxii
Basswood	Tilia americana
Bitternut hickory	Carya cordiformis
Black cherry	Prunus serotina
Black gum	Nyssa sylvatica
Black jack oak	Quercus marilandica
Black locust	Robinia pseudoacacia
Black oak	Quercus velutina
Black walnut	Juglans nigra
Blue vervain	Verbena hastata
Blunt-lobed woodsia[c]	Woodsia obtusa
Bowman's root	Gillenia trifoliata
Bradbury monarda	Monarda bradburiana
Bristly greenbrier	Smilax tamnoides
Broad-leaved panic-grass	Panicum latifolium
Broad-leaved spike grass	Uniola latifolia
Buffalo clover	Trifolium stoloniferum
Bullace plum[c]	Prunus insititia

APPENDIX 3A-1 (continued)

Common Name	Scientific Name
Canada cinquefoil[c]	*Potentilla pumila*
Canada goldenrod	*Solidago canadensis*
Carolina buckthorn	*Rhamnus caroliniana*
Carolina rose	*Rosa carolina*
Cherry	*Prunus* sp.
Choke cherry	*Prunus virginiana*
Clammy ground cherry[c]	*Physalis heterophylla*
Clover	*Trifolium* sp.
Common cinquefoil	*Potentilla simplex*
Common milkweed[c]	*Asclepias syriaca*
Common mullein	*Verbascum thapsus*
Common persimmon	*Diospyros virginiana*
Common ragweed	*Ambrosia artemisiifolia*
Common strawberry	*Fragaria virginiana*
Coral berry	*Symphoricarpos orbiculatus*
Crabgrass	*Digitaria sanguinalis*
Cream-colored false indigo[c]	*Baptisia leucophaea*
Crooked-stemed aster[c]	*Aster prenanthoides*
Crown-beard	*Verbesina occidentalis*
Daisy fleabane	*Erigeron annuus*
Downy serviceberry	*Amelanchier arborea*
Eastern white pine[c]	*Pinus strobus*
Ebony spleenwort	*Asplenium platyneuron*
Elm[b]	*Ulmus* sp.
Elm-leaved goldenrod	*Solidago ulmifolia*

APPENDIX 3A-1 (continued)

Common Name	Scientific Name
False buckthorn[c]	*Bumelia languinosa*
False dragonhead[c]	*Physostegia virginiana*
False Solomon's-seal[c]	*Smilacina racemosa*
Field milkwort	*Polygala sançuinea*
Field garlic[c]	*Allium canadense*
Florida lettuce	*Lactuca floridana*
Flowering dogwood	*Cornus florida*
Four-leaved milkweed[c]	*Asclepias quadrifolia*
Fragrant sumac	*Rhus aromatica*
Frost grape	*Vitis vulpina*
Globose cyperus	*Cyperus ovularis*
Goats-rue[c]	*Tephrosia virginiana*
Golden Alexanders	*Zizia aurea*
Grass	(Unknown)
Green ash	*Fraxinus pennsylvanica*
Green dragon[c]	*Arisaema dracontium*
Ground plum[c]	*Astragalus mexicanus*
Hackberry	*Celtis occidentalis*
Hairy agrimony	*Agrimonia pubescens*
Hairy mountain-mint	*Pycnanthemum pilosum*
Hairy ruellia[c]	*Ruellia carolinensis*
Hairy skullcap	*Scutellaria elliptica*
Hawthorn[c]	*Crataegus* sp.
Hickory	*Carya* sp.
Hog-peanut	*Amphicarpa bracteata*

Common Name	Scientific Name
Hogwort	*Croton capitans*
Honey-locust	*Gleditsia triacanthos*
Honewort	*Cryptotaenia canadensis*
Hop-hornbeam	*Ostrya virginiana*
Horse nettle	*Solanum carolinense*
Inland rush	*Juncus tenuis*
Knotweed	*Polygonum aviculare*
Large-bracted tick-trefoil[c]	*Desmodium cuspidatum*
Late purple aster[c]	*Aster patens*
Lead plant	*Lathyrus japonicus*
Least hop-clover[c]	*Trifolium dubium*
Little bluestem	*Andropogon scoparius*
Loblolly pine[c]	*Pinus taeda*
Loosely-flowered panic-grass[c]	*Panicum laxiflorum*
Low hop-clover	*Trifolium procumbens*
Mad-dog skullcap	*Scutellaria lateriflora*
Mild rose	*Rosa blanda*
Mockernut hickory	*Carya tomentosa*
Naked flowering scape trefoil[c]	*Desmodium nudiflorum*
Onion	*Allium* sp.
Osage orange	*Maclura pomifera*
Pale-leaved wood sunflower[c]	*Helianthus strumosus*
Pale plantain	*Plantago rugellii*
Partridge-Pea	*Cassia fasciculata*
Pecan[c]	*Carya illinoensis*
Perfoliate bellwort	*Uvullaria perfoliata*

Common Name	Scientific Name
Pignut hickory	Carya glabra
Pilose aster	Aster pilosus
Pinkweed[c]	Polygonum pensylvanicum
Pink wild bean	Strophostyles umbellata
Plantain-leaf everlasting	Antennaria plantagnifolia
Poison ivy	Rhus radicans
Pole-spike-lobelia	Lobelia spicata
Possum-Haw[c]	Ilex decidua
Post-oak	Quercus stellata
Prairie blazing star[c]	Liatris pycnostachya
Prairie rose	Rosa setigera
Purple cone flower[c]	Echinacea purpurea
Redbud	Cercis canadensis
Red cedar	Juniperus virginiana
Red clover	Trifolium pratense
Red mulberry	Morus rubra
Red oak	Quercus rubra
Red willow dogwood	Cornus amomum
Rough avens	Geum virginianum
Rough bedstraw	Galium asperellum
Rough buttonweed	Diodia teres
Rough-leaved dogwood	Cornus drummondii
Round-leaved dogwood	Cornus rugosa
Roundseed paspalum	Paspalum circulare
Rue-anenome	Anemonella thalictroides

APPENDIX 3A-1 (continued)

Common Name	Scientific Name
Running serviceberry	*Amelanchier stolonifera*
Rusty nannyberry	*Viburnum rufidulum*
Scotch pine[c]	*Pinus sylvestris*
Scrub pine[c]	*Pinus virginiana*
Shagbark hickory	*Carya ovata*
Sheep sorrel	*Rumex acetosella*
Shingle-oak	*Quercus imbricaria*
Slender mountain-mint	*Pycnanthenum tenuifolium*
Slender gerardia[c]	*Gerardia tenuifolia*
Slender rush	*Juncus tenuis*
Slippery elm[b]	*Ulmus rubra*
Smooth-seeded wild bean	*Strophostyles leiosperma*
Smooth serviceberry	*Amelanchier laevis*
Spanish oak	*Quercus falcata*
Spotted spurge	*Euphorbia maculata*
Squarrose sedge[c]	*Carex squarrosa*
St. John's wort	*Hypericum* sp.
Sugarberry	*Celtis laevigata*
Sugar maple	*Acer saccharum*
Sweet coneflower	*Rudbeckia subtomenetosa*
Sycamore	*Platanus occidentalis*
Tall bellflower	*Campanula americana*
Tall ironweed	*Vernonia altissima*
Thin-leaved hackberry	*Celtis tenuifolia*

APPENDIX 3A-1 (continued)

Common Name	Scientific Name
Three-sided mercury	Acalypha virginiana
Tickseed-sunflower	Bidens aristosa
Trumpet creeper[c]	Campsis radicans
Twice-toothed ragweed	Ambrosia bidentata
Typical paspalum[c]	Paspalum pubescens
Violet	Viola sp.
Virginia creeper	Parthenocissus quinquefolia
Wavy-leaved aster	Aster undulatus
Western ironweed	Veronica fasciculata
White ash	Fraxinus americana
White avens	Geum canadense
White clover	Trifolium repens
White oak	Quercus alba
White oat-grass	Danthonia spicata
White sassafras	Sassafras albidum
White wild licorice	Galium circaezans
Wild bergamot	Monarda russeliana
Wild carrot	Daucus carota
Witchgrass	Panicum capillare
Woodland agrimony	Agrimonia rostellata
Woolgrass[c]	Scirpus cyperinus
Yarrow	Achillea millefolium

APPENDIX 3A-1 (continued)

Common Name	Scientific Name
Yellow foxtail	*Setaria lutescens*
Yellow wood sorrel	*Oxalis europaea*

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a Source: Fernald (1970).

b Considered endangered throughout the state of Missouri due to the Dutch elm disease (Gale, October 25, 1973).

c Randomly sampled.

APPENDIX 3B-1

LIFE HISTORY[a] OF GAME AND FUR MAMMALS
WHOSE RANGES ENCOMPASS CALLAWAY COUNTY, MISSOURI

Species	Preferred Habitat	Home Range[b]	Food Preference	Age at Maturity	Breeding Season	Gestation Period	Litters per Year	Young per Year	Category
Badger	Open prairie	1 to 2 sq. mi.	Rabbits, mice and ground squirrels	1 year	August-September	6-9 months	1	1-7	Fur, game
Beaver	In and along streams, rivers, marshes, lakes	.5 mile	Tender bark of trees, corn, and aquatic plants	3 years	January-February	3-4 months	1	1-8	Fur
Coyote	Brushy areas and open farmlands	1.5-15 miles	Rabbits, mice, carrion and some plants	1-2 years	January-March	58-63 days	1	2-19	Fur
Eastern cottontail	Open brushy land and forest border	1-5 acres	Leaves of grass, weeds, clover, bark	4 months-1 year	March-September	26-30 days	1-6	1-9	Game
Eastern fox squirrel	Hardwood forests and hedgerows	10 acres	Nuts, fruits, corn, bark, buds and seeds	1 year	December-January	44-45 days	2	1-6	Game
Eastern gray squirrel	Hardwood forest	200 yards	Nuts, fruits, corn, bark, buds and seeds	1 year	December-January	44-45 days	2	1-6	Game
Gray fox	Wood areas and open brushlands	.5-5 miles	Rabbits, mice, carrion and some plants	1 year	January-May	51-63 days	1	1-10	Fur, game
Long-tailed weasel	Woodlands and thickets near water	400 acres	Live mice, rats, rabbits and squirrels	Male-1½ years. Female-4 months	July-August	9 months	1	1-12	Fur, game

APPENDIX 3B-1 (continued)

Species	Preferred Habitat	Home Range[b]	Food Preference	Age at Maturity	Breeding Season	Gestation Period	Litters per Year	Young per Year	Category
Mink	Along rivers, streams, lakes, marshes and ponds	2.5 miles	Mice, rabbits, fish, frogs and crayfish	1 year	February-April	40-75 days	1	2-17	Fur
Muskrat	In marshes, streams, rivers, lakes and ponds	200 yards	Aquatic plants, clover, corn, grass and clams	4 months-1 year	March-September	29-30 days	1-5	1-11	Fur
Opossum	Wooded areas along shallow streams	40 acres	Insects, carrion, fruit and grain	1 year	February-May	13 days	2	5-13	Fur, game
Raccoon	Hardwood timber	.5 miles	Fruit, grass, grain, nuts, fish, and clams	1-2 years	January-June	63 days	1	1-7	Fur, game
Red fox	Borders of woods and adjacent open lands	.5-5 miles	Rabbits, mice, carrion and some plants	1 year	December-March	49-56 days	1	1-10	Fur, game
River otter	Along streams, rivers and lakes	50-100 miles of shore-line	Fish, crayfish, and other aquatic animals	2 years	Winter or early spring	9-12 months	1	1-5	Fur[c]
Spotted skunk	Prairie, brushy areas and cultivated lands	4 sq. miles	Insects, mice, fruit, corn	1 year	February-March (and later?)	7-10 weeks?	1 2?	2-6	Fur, game

APPENDIX 3B-1 (continued)

Species	Preferred Habitat	Home Range[b]	Food Preference	Age at Maturity	Breeding Season	Gestation Period	Litters per Year	Young per Year	Category
Striped skunk	Forest borders and brushy fields near water	.5-.75 miles	Insects, mice, fruit, grass, leaves	1 year	February-March	7-10 weeks	1	2-16	Fur, game
White-tailed deer	Edges and openings in forests	.5-1.5 sq. mi.	Twigs, leaves, nuts, fungi	7 months-1.5 years	October-November	7 months	1	1-4	Game
Woodchuck	Borders of timber and open land	.13-.25 miles	Leaves, seeds, flowers, few insects, fruits	1-2 years	February-March	31-32 days	1	2-9	Game

a Information provided by the Missouri Department of Conservation.

b From Schwartz and Schwartz (1959).

c Not harvested due to low population numbers.

APPENDIX 3B-2

LIFE HISTORY[a] OF NON-GAME MAMMALS WHOSE RANGES ENCOMPASS CALLAWAY COUNTY, MISSOURI

Species	Preferred Habitat	Home Range	Food Preference	Age at Maturity	Breeding Season	Gestation Period	Litter/ yr.	Young/ Litter
Big brown bat	Hollow trees, mines, caves, buildings	10 mile radius	Insects	2½ months	Fall	2-2½ months	1	1-2
Deer mouse	Pastures, meadows, cultivated fields, and along field borders	½-1½ acres	Insects, nuts, wild seeds domestic grains, and fruits	Female - 46-51 days Male - 56-61 days	Spring and fall	21-23 days	4	1-9
Evening bat	Roosts in foliage of trees, and in hollow trees		Flying insects		Fall and Spring	2-2½ months	1	1-2
Eastern chipmunk	Forest borders and in shrubbery in residential areas	2/5-3 acres	Nuts, seeds, berries; occasional small mammals	1 year	Spring and throughout summer	31 days	1-2	1-8
Eastern mole	Under ground in meadows, pastures, lawns, open woodlands	2-3 moles/ acre	85% animal foods; seeds of oats, wheat, corn, and grass	1 year	Spring	4-6 weeks	1	2-5
Eastern pipistrelle (bat)	Live in retreats about cliffs, buildings and caves		Flying insects		Fall and Spring		1	1-2
Franklin ground squirrel	Borderland between woods and prairies	100 yards in diameter, around den	3/4 vegetable matter, seeds, fruits, roots, and green vegetation	Mature in their first Spring	Spring		1	4-11
Gray myotis (bat)	Caves	Migrate as many as 200 miles	Insects	---	---	---	---	---
Hispid cotton rat	Dense grassy fields, roadside grown with weeds	Female ½-3/4 acre Male 1-1½ acres	Stems, leaves, roots, seeds, and sedges; crayfish and eggs of ground nesting birds	5 months	Year round	27 days	several	5-7
Hoary bat	Wood regions, preferring coniferous forest	---	Insects	---	Late summer, early fall	90 days	1	1-2
House mouse	Well hidden places, in homes or outside	11 feet when indoors	Grain and vegetable products	6 weeks	Early spring to late fall	19-21 days	5-10	2-13
Indiana myotis (bat)	Caves	---	Insects	---	---	---	---	---
Keen myotis (bat)	Caves	May move as many as 150 miles to new caves	Soft-bodied adult insects	1 year	Fall, winter, spring	50-60 days	1	1
Least shrew	Open grass, brush, and dry fallow fields	---	Small insects, snails, slugs, earthworms, dead small mammals	1 month	February - November	21-23 days	Several	2-6
Little brown myotis (bat)	Caves in winter, and attics, under loose bark on trees in summer	May move as many as 150 miles to new caves	Soft-bodied adult insects	1 year	Fall, winter, spring	50-60 days	1	1

Species	Preferred Habitat	Home Range	Food Preference	Age at Maturity	Breeding Season	Gestation Period	Litter/ Yr.	Young/ Litter
Meadow jumping mouse	Open grassy habitats	1 acre	Grass seeds	3 months	Early spring to August	18 days	3	5-6
Norway rat	Buildings, sewers, around dumps	100-200 feet of their nest	Omnivorous, vegetable and animal	3-5 months	Year round	21-26 days	5	7-11
Pine vole	Under ground in oak-hickory forest or mixed hardwoods	¼ acre	Succulant roots, sprouts, tubers, tender bark of tree roots, fruit and occassional insects	2 months	January-October	21 days	Several	2-4
Plains pocket gopher	Open lands; prairie grasslands, pastures, cultivated areas	---	Fleshy roots, underground stems of grasses and legumes	1 year	Spring	4 weeks	1	4 5
Prairie vole	Upland herbaceous forests, grasslands, thickets, fallow fields and under grain shocks	1/15 acre	Tender stems, leaves, roots, tubers, flowers, seeds, and fruits of grasses and sedges	Male - 5 weeks Female - 25 days	Year-round with peaks in spring and fall	21 days	Several	1-7
Red bat	Wood areas, roost in trees	---	Flying insects	---	Fall, winter, spring	80-90 days	1	1-4
Short-tailed shrew	Dark, damp, wet locations in wooded areas	½-1 acre	Earth worms, snails, slugs, spiders, salamanders, birds, snakes, mice	Spring after birth	Early spring to late fall	21-22 days	1-2	3-10
Silver-haired bat	Forest and along wooded water courses	---	Flying, soft-bodied insects	---	August or September	---	1	1-2
Small-footed myotis (bat)	Cave and tunnels, prefers cooler places	---	Soft-bodied flying insects	---	---	---	---	---
Southern bog lemming	Low damp bogs and meadows with heavy growth of vegetation	1/3 acre	Green vegetation	---	Year-round	23 days	2-3	2-6
Southern flying squirrel	Heavy, deciduous timber not far from water	4-5 acres	Hickory nuts, acorns	1 year	February-March May-July	40 days	1	1-6
Thirteen-lined ground squirrel	Flat open grasslands, or other dry open fields	1½ acres	Insects, earthworms, eggs and young of ground nesting birds; seeds, fruits, roots, and foliage	1 year	Spring	27-28 days	1	4-14
Western harvest mouse	Abandoned fields, meadows, fence rows, preferably near water	½-1½ acres	Seeds of legumes and grasses	3-4 months	Spring to fall	33-24 days	Several	1-7
White-footed mouse	Pasture, meadows, cultivated fields, field borders, fence rows	½-1½ acres	Insects, nuts, wild seeds, domestic grains	Female - 46-51 days Male - 56-61 days	Spring and fall	21-23 days	4	1-9

a Schwartz and Schwartz (1959).

APPENDIX 3B-3

CHECKLIST OF MAMMALS WHOSE RANGE[a] ENCOMPASSES CALLAWAY COUNTY, MISSOURI

FAMILY Scientific Name	Common Name
DIDELPHIDAE	
Didelphis marsupialis[d]	Opossum
SORICIDAE	
Blarina brevicauda	Short-tailed shrew
Cryptotis parva	Least shrew
TALPIDAE	
Scalopus aquaticus[d]	Eastern mole
VESPERTILIONIDAE	
Myotis lucifugus	Little brown myotis
Myotis grisescens	Gray myotis
Myotis keenii[c]	Keen myotis
Myotis sodalis[b,e]	Indiana myotis
Myotis subulatus[b]	Small-footed myotis
Lasionycteris noctivagans	Silver-haired bat
Pipistrellus subflavus	Eastern pipistrelle
Eptesicus fuscus	Big brown bat
Lasiurus borealis	Red bat
Lasiurus cinereus	Hoary bat
Nycticeius humeralis	Evening bat
LEPORIDAE	
Sylvilagus floridanus[d]	Eastern cottontail
SCIURIDAE	
Marmota monax[d]	Woodchuck

FAMILY Scientific Name	Common Name
SCIURIDAE	
Citellus tridecemlineatus	Thirteen-lined ground squirrel
Citellus franklini	Franklin ground squirrel
Tamias striatus	Eastern chipmunk
Sciurus carolinensis[d]	Eastern gray squirrel
Sciurus niger[d]	Eastern fox squirrel
Glaucomys volans	Southern flying squirrel
GEOMYIDAE	
Geomys bursarius	Plains pocket gopher
CASTORIDAE	
Castor canadensis[f]	Beaver
CRICETIDAE	
Reithrodontomys megalotis	Western harvest mouse
Peromyscus maniculatus[d]	Deer mouse
Peromyscus leucopus[d]	White-footed mouse
Sigmadon hispidus	Hispid cotton rat
Synaptomys cooperi	Southern bog lemming
Microtus ochrogaster	Prairie vole
Microtus pinetorium	Pine vole
Ondatra zibethicus[d]	Muskrat
MURIDAE	
Rattus norvegicus	Norway rat
Mus musculus	House mouse

FAMILY Scientific Name	Common Name
ZAPODIDAE	
Zapus husdonius	Meadow jumping mouse
CANIDAE	
Canis latrans[d]	Coyote
Vulpes fulva	Red fox
Urocyon cinereoargenteus	Gray fox
PROCYONIDAE	
Procyon lotor[d]	Raccoon
MUSTELIDAE	
Mustela frenata[c,d]	Long-tailed weasel
Mustela vison	Mink
Taxidea taxus	Badger
Spilogale putorius	Spotted skunk
Mephitis mephitis[d]	Striped skunk
Lutra canadensis	River otter
CERVIDAE	
Odocoileus virginianus[d]	White-tailed deer

a After Burt and Grossenheider (1952).

b Considered "endangered" by the Missouri Department of Conservation (Gale, October 25, 1973).

c Considered "rare" by the Missouri Department of Conservation (Gale, October 25, 1973).

d Identified on the site.

e Considered "threatened" by the U.S. Department of Interior (1973).

f Identified on the Missouri River.

APPENDIX 3C-1

LIFE HISTORY[a] OF BIRDS IDENTIFIED
WITHIN THE GENERAL STUDY AREA, CALLAWAY COUNTY, MISSOURI

Species	Habitat Preference	Food Preference	Average Number of Eggs Per Clutch	Number of Clutches Per Year	Average Incubation Period (days)
Acadian flycatcher	Wooded area, near water	Insects	3	1	13
American bittern	Marsh, pond	Small vertebrates, large invertebrates	4	1	28
American goldfinch	Hedgerow	Seeds, vegetation	5	1	13
American widgeon[b]	Open water, rivers	Aquatic plants, molluscs	10	1	24
Baltimore oriole	Orchard, forest	Insects	4	1	12
Bald eagle[b]	Rock outcrops near water	Fish, muskrat	2	1	34
Barn swallow	Agricultural area	Insects	4	1	15
Belted kingfisher	Near water	Fish	6	1	23
Black-billed cuckoo	Forest	Insects	2-3	1	14
Black-capped chickadee	Forest, hedgerow	Insects, seeds	7	1	12
Black duck[b]	River, stream, marsh	Aquatic insects, snails, plants	9	1	26
Blue goose	River, marsh, pond	Grasses, aquatic plants	4	1	23
Blue grosbeak	Old field, hedgerow	Insects, seeds	4	1	11
Blue jay	Forest	Acorns, berries, insects	4	1	18
Blue-winged teal	Marsh	Invertebrates, aquatic plants	10	1	22
Bobwhite	Hedgerow agricultural fields	Seeds, fruits	15	1	23
Brown-headed cowbird	Agricultural fields	Insects, seeds	5	1	10
Brown thrasher	Hedgerow, thicket	Insects, grain	4	1	13
Canada goose[b]	Lake, pond, river, fields	Grain	5-6	1	29
Cardinal	Hedgerow	Insects, seeds	3	1	12
Catbird	Thicket, hedgerow	Fruits, seeds	4	1	13
Cedar waxwing	Orchard	Fruits, insects	4	1	12
Chimney swift	Residential area	Insects	4	1	19
Chipping sparrow	Residential and agricultural areas	Seeds, insects	4	1	11
Common crow	Agricultural area	Grain, seeds, berries, insects	5	1	18

Species	Habitat Preference	Food Preference	Average Number of Eggs Per Clutch	Number of Clutches Per Year	Average Incubation Period (days)
Common grackle	Agricultural area	Insects, grain	4	1	14
Common nighthawk	Agricultural area	Insects	2	1	19
Common redpoll	Forest edge, open fields	Seeds	4-5	1	11
Dickcissel	Open meadow, pasture	Seeds, fruits	4	1	12
Downy woodpecker	Forest, residential areas	Insects	4	1	12
Eastern bluebird	Orchard, hedgerow	Insects, fruit	5	1	12
Eastern kingbird	Brushy old fields	Insects	3	1	13
Eastern phoebe	Farm	Insects	5	1	16
Eastern wood pewee	Agricultural areas	Insects	3	1	13
Field sparrow	Brushy fencerows	Insects, seeds	4	1	12
Fox sparrow	Brushland	Seeds	4	1	13
Golden eagle	Forest	Large mammals, birds, snakes	2	1	31
Grasshopper sparrow	Grassland with shrubs	Insects	4-5	1	11
Great blue heron[b]	Lake, marsh	Fish, insects, amphibians	4	1	28
Great crested flycatcher	Forest	Insects	5	1	15
Great horned owl	Forest	Mammals, birds	2	1	30
Green heron	Marsh	Small vertebrates, large invertebrates	4	1	17
Hairy woodpecker	Forest, orchard	Insects	4	1	14
Harris' sparrow	Brushland	Seeds	4	1	13
Herring gull	Lake, river	Scavenger, decaying fish, carrion	3	1	26
Horned lark	Prairie, agricultural area	Seeds	4	1	13
House sparrow	Residential	Grain, insects	5	3	13
House wren	Forest edge, hedgerow	Insects	7	1	13
Indigo bunting	Hedgerow, agricultural	Invertebrates, seeds	4	1	12
Killdeer	Shoreline, open field	Insects	4	1	24
Loggerhead shrike	Open country	Mice, small birds, grasshoppers	4-5	1	11
Mallard	Marsh	Aquatic plants, grains, invertebrates	10	1	28

Species	Habitat Preference	Food Preference	Average Number of Eggs Per Clutch	Number of Clutches Per Year	Average Incubation Period (days)
Marsh hawk	Marsh	Rodents	5	1	26
Meadowlark	Agricultural fields	Insects, seeds	5	1	14
Mockingbird	Residential area	Insects, fruits	4-5	1	12
Mourning dove	Agricultural land	Seeds, grain	2	2	15
Myrtle warbler	Forest	Insects	4-5	1	12
Osprey[b]	River, lake, stream	Fish	3	1	28
Pied-billed grebe	Deep water marsh	Aquatic invertebrates, small vertebrates	6	1	25
Pileated woodpecker	Forest	Insects	4	1	20
Pintail[b]	Ponds, river, marsh	Aquatic plants, molluscs	10	1	22
Purple martin	Residential area	Insects	4	1	13
Red-bellied woodpecker	Bottomland, forest	Insects, seeds	4	1	14
Red-eyed vireo	Forest	Insects, fruits	4	1	13
Red-headed woodpecker	Open groves of trees	Insects, seeds	5	1	14
Red-tailed hawk	Forest	Rodents	2	1	28
Red-winged blackbird	Marsh, agricultural field	Seeds, insects	4	1	11
Ring-necked duck	Marsh, slough	Aquatic plants, insects	10	1	--
Robin	Residential area, forest	Insects, earthworms, fruit	4	1	13
Rock dove	Agricultural land	Seeds, grain	2	3	15
Rough-legged hawk	Forest with open areas	Rodents, insects	4-5	1	28
Rough-winged swallow	Gravel pit, bank	Insects	6-7	1	16
Ruby-throated hummingbird	Residential area	Nectar	2	1	14
Ruffed grouse	Forest	Nuts, fruits, buds, grain	10	1	21
Rufous-sided towhee	Hedgerow, thicket	Seeds, insects	3	1	13
Slate-colored junco	Field, forest	Seeds, insects	4	1	12
Snow goose	Lake, pond, river, floodplain	Grain, grasses	6	1	22

APPENDIX 30-1 (continued)

Species	Habitat Preference	Food Preference	Average Number of Eggs Per Clutch	Number of Clutches Per Year	Average Incubation Period (days)
Song sparrow	Lowland thicket	Insects, seeds	4-5	3	12
Sparrow hawk	Agricultural area	Insects, birds	4	1	29
Starling	Agricultural and residential areas	Insects, fruits	5	1	14
Swamp sparrow	Hedgerows	Insects, seeds	4	1	13
Summer tanager	Upland wood	Insects	4	1	12
Tree sparrow	Hedgerows	Insects, seeds	4	1	13
Tufted titmouse	Forest, hedgerow	Insects, seeds	5-6	1	12
Turkey	Forest	Fruit, mast, seeds, insects	12	1	28
Turkey vulture	Forest	Carrion	2	1	41
Whip-poor-will	Hardwood forest	Insects	2	1	14
White-breasted nuthatch	Forest	Nuts, seeds, insects	8	1	12
White-crowned sparrow	Brushland	Seeds, insects	4	1	11
White-throated sparrow	Brushland	Seeds, insects	5	1	13
Wood duck[b]	Flooded forest, floodplain	Nuts, fruits	1[illegible]	1	29
Wood thrush	Forest	Insects, fruit	[illegible]	1	14
Yellow-billed cuckoo	Orchard, garden, woodland	Insects	3-4	1	14
Yellow-breasted chat	Forest	Insects	5	1	11
Yellow-shafted flicker	Agricultural area	Insects, plants	7	1	17
Yellowthroat	Brushland, swamp-woodland ecotone	Insects	4	1	12

a Bent, 1961 through 1966.

Kortright, 1942.

b Species observed along the Missouri River and not observed in the General Study Area.

CHECKLIST OF BIRDS WHOSE RANGE[a] ENCOMPASSES CALLAWAY COUNTY, MISSOURI

Common Name	Scientific Name	Sampling Period Observed[b]	Residency Status[c]	Abundance Status[d]
Acadian flycatcher	Empidonax virescens	ES	SR	c
American bittern	Botaurus lentiginosus	S	SR	r
American coot	Fulica americana		SR,SV	r
American goldfinch	Spinus tristus	ES LS F	PR	ca
American redstart	Setophaga ruticilla		SR	c
American widgeon	Mareca americana		WR SV	u ca
American woodcock	Philohela minor		SR WR	r ca
Bald eagle[f]	Haliaeetus leucocephalus		WR SR	c ca
Baltimore oriole	Icterus galbula	ES	SR WR	c ca
Bank swallow	Riparia riparia		SR	u
Barn owl[f]	Tyto alba		PR	r
Barn swallow	Hirundo rustica	ES,LS	SR	c
Barred owl	Strix varia		PR	c
Bell's vireo	Vireo bellii		SR	u
Belted kingfisher	Megaceryle alcyon	ES	SR	c
Black-billed cuckoo	Coccyzus erythropthalmus	ES LS	SR	r
Black-capped chickadee	Parus atricapillus	ES LS W F	PR	c
Black-crowned night heron	Nycticorax nycticorax		SR WR	u ca
Black duck	Anas rubripes		WR SV	u ca
Black tern	Chlidonias niger		SV	r
Blue goose	Chen caerulescens	F	WR SV	u ca
Blue-gray gnatcatcher	Polioptila caerulea		SR	c
Blue grosbeak	Guiraca caerula	LS	SR	r
Blue jay	Cyanocitta cristata	S ES LS F W	PR	c
Blue-winged teal	Anas discors	LS	SR,WR	ca
Bobwhite	Colinus virginianus	S ES LS F W	PR	c
Bohemian waxwing	Bombycilla garrulus		WR	ca
Bonaparte's gull	Larus philadelphia		WR	ca
Brewer's blackbird	Euphagus cyanocephalus		WR	ca
Broad-winged hawk	Buteo platypterus		SR	u
Brown creeper	Certhia familiaris		WR	u

Common Name	Scientific Name	Sampling Period Observed[b]	Residency Status[c]	Abundance Status[d]
Brown-headed cowbird	Molothrus ater	S ES LS	SR	c
Brown thrasher	Toxostoma rufum	S ES LS	SR	c
Bufflehead	Bucephala albeala		WR	r
Canada goose	Branta canadensis		WR SR	c u
Canvasback	Aythya valisineria		WR	u
Cardinal	Richmondena cardinalis	S ES LS F W	PR	c
Carolina wren	Thryothorus ludovicianus		PR	u
Caspian tern	Hydroprogne caspia		SV	ca
Catbird	Dumetella carolinensis	ES LS F [illegible]	SR	c
Cattle egret	Bubulcus ibis		SV	ca
Cedar waxwing	Bombycilla cedrorum	F	WR SR	c r
Chestnut-collared Longspur	Calcarius ornatus		WR	ca
Chimney swift	Chaetura pelagica	ES LS	SR	c
Chipping sparrow	Spizella passerina	ES	SR	c
Chuck-will's widow	Caprimulgus carolinensis		SR	u
Cliff swallow	Petrochelidon pyrrhonota		SR	u
Common crow	Corvus brachyrynchos	S ES LS F W	PR	c
Common egret	Casmerodius albus		SR	c
Common gallinule	Gallinula chloropus		SR	r
Common goldeneye	Bucephala clangula		WR	c
Common grackle	Quiscalus quiscula	S ES LS F W	SR WR	c u
Common loon	Gavia immer		WR	ca
Common merganser	Mergus merganser		WR	c
Common nighthawk	Chordeiles minor	ES LS	SR	c
Common redpoll	Acanthis flammea	F W	WR	ca
Common snipe	Capella gallinago		WR	r
Common tern	Sterna hirundo		SV	ca
Cooper's hawk[e]	Accipiter cooperii		PR	u
Dickcissel	Spiza americana	ES	SR	c
Double-crested cormorant[e]	Phalacrocorax auritus		SR,WR	ca
Downy woodpecker	Dendrocopos pubescens	F W	PR	c
Eastern bluebird	Sialia sialis	S ES LS F W	SR WR	c u
Eastern kingbird	Tyrannus tyrannus	ES LS	SR	c
Eastern meadowlark	Sturnella magna	S ES LS F W	PR	c
Eastern phoebe	Sayornis phoebe	LS	SR	c
Eastern wood pewee	Contopus virens	LS LS F	SR	c
Evening grosbeak	Hesperiphona vespertina		WR	r

Common Name	Scientific Name	Sampling Period Observed[b]	Residency Status[c]	Abundance Status[d]
Field sparrow	*Spizella pusilla*	S ES LS	SR	c
Forster's tern	*Sterna forsteri*		SV	ca
Fox sparrow	*Passerella iliaca*	F	WR	u
Gadwall	*Anas strepera*		WR	u
			SV	ca
Glossy ibis	*Plegadis falcinellus*		SV	ca
Golden-crowned kinglet	*Regulus calendula*		WR	c
Golden eagle	*Aquila chrysaetos*	W	WR	r
Goshawk	*Accipiter gentilis*		WR	r
Grasshopper sparrow	*Ammodramus savannarum*	ES	SR	c
Great blue heron	*Ardea herodias*		SR	c
			WR	r
Great crested flycatcher	*Myiarchus crinitus*	ES	SR	c
Great horned owl	*Bubo virginianus*	ES F W	PR	c
Greater scaup	*Aythya marila*		WR	r
Green heron	*Butorides virescens*	ES	SR	c
Green-winged teal	*Anas carolinensis*		WR	u
			SV	ca
Hairy woodpecker	*Dendrocopos scalaris*	S F W	PR	u
Harlan's hawk	*Buteo harlani*		WR	[illegible]
Harris's sparrow	*Zanotrichia querula*	F W	WR	r
Henslow's sparrow[f]	*Passerherbulus henslowii*		SR	r
Herring gull	*Larus argentatus*		WR	u
Hooded merganser	*Lophodytes cucullatus*		WR	u
Horned lark	*Eremophila alpestris*	ES W	PR	c
House sparrow	*Passer domesticus*	S ES LS F W	PR	c
House wren	*Troglodytes aedon*	ES	SR	c
Indigo bunting	*Passerina cyanea*		SR	c
		ES LS	WR	ca
Kentucky waterthrush	*Sciurus noveboracensis*		SR	u
Killdeer	*Charadrius vociferus*	S LS F W	SR	c
King rail[f]	*Rallus elegans*		SR	ca
Lapland longspur	*Calcarius lapponicus*		WR	c
Lark sparrow	*Chandestes grammacus*		SR	u
Least bittern	*Ixobrychus exilis*		SR	u
Least flycatcher	*Empidonax minimus*		SR	ca
Least tern[f]	*Sterna albifrons*		SR	r
Lesser scaup	*Aythya affinis*		WR	u
			SV	r
Lincoln's sparrow	*Melospiza lincolnii*		WR	r
Little blue heron	*Florida caerulea*		SR	c

Common Name	Scientific Name	Sampling Period Observed[b]	Residency Status[c]	Abundance Status[d]
Loggerhead shrike	Lanius ludovicianus	ES LS F W	PR	c
Long-billed marsh wren	Telmatodytes palustris		SR WR	r ca
Long-eared owl	Asio otus		WR SR	r ca
Louisianna waterthrush	Seiurus motacilla		SR	u
Mallard	Anas platyrhynchos	LS W	WR SR	c r
Marsh hawk	Circus cyaneus	F W	WR SR	c r
Mockingbird	Mimus polyglottos	S ES LS F W	SR	c
Mourning dove	Zenaidura macroura	S ES LS F W	SR WR	c r
Myrtle warbler	Dendroica coronata	S	WR	r
Northern shrike	Lanius excubitor		WR	ca
Oldsquaw	Clangula hyemalis		WR	r
Orchard oriole	Icterus spurius		SR	c
Oregon junco	Junco oreganus		WR	r
Osprey[e]	Pandion haliaetus		SV	ca
Painted bunting[f]	Passerina ciris		SE	ca
Parula warbler	Parula americana		SR	c
Peregrine falcon[e]	Falco peregrinus		WR	ca
Pied-billed grebe	Podilymbus podiceps	F	SR	r
Pigeon hawk	Falco columbarius		WR	ca
Pileated woodpecker	Dryocopus pileatus	S ES W	PR	u
Pine grosbeak	Pinicola enucleator		WR	ca
Pine siskin	Spinus pinus		WR SR	u ca
Pintail	Anas acuta		WR	u
Prairie falcon	Falco mexicanus		WR	ca
Prothonotary warbler	Prontonotaria citrea		SR	u
Purple finch	Carpodacus purpureus		WR	u
Purple gallinule	Porphyrula martinica		SV	ca
Purple martin	Progne subis	LS	SR	c
Red-bellied woodpecker	Centurus carolinus	S ES LS F W	PR	c
Red-breasted merganser	Mergus serrator		WR,SV	ca
Red-breasted nuthatch	Sitta canadensis		WR SR	u ca
Red crossbill	Loxia curvirostra		WR SV	r ca
Red-eyed vireo	Vireo olivaceus	ES LS	SR	c
Redhead	Aythya americana		WR	r
Red-headed woodpecker	Melanerpes erythrocephalus	ES LS F W	PR	c

Common Name	Scientific Name	Sampling Period Observed[b]	Residency Status[c]	Abundance Status[d]
Red-shafted flicker	Colaptes cafer		WR	r
Red-shouldered hawk[f]	Buteo lineatus		PR	u
Red-tailed hawk	Buteo jamaicensis	S ES LS F W	PR	c
Red-winged blackbird	Agelaius phoeniceus	S ES LS F	SR WR	c u
Ring-billed gull	Larus delawarensis		WR	c
Ring-necked duck	Aythya collaris	F	WR	u
Robin	Turdus migratorius	S ES LS F W	SR WR	c u
Rock dove	Columba livia	ES LS	PR	c
Rose-breasted grosbeak	Pheucticus ludovicianus		SR	u
Rough-legged hawk	Buteo lagopus	F	WR	u
Rough-winged swallow	Stelgidopteryx ruficollis	LS	SR	c
Ruby-crowned ringlet	Regulus satrapa		WR	r
Ruby-throated Hummingbird	Archilochus colubris	ES LS	SR	c
Ruddy duck	Oxyura jamaicensis		WR,SV	ca
Ruffed grouse[f]	Bonasa umbellus	F	PR	ca
Rufous-sided towhee	Pipilo erythrophthalmus	ES LS	SR	c
Rusty blackbird	Euphagus carolinus		WR	r
Savannah sparrow	Passerculus sandwichensis		WR	ca
Saw-whet owl	Aegolius acadicus		WR	ca
Scarlet tanager	Piranga olivacea		SR	u
Screech owl	Otus asio		PR	u
Sharp-shinned hawk[f]	Accipiter striatus		PR	u
Short-billed marsh wren	Cistothorus platensis		SR WR	u ca
Short-eared owl	Asio flammeus		WR	u
Shoveler	Spatula clypeata		WR SV	r ca
Slate-colored junco	Junco hyemalis	F W	WR	c
Snow bunting	Plectrophenax nivalis		WR	ca
Snow goose	Chen hyperborea	F	WR SV	u ca
Snowy egret	Leucophoyx thula		SV	u
Snowy owl	Nyctea scandiaca		WR	ca
Song sparrow	Melospiza melodia	S ES F W	SR WR	ca c
Sora rail	Porzana carolina		SR	ca
Sparrow hawk	Falco sparverius	S ES LS F W	PR	c
Spotted sandpiper	Actitis macularia		SR	u
Starling	Sturnus vulgaris	S ES LS F W	PR	c
Summer tanager	Piranga rubra	S ES	SR	c

Common Name	Scientific Name	Sampling Period Observed[b]	Residency Status[c]	Abundance Status[d]
Swamp sparrow	Melospiza georgiana	F	WR	u
Traill's flycatcher	Empidonax traillii		SR	u
Tree sparrow	Spizella arborea	W	WR	c
Tree swallow	Iridoprocne bicolor		SR	u
Tufted titmouse	Parus bicolor	ES F W	PR	c
Turkey	Meleagris gallopavo	S F	PR	r
Turkey vulture	Cathartes aura	S ES LS	SR WR	c r
Upland plover[e]	Bartramia longicauda		SR	u
Virginia rail	Rallus limicola		SR	ca
Warbling vireo	Vireo gilvus		SR	c
Western meadowlark	Sturnella neglecta		SR	u
Whip-poor-will	Caprimulgus vociferus	ES LS	SR	c
Whistling swan	Olor columbianus		WR	r
White-breasted nuthatch	Sitta carolinensis	F W	PR	c
White-crowned sparrow	Zanotrichia leucophrys	F	WR	c
White-eyed vireo	Vireo griseus		SR	u
White-fronted goose	Anser albifrons		SV,WR	ca
White ibis	Eudocimus albus		SV	ca
White pelican	Pelecanus erythrorhynchos		WR,SV	ca
White-throated sparrow	Zanotrichia albicallis	F	WR	c
White-winged crossbill	Loxia leucoptera		WR SV	ca
Winter wren	Troglodytes troglodytes		WR	u
Wood duck	Aix sponsa		SR WR	c r
Wood thrush	Hylocichla mustelina	ES	SR	c
Worm-eating warbler	Helmitheros vermivorus		SR	r
Yellow-bellied sapsucker	Sphyrapicus varius		WR	u
Yellow-billed cuckoo	Coccyzus americanus	ES	SR	c
Yellow-breasted chat	Icteria virens	ES	SR	r
Yellow-crowned night heron	Nycticorax violacea		SR	u

Common Name	Scientific Name	Sampling Period Observed[b]	Residency Status[c]	Abundance Status[d]
Yellow-shafted flicker	Colaptes auratus	ES LS F W	PR	c
Yellowthroat	Geothlypis trichas	ES	SR	c
Yellow-throated vireo	Vireo flavifrons		SR	u
Yellow warbler	Dendroica petechia		SR	c

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a Robbins et al., (1966)
b S - Spring
ES - Early Summer
LS - Late Summer
F - Fall
W - Winter
c Audubon Society (1971)
PR - Permanent resident
WR - Winter resident (December 21 - February 20)
SR - Summer resident (breeding)
SV - Summer visitor
d Audubon Society (1971)
C - Common (easily observed)
U - Uncommon (infrequently reported)
R - Rare (sparingly recorded)
CA - Casual (reported only a few times)
e Gale (October 25, 1973)
Species is considered "endangered" (survival within Missouri is in jeopardy) by the Missouri Department of Conservation.
f Gale (October 25, 1973)
Species is considered "rare" (in small numbers and may become endangered) by the Missouri Department of Conservation.

APPENDIX 3D-1

CHECKLIST OF AMPHIBIANS WHOSE
RANGE[a] ENCOMPASSES CALLAWAY COUNTY, MISSOURI

FAMILY Scientific Name	Common Name	Habitat
CRYPTOBRANCHIDAE		
Cryptobranchus alleganiensis alleganiensis	Hellbender	Aquatic
Necturus maculosus	Mudpuppy	Aquatic
SALAMANDRIDAE		
Diemictylus viridescens louisianensis[b]	Central newt	Aquatic
AMBYSTOMIDAE		
Ambystoma maculatum	Spotted salamander	Deciduous forest
Ambystoma texanum	Small-mouthed salamander	Under old logs
Ambystoma tigrinum tigrinum	Eastern tiger salamander	Forests
BUFONIDAE		
Bufo americanus[b]	American toad	Shallow body of water
Bufo woodhousei fowleri	Fowler's toad	Sandy river bottom
HYLIDAE		
Hyla versicolor[b]	Gray treefrog	Trees, shrubs
Hyla crucifer	Spring peeper	Marshes

APPENDIX 3D-1 (continued)

FAMILY Scientific Name	Common Name	Habitat
Acris crepitans blanchardi	Blanchard's cricket frog	Ponds, marshes
Pseudacris triseriata triseriata	Western chorus frog	Low vegetation
MICROHYLIDAE		
Gastrophryne carolinensis	Eastern narrow-mouthed toad	Various habitats
RANIDAE		
Rana palustris	Pickerel frog	Streams, bogs
Rana pipiens complex[b]	Leopard frogs	Marsh, ponds, backwaters
Rana areolata circulosa	Northern crawfish frog	Burrows
Rana clamitans melanota[b]	Green frog	Springs, creeks, ditches
Rana catesbeiana[b]	Bullfrog	Aquatic

a By Conant (1958).

b The species has been identified on the site.

APPENDIX 3D-2

CHECKLIST OF REPTILES WHOSE RANGE[a] ENCOMPASSES CALLAWAY COUNTY, MISSOURI

FAMILY Scientific Name	Common Name	Habitat
CHELYDRIDAE		
Chelydra serpentina[b]	Common snapping turtle	Aquatic
Sternothaerus odoratus	Stinkpot	Muddy ponds
TESTUDINIDAE		
Terrapene carolina triunguis[b]	Three-toed box turtle	Timbered hillsides
Terrapene ornata ornata	Ornate box turtle	Grassy fields
Graptemys geographica	Map turtle	Streams, rivers
Graptemys kohni	Mississippi map turtle	Rivers, lakes
Graptemys pseudogeographica ouachitensis	Ouachita map turtle	Rivers
Chrysemys picta belli	Western painted turtle	Muddy ponds
Pseudemys scripta elegans	Red-eared turtle	Ponds, ditches
TRIONYCHIDAE		
Trionyx spinifer hartwegi	Western spiny softshell	Muddy ponds, rivers
Trionyx muticus	Smooth softshell	Muddy ponds, rivers
IGUANIDAE		
Sceloporus undulatus hyacinthinus	Northern fence lizard	Timbered hillsides
ANGUIDAE		
Ophisaurus attenuatus attenuatus	Western slender glass lizard	Grassy fields
TEIIDAE		
Cnemidophorus sexlineatus	Six-lined racerunner	Grassy fields
SCINCIDAE		
Lygosoma laterale	Ground skink	Wooded areas
Eumeces laticeps	Broad-head skink	Arboreal
Eumeces anthracinus pluvialis	Southern coal skink	Moist areas
Eumeces fasciatus	Five-lined skink	Decaying vegetation
COLUBRIDAE		
Natrix grahami	Graham's water snake	Ponds, lakes
Natrix erythrogaster transversa	Blotched water snake	Streams, ponds
Natrix sipedon sipedon	Northern water snake	Streams
Natrix rhombifera rhombifera	Diamond-backed water snake	Sloughs, ponds
Storeria occipitomaculata occipitomaculata	Northern red-bellied snake	Woodlands
Storeria dekayi wrightorum	Midland brown snake	Moist woods, marshes
Storeria dekayi texana	Texas brown snake	Moist woods, bogs
Thamnophis sauritus proximus	Western ribbon snake	Ditches, marshes
Thamnophis sirtalis sirtalis[b]	Eastern garter snake	Grasslands, ditches
Thamnophis sirtalis parietalis	Red-sided garter snake	Grasslands, ditches

FAMILY Scientific Name	Common Name	Habitat
COLUBRIDAE		
Tropidoclonion lineatum lineatum	Northern lined snake	Under rocks
Haldea valeriae	Smooth earth snake	Timbered hillsides
Heterodon platyrhinos	Eastern hognose snake	Open fields
Diadophis punctatus arnyi	Prairie ringneck snake	Open woods
Carphophis amoenus vermis	Western worm snake	Moist woods
Coluber constrictor flaviventris	Eastern yellow-bellied racer	Rocky hillsides
Opheodrys aestivus	Rough green snake	Arboreal
Opheodrys vernalis blanchardi[c]	Western smooth green snake	Grasslands, timbered hillsides
Elaphe obsoleta obsoleta	Black rat snake	Moist woodlots
Pituophis melanoleucos sayi	Bullsnake	Timbered areas
Lampropeltis calligaster calligaster	Prairie kingsnake	Pastures, open fields
Lampropeltis getulus holbrooki	Speckled kingsnake	Hillsides, uplands
Lampropeltis doliata syspila	Red milk snake	Moist habitats
VIPERIDAE		
Agkistrodon contortrix mokeson	Northern copperhead	Wooded hillsides
Sistrurus catenatus catenatus[c]	Eastern massasaugas	Marshy areas
Crotalus horridus horridus	Timber rattlesnake	Bluffs

a After Conant (1958)

b The species has been observed on the site.

c Considered rare within Missouri (Gale, October 25, 1973).

CALLAWAY PLANT
UNITS 1 and 2

PRECONSTRUCTION MONITORING

ANNUAL SUMMARY

UNION ELECTRIC COMPANY

8102120017

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1. GENERAL INTRODUCTION

This report summarizes the first year (preconstruction) of a two-year preoperational monitoring program. The preconstruction monitoring program consisted of three sampling periods (winter, spring, and fall) for monitoring selected aquatic parameters and three (spring, midsummer, and fall) for monitoring selected terrestrial parameters. The results of the winter sample were included in the five aquatic sampling periods comprising the baseline inventory and summarized in the Callaway Plant, Units 1 and 2, Environmental Baseline Inventory Annual Summary.

The objectives of the preconstruction monitoring program are generally complementary to those of the previously completed baseline studies. However, the orientation of investigation differs. Whereas the baseline study was a broad-based investigation to characterize factors or components of the plant site environment, the focus of monitoring studies is to document intensively the ecological relationships of selected permanent sampling stations for the purpose of detecting changes in the natural system. The ultimate goal of the monitoring program is to obtain sufficient background data and a degree of surveillance compatability whereby natural variation in key environmental parameters can be distinguished from significant environmental impact, if any, caused by plant construction and operation.

Although the preconstruction monitoring program was designed and to a considerable extent implemented by Dames and Moore, outside consultants were retained to undertake portions of the monitoring program. Dr. David B. Dunn, Professor and Curator of the Herbarium, University of Missouri-Columbia, performed all plant identification and supervised fall sampling of vegetation and birds; Dr. Dean E. Me[illegible]er, Associate Professor of Zoology, University of Missouri-Columbia, performed the fall sampling and identification of the amphibians and reptiles; and Dr. Thomas R. Yonke, Associate Professor of Entomology, University of Columbia-Missouri, was responsible for identification of the invertebrates and invertebrate sampling in the fall.

This report consists of two major parts: Aquatic Ecology and Terrestrial Ecology. Each is an entity, with its own Introduction, Methods and Materials, Results and Discussion, Ecological Summary, and Conclusions and Recommendations. The subsections are the standard divisions found in most environmental reports, with the possible exception of the Ecological Summary and Conclusion and Recommendations. The Ecological Summary for both the aquatic and terrestrial disciplines attempts to summarize the ecological interrelationships pertinent to the plant site. The biotic and abiotic interrelationships are discussed very briefly and at a very general level because the lack of published information of this type precludes a more elaborate discussion. The Conclusions and Recommendations section attempts to relate survey data to potential environmental impact from plant construction and operation.

Tables and figures are placed in the text following the three-digit subsection in which they are mentioned.

2. AQUATIC ECOLOGY

2.1 INTRODUCTION

This report contains the spring and fall survey results for the proposed Callaway Nuclear Power Plant preconstruction environmental monitoring program. Aquatic sampling was conducted from the 20th to the 23rd of June and from the ˜nd to tne 7th of September, 1974.

The purpose of the monitoring program is to detect impact resulting from plant construction and operation. The preconstruction monitoring program is designed to further inventory important aquatic flora and fauna near the proposed plant site and to document seasonal variation in local populations. Specifically, the first year's preconstruction monitoring program is designed to estimate the degree of homogeneity among sampling stations and to provide a quantitative base from which plant-induced effects, if any, can be measured. Components of the aquatic ecosystem being considered in this investigation are:

Water Quality	Benthic Macroinvertebrates
Phytoplankton	Vascular Hydrophytes
Zooplankton	Fish

This portion of the report is divided into six major subsections. Section 2.1 (Introduction) outlines the purpose and scope of the study and discusses report format. Subsection 2.2 (Methods and Materials) describes sampling stations and methods and materials used to analyze various aquatic parameters. Subsection 2.3 is Results and Discussion; 2.4, Ecological Summary; 2.5, Conclusions and Recommendations; and 2.6, References.

2.2 METHODS AND MATERIALS

2.2.1 DESCRIPTION OF SAMPLING LOCATIONS

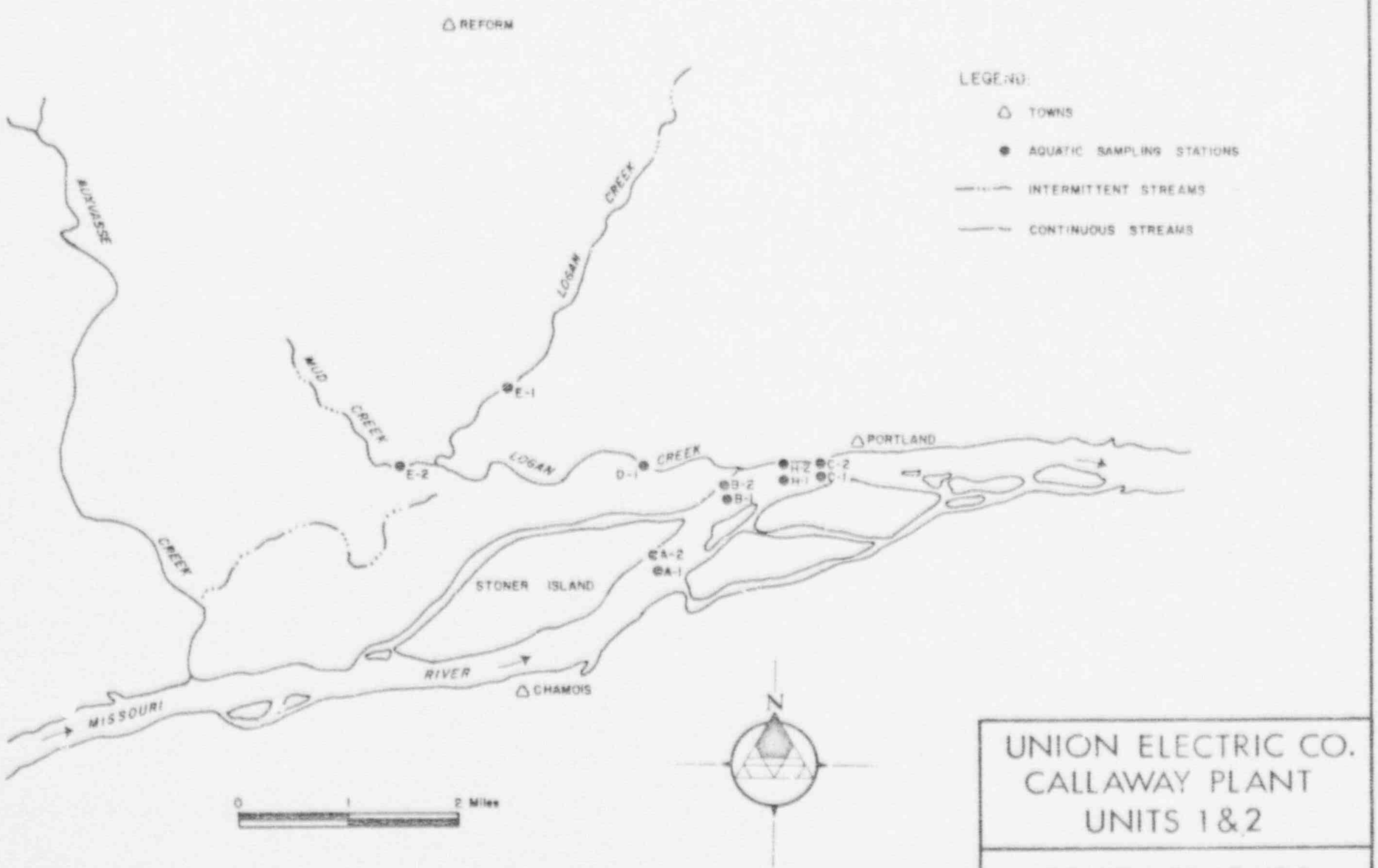
The preconstruction monitoring program was designed to interface with the baseline study (Union Electric Company, 1974). Accordingly, several of the previously established sampling locations were used. These are Transects A, B, and C in the Missouri River and Stations D and E in Logan Creek (Figure 2.2.1-1). Two additional sampling locations were established to provide a better representation of the area that may be affected by plant construction and operation. Transect H was established about midway between Transects B and C on the Missouri River. Station E-2 was added about midway between Stations D and E on Logan Creek, just below the mouth of Mud Creek. Station E-2 was relocated on Mud Creek in September to provide a measure of water quality for this creek.

Sampling stations on the Missouri River transects are designated with the numerals -1 and -2 for mid-channel and north shore locations, respectively. North and south ends of the transects, as discussed in Section 2.3.7, are designated by letters. For example, H-S and H-N refer to the south shore and north shore areas of Transect H, respectively.

The 1974 aquatic monitoring program consisted of three sampling periods, winter, spring, and fall. The winter sample was completed as scheduled and the results are presented in Callaway Plant Units 1 and 2, Environmental Baseline Inventory, Annual Summary, and will not be included in this report.

Spring sampling was scheduled to begin mid-May, but spring rainfall and high water levels delayed sampling until June 20th. During the sampling period, Missouri River flow ranged from 95,000 to 103,000 cfs; river flow had reached 278,000 cfs during May and 232,000 cfs in early June. The delay in the aquatic sampling program is not believed to have significantly affected achievement of the objectives of the preconstruction monitoring program or the quality of the data collected.

Fall sampling occurred as scheduled in early September.



UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

LOCATION OF AQUATIC SAMPLING STATIONS

Figure 2.2.1-1

2.2.2 WATER QUALITY

In order to expedite sampling and prevent further delays, the June water quality sampling was restricted to Transects H and C. This modification of the program was acceptable because previous statistical analyses of water quality data had shown that all river transects were generally homogeneous with respect to water quality parameters (Union Electric Company, 1974). Therefore, for the spring survey, water quality at Transect H was considered representative of that at Transects A and B. Further, samples were taken both upstream (Transect H) and downstream (Transect C) of Logan Creek to detect any differences in water quality due to the influence of the creek.

Analyses of the June water quality data and further review of the sampling program led to the implementation of a modified water quality sampling program for the fall. Based on knowledge of the relationship among transects and the proposed location of the Callaway Plant intake and discharge structures, Stations A-2, B-2, H-2, C-1, and C-2 were selected for sampling in the September and subsequent surveys. It is believed that Station B-2 will provide a base from which to compare plant discharge, which is proposed to emanate from that point. Station C-2 and H-2 will provide a baseline from which the downstream effect of the discharge may be measured. Also, given that Stations A-2 and A-1 are statistically homogeneous, A-2 will provide an upstream "control" sample for comparison with other downstream samples. Finally, the extent to which the discharge plume will extend into the open river channel will be assessed, in part, through comparisons with water quality data from C-1.

Samples were collected from the first 1 meter below the surface with a Van Dorn PVC sampler and placed in polyethylene bottles containing appropriate preservations, as recommended by the U.S. Environmental Protection Agency (1971). Samples for fecal and total coliform analyses were collected in sterilized glass bottles. Following collection, all samples were packed in ice for transportation to the laboratory. Field determinations were made for dissolved oxygen (YSI Model 54), conductivity (YSI Model 33), temperature (YSI Model 54), pH (Fisher Acumet), and alkalinity (field titration).

Water samples were also collected in June for pesticide analyses. Samples were placed in glass containers and shipped to Analytical Biochemistry Laboratory, Columbus, Missouri for analyses of 15 different pesticides and herbicides.

Wilcoxan's sum rank test was used in the statistical analysis of the water quality data. Wilcoxan's test is a nonparametric test designed to evaluate two independent samples (Hollander and Wolfe, 1973). The analysis was conducted on the following variables: pH, dissolved oxygen, chemical oxygen demand, total suspended solids, total dissolved solids, temperature, and specific conductivity. Data collected for four distinct sampling locations were analyzed for each parameter listed above. Specifically, station comparisons included:

A-2 vs B-2	A-2 vs C-2	A-2 vs C-1
B-1 vs B-2	B-2 vs C-1	C-1 vs C-2
B-1 vs C-1	B-2 vs C-2	B-1 vs C-2

Copper and cadmium were found to be present in the water samples at concentrations that warranted further analysis. This analysis consisted of single and step-wise multiple regression analyses to correlate and rank selected water quality parameters with copper and cadmium concentration. Those water quality parameters that, in single regression analysis, accounted for 50 percent or more of the variability in concentrations of copper and cadmium were then reevaluated by means of multi-regression analysis.

2.2.3 PHYTOPLANKTON

One gallon whole-water subsurface samples for phytoplankton analyses were taken with a Van Dorn sampler. These samples were preserved with merthiolate. (USEPA, 1971).

Phytoplankters were identified and enumerated from Sedgwick-Rafter cell preparations in the following taxonomic categories: coccoid and filamentous blue-green algae; coccoid, filamentous, flagellated, and colonial green algae; euglenoid algae; and centric and pennate diatoms. The following taxonomic references were used in identifications: Palmer (1962), Prescott (1962, 1970), Smith (1950), Whitford and Shumacher (1969), and U.S. Department of the Interior (1966).

Chlorophyll a, b, and c analyses were attempted but, due to interference from large amounts of suspended solids in the samples, no reliable data were obtained. In lieu of chlorophyll analysis the ^{14}C method was used to determine river productivity.

Phytoplankton primary productivity was estimated *in situ* by the ^{14}C method (Strictland and Parsons, 1972). A solution of radioactive carbonate (HCO_3) was added to light and dark bottles filled with water samples from Stations H-2, C-2, D, and E plus one additional location downstream of Logan Creek in June; and from Stations A-2, C-2, and H-2 in September. Bottles were placed at their respective stations and suspended at the depth from which subsurface phytoplankton samples were collected. After an approximate 4-hour *in situ* incubation, the water samples were fixed with 10 ml of formalin. The samples were later filtered in the laboratory and treated with hydrochloric acid to remove inorganic carbon. Liquid scintillation counting was conducted at Virginia Commonwealth University.

2.2.4 ZOOPLANKTON

Subsurface net zooplankton samples were taken by filtering 24.3 liters of water (collected with a Van Dorn sampler) through a Wisconsin plankton net having a No. 20 mesh plankton bucket. The concentrate was washed into sample bottles and preserved with Lugol's solution.

Sedgwick-Rafter cell preparations were examined in the laboratory at 200X magnification. Zooplankters were enumerated and identified to the genus level according to the following taxonomic references: Ahlstrom (1940, 1943), Edmondson (1959), Pennak (1953), and Brooks (1957).

2.2.5 VASCULAR HYDROPHYTES

Vascular hydrophyte investigations were limited to field observations of aquatic vegetation in both the Missouri River and Logan Creek.

2.2.6 BENTHIC MACROINVERTEBRATES

Missouri River benthic macroinvertebrates were collected with a Ponar dredge, larval meter nets, and by random sampling. Ponar dredge samples were taken in duplicate (June) and in triplicate (September) at the four north shore stations with a 520 cm^2 Ponar in approximately 0.5 to 0.8 meters of water. Samples were screened in the field with a U.S. No. 30 standard sieve (0.59 mm). All material retained by the sieve was washed into 0.95-liter wide-mouth jars and preserved with 10 percent buffered formalin containing 0.002 percent rose bengal. Larval meter net samples were taken in triplicate at Stations B-2 and C-2 with a 0.6-m-diameter conical drift net having a 0.76-mm mesh collecting bucket. A flow meter attached to the net opening quantitatively measured water passing through the net. Triplicate samples of approximately 7 minutes each were made at the two stations. Random sampling consisted of identifying organisms attached to gill nets (used for fish sampling) and sticks and rocks contained in the grab samples.

Logan Creek benthic macroinvertebrate collections were similar to those of the Missouri River, except that the Ekman sampler (230 cm^2) was used instead of the Ponar dredge and a drift net (No. 6; 30 x 45 cm) was used in lieu of the larval meter net. Random sampling consisted of identifying organisms attached to rocks and sticks.

All samples from both the Missouri River and Logan Creek were washed in a No. 35 sieve (0.50 mm) in the laboratory and placed in a white enamel tray, where invertebrates were sorted from detritus. Wet-weight biomass was determined for all major groups. Each group was blotted dry and immediately weighed to the nearest 0.1 mg. Worms and midge larvae were then permanently mounted with $CMCP_{10}$ mounting medium on glass slides for identification and enumeration. Remaining macroinvertebrates were preserved in 70 percent ethanol after identification. All samples were retained as legal voucher specimens.

The following taxonomic references were used: Beck (1968); Brinkhurst (1964, 1965); Brown (1972); Hamilton, Saether, and Oliver (1969); Hilsenhoff and Narf (1968); Hiltunen (1973); Holsinger (1972); Kennedy (1969); Mason (1973); Roback (1957); Ross (1944); Usinger and Day (1968); and Williams (1972).

Species diversity was calculated for Ponar and Ekman grabs; the Shannon-Wiener diversity index was used:

$$\bar{d} = \Sigma\ (N_i/N)\ \log_2\ (N_i/N)$$

where: $\bar{d}$ = species diversity

N = total number of individuals in a composite sample for a particular station

N_i = total number of individuals of a particular species in the composite sample.

2.2.7 FISH

In June, the fish community of the Missouri River near the plant site was sampled by nets and boom electroshocking. Gill and fyke netting was conducted behind L-head dikes, revetments, and in back chutes on both the north and south sides of the river. Transects were sampled in the following general areas: A-S, B-N, C-N, C-S. Electroshocking was conducted along the north and south ends of Transects A, B, H, and C. The fish sampling gear was the same as that used previously and is described in the Annual Report (Union Electric Company, 1974). In September, fish sampling was the same, except that boom electroshocking was omitted. Earlier experience with boom shocking in the Missouri River showed that this technique is ineffective in collecting fish.

In Logan Creek fish were sampled at Stations D, E-2, and E using electroshocking and seines. In addition, standing crop biomass estimates were made at Station E. A measured area of creek at Station E was blocked off with seines; fish were collected either with a back-pack electroshocker or minnow seine. The area was fished until catch per unit effort was reduced significantly. The total population estimate was then made from the relation of fishing success to cumulative fish catch (Leslie and Davis, 1939). This technique was utilized both on the 31st of May and 23rd of June, 1974.

Fish were weighed to the nearest gram and total length was measured to the nearest millimeter. Scales were removed from selected forage and sport species for age and growth analyses. Selected specimens were preserved in 10 percent formalin for later ta[illegible]ic identification or retained as voucher specimens. Taxonom[illegible] [illegible]ences used for identification were Eddy (1969), Hubbs an[illegible] [illegible]r (1967), Cross (1967), Pflieger (1968), and Moore ([illegible]). Larval and juvenile fish were identified with the aid o[illegible] a key by May and Gasaway (1967).

Length-weight relationships of selected fishes were calculated; log-transformed values were used in the cal[illegible]ulations. Regression lines were fitted by the least squares method; the equation describing the line is presented in the general form:

$$\log W = \log a + b \log L$$

where: W = estimated weight in grams (gm)

a = intercept of the regression line

L = total length in millimeters (mm)

b = regression coefficent

The correlation coefficient was also calculated for each regression.

Condition factor (K_{TL}) was calculated for individual fish, and the mean value for each of the selected species in each age group was calculated. The condition factor, which describes the relative plumpness or well-being of a fish, is defined as:

$$K_{TL} = \frac{W \times 10^5}{L^3}$$

where: K_{TL} = condition factor

W = weight (gm)

L = total length (mm)

Larval fish were sampled in both the Missouri River and Logan Creek. The Missouri River was sampled near the north end of Transects B and C with a 0.6-m diameter conical drift net having a 0.76-mm mesh collecting bucket. A flow meter attached to the net opening quantitatively measured the water passing through the net. Triplicate tows of approximately 7 minutes each were made at the two stations. Larval fish in Logan Creek were sampled with smaller drift nets, as described in Section 2.2.6.

Age and growth analyses of fish were made from scales collected during the study. Impressions of at least three scales per fish were made in the laboratory on plastic slides with a roller press. Scale measurements (mm) were then made with the aid of a microscopic projector; two or more scales were examined to verify the number of annuli. Total scale radius was obtained by measuring from the center of the focus to the anterior-most portion of the scale.

Linear regression analysis was used to determine body-scale relationships for each fish species. Lee's formula (Tesch, 1971) was used to perform calculations of growth. The intercept values were derived from linear regressions.

2.3 RESULTS AND DISCUSSION

2.3.1 WATER QUALITY

2.3.1.1 Missouri River

Water quality data from both the spring and fall collections are presented in Tables 2.3.1-1 and 2.3.1-2. Wilcoxan's sum-rank test, applied to data from Stations A-2, B-1, B-2, C-1, and C-2, confirmed previous assumptions regarding homogeneity among water quality stations and further supports the basis for the selected modification in the sampling program.

Water quality of the Missouri River near the site has been characterized as primarily influenced by agricultural runoff, dilution phenomena, and industrial and municipal pollution (Union Electric Company, 1974). Variation in concentration of chemical constituents has largely been a function of river discharge. Total dissolved solids generally decreased in concentration with increased river discharge, while suspended materials and sediment load increased. Data from the present study illustrate this phenomenon (Tables 2.3.1-1 and 2.3.1-2). The mean river flow during June sampling was 95,600 cfs; the discharge during the September sampling was 81,800 cfs. Biochemical oxygen demand (BOD), chloride, total hardness, sulfate, and total dissolved solids (TDS) varied inversely with river flow. Constituents that varied directly with discharge, such as chemical oxygen demand (COD), nitrate, Kjeldahl nitrogen, total phosphorus, are directly related to the quantity of suspended particulate matter (seston) in the waterway. The increase in coliform bacteria with increased discharge is probably related to the amount of runoff from livestock grazing land. The State Water Quality Standard of 2,000 coliform bacteria/100 ml (Missouri Clean Water Commission, 1973) river water was exceeded at Station B-2 in September and was probably exceeded in June, as suggested by the over-growth in the plate cultures (Tables 2.3.1-1 and 2.3.1-2). Ballentine, et al. (1970) also found that coliform bacteria densities exceeded several times the National Technical Advisory Committee criteria of 10,000/100 ml total coliform and 2,000/100 ml fecal coliforms. Fall counts upstream at River Mile 118.0 averaged 36,000/100 ml total and 4,700 fecal from October 28 to November 8, 1968 (Ballentine, et al., 1970).

Pesticide contamination was not evident, as concentrations in the spring were below detectable limits. This agrees with results of previous pesticide tests on water samples taken in July, September, and December, 1973 (Union Electric Company, 1974). Only the April 1973 samples revealed the presence of chlorinated pesticides, which were in low concentrations (19-31 μg/l). Chronic pesticide contamination from leached agricultural soils in this area, therefore, does not appear to exist.

The moderately high COD and dissolved oxygen (DO) with concurrently low BOD levels (Tables 2.3.1-1 and 2.3.1-2) are probably related to the presence of allochthonous organic materials in the seston that are more resistant to biological degradation. It is also possible that certain organic materials leached from the surrounding watershed are adsorbed on clay particles where they become more resistant to biological degradation.

Trace metal analyses from previous studies at the site and historical data from Hermann, Missouri point to copper and cadmium as occurring in concentrations that may occasionally be toxic to aquatic organisms (Union Electric Company, 1974). Copper concentrations during the present study ranged from .007 to .04 mg/l (Tables 2.3.1-3 and 2.3.1-4). Although copper toxicity to aquatic organisms has been observed at concentrations as low as .02 mg/l (Battelle's Columbus Laboratory, 1971), it is probable that the copper in the Missouri River is either largely a mineral constituent of the organic detritus in the seston, or adsorbed to suspended clay particles. Figure 2.3.1-1 illustrates the relationship of total suspended solids (TSS) and discharge to copper and cadmium concentrations. Copper concentrations vary directly with TSS, while cadmium appears to be more a function of discharge.

To test the hypothesis that copper concentration is related more to the concentration of suspended solids than to dissolved solids, step-wise multiple regression analyses were performed on data collected from the site since 1973. Independent parameters in the analyses were COD, TDS, TSS, discharge, cadmium, and iron. Sixty-seven percent of the variation in copper concentration was explained by the concentration of TSS; the linear expression:

$$Y = .0075 + .000025X$$

Where: Y = Cu concentration in mg/l

X = TSS concentration in mg/l

No other regressions were significant ($p<.05$); that is, no other variables used in the analyses contributed significantly to the observed variation in copper concentrations. Therefore, these results suggest that the potential for acute copper toxicity to aquatic organisms is minimal because the copper appears to be either a constituent of the organic seston or is adsorbed to clay particles and is not readily available to most aquatic organisms. However, chronic copper toxicity to detritophageous organisms could occur because these organisms ingest organic seston and clay particles.

Multiple regression analysis was performed on the same data; cadmium was used as the dependent variable. The only parameter that contributed significantly to the observed variability in cadmium concentration was discharge, which accounted for 68 percent. The linear regression is:

$$Y = .0085 + .00008X$$

Where: Y = cadmium concentration in mg/l

X = discharge in cfs

Therefore, cadmium concentrations vary directly with discharge levels.

2.3.1.2 Logan Creek

The water quality of Logan Creek is generally better than that of the Missouri River. Concentrations of most water quality parameters measured in Logan Creek increased downstream, probably as a function of increased runoff. In previous samples, evidence of organic pollution generally was not found, although fecal coliform counts were occasionally high. Data from the present study show similar patterns, although a great deal of variation is evident in some parameters (Tables 2.3.1-1 and 2.3.1-2). For example, TSS, COD, BOD, organic nitrogen, and phosphorus levels were higher during the spring, when discharge was high, than during the fall. Most variations in concentration, however, can be explained as a function of discharge rates.

Station E-2 was added in the fall to provide a measure of the effects of Mud Creek on water quality of Logan Creek. Mud Creek appeared to be higher in dissolved solids than upper Logan Creek and, at times, has some bacterial contamination.

TABLE 2.3.1-1

WATER QUALITY DATA FROM THE MISSOURI RIVER AND LOGAN CREEK, SPRING 1974[a]

Parameter	Missouri River Stations				Logan Creek Stations		
	H-1	H-2	C-1	C-2	D	E	E-2
Alkalinity (as $CaCO_3$) Bicarbonate	150	168	157	164	333	139	212
Ammonia	.08	.08	.07	.06	.02	.02	.02
Biochemical Oxygen Demand	0.8	0.9	0.6	0.9	0.4	1.0	1.7
Chemical Oxygen Demand	25.6	32.6	21.0	42.1	12.8	20.8	16.3
Chloride	15.3	19.9	16.7	20.5	5.80	5.30	4.60
Total Hardness (as $CaCo_3$)	196	217	198	220	323	184	231
Hexane Sol. Materials	<.022	<.001	<.001	<.001	<.001	<.002	<.001
Nitrate	1.59	1.59	0.80	2.80	0.78	0.69	0.60
Nitrite	0.01	0.01	<0.01	<0.01	0.02	0.01	<0.01
Total Nitrogen, Kjeldahl	2.30	2.51	3.20	3.40	0.75	1.22	1.75
Orthophosphate, sol.	0.48	0.86	0.63	0.93	0.12	0.36	0.23
Total Phosphorus	0.62	1.10	0.89	1.10	0.40	0.55	0.55
Sulfate	151	154	115	151	157	50	52
Total Dissolved Solids	340	382	322	368	370	238	261

TABLE 2.3.1-1 (continued)

Parameter	Missouri River Stations				Logan Creek Stations		
	H-1	H-2	C-1	C-2	D	E	E-2
Total Suspended Solids	318	350	256	386	16	92	52
Total Solids	720	786	652	826	420	360	368
Total Coliform (col/100 ml)	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
Fecal Coliform (col/100 ml)	O.G.[b]	O.G.	O.G.	288	60	2148	204
pH (standard units)	7.9	7.9	7.8	7.9	8.0	7.9	7.8
Temperature (^{o}C)	25.2	25.0	25.0	25.0	25.0	25.0	25.0
Specific Conductivity (µmho/cm)	520	600	490	610	620	270	430
Dissolved Oxygen	6.4	7.6	6.8	7.6	5.0	7.3	6.2
Turbidity (FTU)	80	97	84	100	13	65	33

[a]All values are expressed in mg/l except where noted.

[b]O.G. = over-grown (to numerous to count).

TABLE 2.3.1-2

WATER QUALITY DATA FROM THE MISSOURI RIVER AND LOGAN CREEK, SEPTEMBER 1974[a]

Parameter	Missouri River Stations					Logan Creek Stations		
	P-2	B-2	H-2	C-1	C-2	D	E	E-2
Alkalinity (as $CaCO_3$)								
Carbonate	0	0	0	0	0	0	0	0
Bicarbonate	153	155	151	129	152	225	230	266
Ammonia (as N)	.08	.08	.04	.06	.08	.08	.02	.02
Biochemical Oxygen Demand	0.7	0.6	1.0	1.1	1.4	0.9	1.4	1.0
Chemical Oxygen Demand	18.8	25.6	22.0	17.2	20.0	20.8	7.8	17.2
Chloride	25.5	25.9	25.5	11.5	25.5	2.47	4.11	3.70
Hardness, Total (as $CaCO_3$)	244	222	226	161	220	272	258	293
Hexane Sol. Materials	.001	.001	<.001	<.001	.002	.002	<.001	<.001
Nitrate (as N)	.55	.51	.42	.29	.31	.14	.16	.24
Nitrite (as N)	.01	.01	.01	.01	.01	.02	<.01	<.01
Nitrogen, Total Kjeldahl (as N)	.97	.08	.75	.73	.87	.83	.25	1.02
Orthophosphate, Sol. (as P)	.10	.09	.11	.07	.11	.03	.02	.02
Phosphorus, Total (as P)	.13	.13	.12	.08	.13	.03	.04	.02
Sulfate	164	161	162	70.8	157	226	16.9	20.6
Total Dissolved Solids	424	418	410	284	456	282	250	302

TABLE 2.3.1-2 (continued)

Parameter	Missouri River Stations					Logan Creek Stations		
	A-2	B-2	H-2	C-1	C-2	D	E	E-2
Total Suspended Solids	96	103	93	87	94	26	<10	17
Total Solids	581	580	582	344	548	328	274	322
Total Coliform (col/100 ml)	3,000	3,000	2,800	2,200	2,300	375	400	2,100
Fecal Coliform (col/100 ml)	900	2,300	1,300	900	850	700	290	360
Turbidity	33	32	24	25	23	15	3.8	5.8
Temperature (°C)	20.5	21.8	21.5	23.0	21.8	20.0	20.0	21.0
Specific Conductivity (µmho/cm)	490	690	1500	400	690	455	425	465
Dissolved Oxygen	8.7	8.5	8.1	6.8	7.5	5.0	10.4	9.3

[a] All values are expressed in mg/l except where noted.

TABLE 2.3.1-3

TRACE METAL CONCENTRATIONS FROM MISSOURI RIVER AND LOGAN CREEK WATER SAMPLES, SPRING 1974[a]

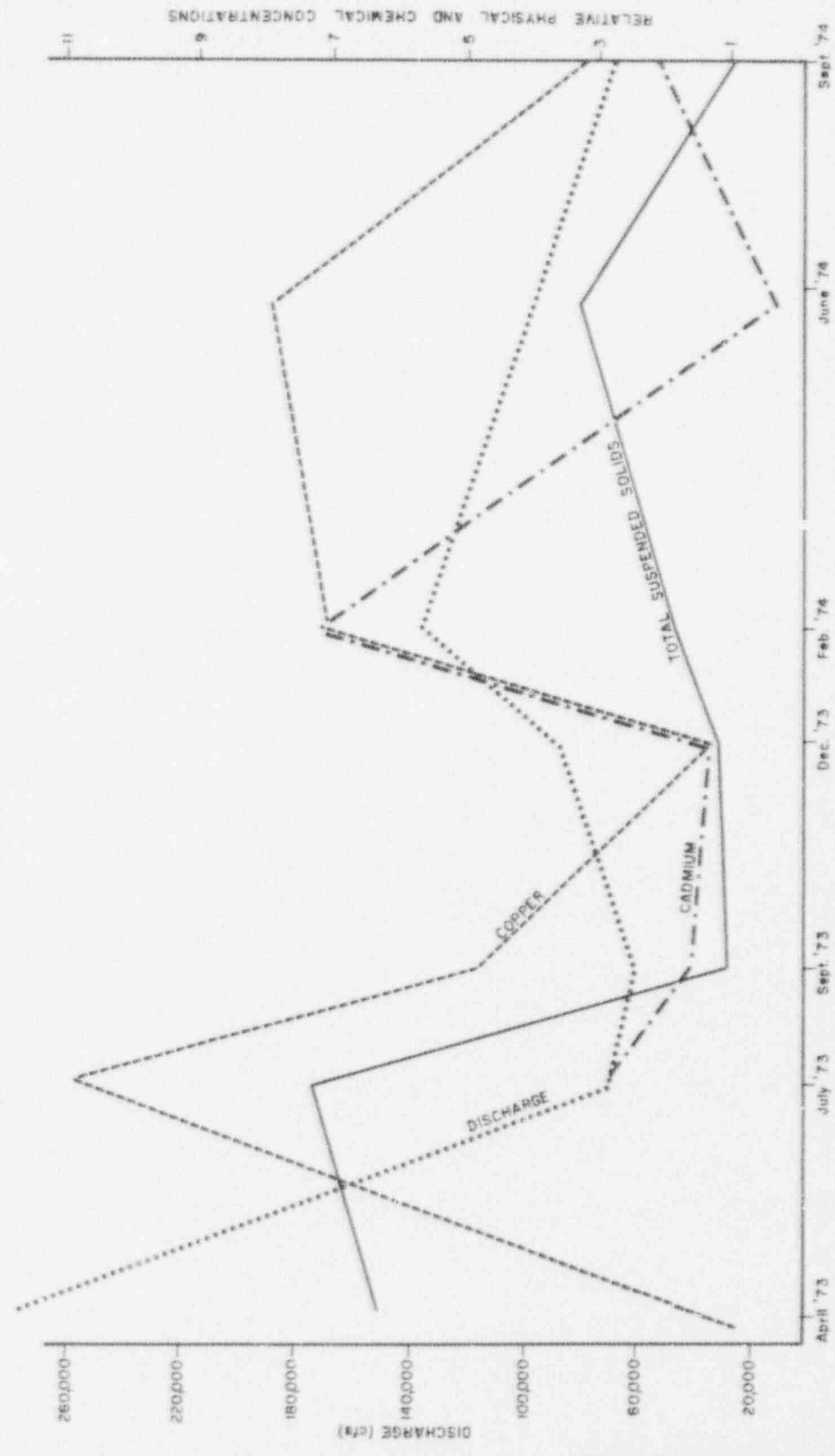
Parameter	Missouri River Station				Logan Creek Station		
	H-1	H-2	C-1	C-2	D-1	E	E-2
Arsenic	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Cadmium	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Calcium	60	54	54	56	94	50	72
Total Chromium	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Copper	.04	.019	.012	.011	.004	.008	.006
Iron	8.5	11	8.0	11	1.6	6.5	4.0
Total Iron	14	20	16	20	1.6	8.5	4.[illegible]
Lead	.140	.047	.047	<.020	<.020	.195	.080
Magnesium	15	17	16	17	32	16	23
Mercury	.001	.0003	.0005	.0003	.0002	.0002	.0009
Selenium	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Sodium	29	39	29	36	7.6	4.0	5.2
Zinc	.02	.04	.04	.04	.02	.02	.05

[a] All values are expressed in mg/l

TABLE 2.3.1-4

TRACE METAL CONCENTRATIONS (mg/l) FROM MISSOURI RIVER AND LOGAN CREEK WATER SAMPLES, SEPTEMBER 1974

Parameter	Missouri River Stations					Logan Creek Stations		
	A-2	B-2	H-2	C-1	C-2	D	E	E-2
Arsenic	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Cadmium	.009	.007	.004	.004	.003	.006	.005	.005
Calcium	52	55	52	42	52	57	55	63
Chromium, Total	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Copper	.011	.007	.007	.008	.008	.006	.004	.006
Iron	3.3	2.1	1.6	1.4	1.6	1.2	0.5	0.5
Iron, Total	5.2	3.8	2.8	2.7	2.8	1.9	0.5	0.6
Lead	.020	.020	<.020	<.020	<.020	<.020	<.020	.120
Magnesium	19	19	18	12	18	25	26	31
Mercury	.0003	.003	.0007	.0006	.003	.016	.001	.001
Selenium	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005
Sodium	58	59	58	23	54	4.4	4.8	4.6
Zinc	.04	.06	.04	.04	.04	.06	.01	.04



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RELATIONSHIP BETWEEN
WATER QUALITY
AND DISCHARGE

Figure 2.3.1-1

2.3.2 PHYTOPLANKTON

2.3.2.1 Missouri River

Phytoplankton of the lower Missouri River characteristically occur in low densities and are dominated numerically by diatoms (Berner, 1951; Damann, 1951; Williams, 1966; Stern and Stern, 1971; Union Electric Company, 1974; University of Missouri-Rolla, 1974). The paucity of phytoplankton is related to excessive turbidity, high current velocity, and the lack of adjoining lentic waters (Berner, 1951). The harsh conditions of the Missouri River are illustrated by their effects on plankton populations entering from tributary rivers. Damann (1951) reports that plankters entering the Missouri River from tributaries were subjected to adverse conditions and did not multiply. A reduction in tributary phytoplankton populations after entering the Missouri River was also noted by Ballentine, et al. (1970). Berner (1951) had earlier suggested that, in the absence of backwater areas, plankton production was autogenic, with little contribution from tributaries. Ballentine, et al. (1970) supported the suggestions of others that the Missouri River phytoplankton community originates in lentic waters.

Diatoms clearly were numerically dominant in the present study, comprising 80 and 76 percent of the total phytoplankton numbers in June and September, respectively (Tables 2.3.2-1 and 2.3.2-2). Diatoms in the June sample were predominately of the pennate form, while the September sample contained primarily centric diatoms. This form of seasonal variation is typical of diatom populations (Patrick, 1948).

Densities of phytoplankton from the present study show a fall maximum not observed in past investigations (Table 2.3.2-2). The mean density increased from 89,842/liter (l) in June to 11,430,780/l in September. Although fall diatom blooms are a common phenomenon in rivers (Williams, 1964), the September value represents a greater than 100X increase in density over the June sample and is greater than any reported for the lower Missouri River. Ballentine, et al. (1970) found total phytoplankton densities of 1,593,000/l upstream at Chamois (RM 118.0) in the fall of 1968. Mean discharge during their study was 55,600 cfs. The greatest observed density reported by Ballentine, et al. (1970) was 2,178,000/l in collections taken between Kansas City and St. Joseph, Missouri.

The high fall densities of phytoplankton observed in the present study illustrate the limiting effect of turbidity on photosynthetic processes in the river. In late summer and early fall, flow rates and water levels decline (Figures 2.3.2-1 and 2.3.2-2), and larger suspended particles settle, reducing river turbidity. General river turbidity is further reduced under low flow conditions due to the increased proportion of groundwater to surface runoff water in the river. As the water level continues to drop, revetments become especially good habitats for phytoplankton because they become closed off, forming lentic pools. The decrease in turbidity coupled with the abundant nutrients (Union Electric Company, 1974) in the Missouri River explain the phytoplankton bloom observed in the fall sampling period.

2.3.2.2 Logan Creek

Past investigations of phytoplankton in Logan Creek have shown species composition to be similar to the Missouri River near the site; phytoplankton densities, however, were one to four orders of magnitude higher (Union Electric Company, 1974). Higher phytoplankton densities in Logan Creek relative to those of the Missouri River appeared to be related to the presence of a stable substrate, lower current velocities, and lower turbidity levels. Seasonal variations in densities and species composition of Logan Creek phytoplankton were found to be typical of temperate streams, where green and euglenoid species attain maximum densities during warmer months but are absent in winter when diatoms predominate. Most of the principal taxa in the creek were benthic diatoms.

The June 1974 phytoplankton sample contained predominately pennate diatoms (see Table 2.3.2-1). Densities were low and did not show the previously observed pattern of increased upstream abundance. Also, in contrast to previous findings, densities in Logan Creek were lower than those in the Missouri River. Presumably, low spring densities were due to the high water levels and discharge that had existed prior to sampling (see Figures 2.3.2-1 and 2.3.2-2).

The September 1974 samples also were dominated numerically by pennate diatoms (see Table 2.3.2-2). Centric diatoms, predominate in the Missouri River samples, comprised only from 4.5 to 23 percent of the total diatom numbers. Total phytoplankton densities were unusually high but were always lower than densities in the river samples. Phytoplankton were slightly more abundant upstream at Station E than at Station D.

The fall maxima in phytoplankton densities in Logan Creek are greater than the previous maximum of 1,115,000 cells/l observed at Station E in July 1973. The maximum phytoplankton density observed in September 1973 was 10,222/l at Station E. Turbidity levels corresponding to these two periods were 90 and 3 Jackson Turbidity Units (JTU's), respectively.

TABLE 2.3.2-1

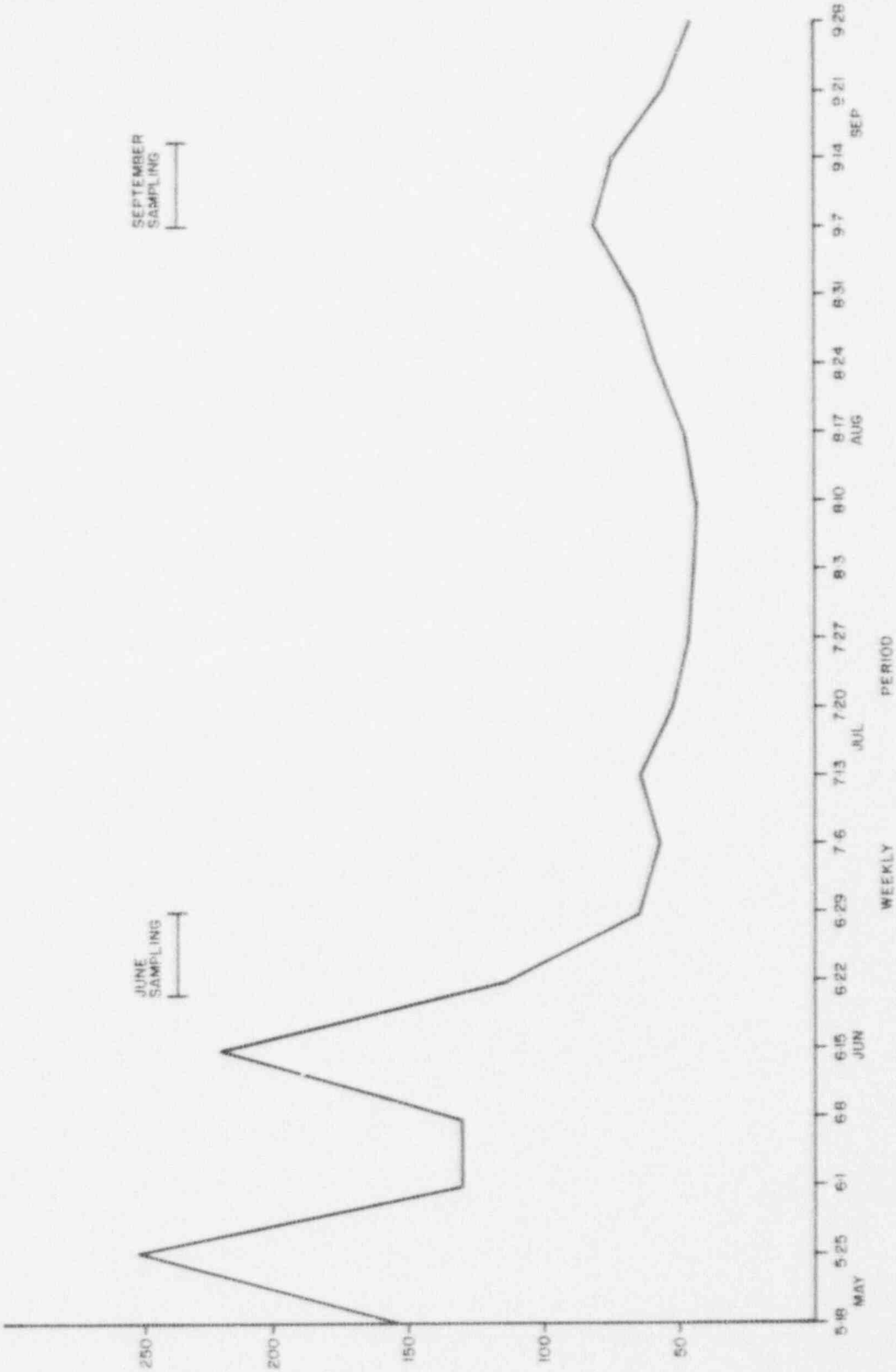
DENSITIES (cells/liter) OF PHYTOPLANKTON COLLECTED IN THE MISSOURI RIVER AND LOGAN CREEK, JUNE 1974

Organism	Missouri River Stations				Logan Creek Stations	
	H-1	H-2	C-1	C-2	D	E
Green						
Coccoid	3,266		6,532	+	1,633	+
Filamentous	+	+	+	1,633	+	+
Flagellated	+	+	+	+	+	+
Other	9,798	14,697	6,532	14,697	3,266	9,798
Euglenoid	+	+	+	1,633	+	+
Diatoms						
Centric	4,899	9,798	8,165	3,266	3,266	6,532
Pennate	71,852	73,540	52,311	65,320	39,192	50,623
Blue-green						
Coccoid	+	+	+	+	+	+
Filamentous	1,633	3,266	3,266	3,266	4,899	
Total	91,448	101,301	76,806	89,815	52,256	66,953

TABLE 2.3.2-2

DENSITIES (CELLS/LITER) OF PHYTOPLANKTON COLLECTED IN THE MISSOURI RIVER AND LOGAN CREEK, SEPTEMBER 1974

Organism	Missouri River Stations					Logan Creek Stations	
	A-2	B-2	H-2	C-1	C-2	D	E
Green							
Coccoid	163,300	163,300	163,300	326,600	163,300	+	+
Filamentous	+	+	+	+	+	+	+
Flagellated	+	+	+	163,300	+	+	+
Other	2,122,900	2,776,100	1,796,300	653,200	1,632,900	979,800	+
Euglenoid	+	163,300	+	+	+	+	+
Diatoms							
Centric	5,388,900	6,042,100	6,205,400	3,919,200	5,551,200	489,900	163,300
Pennate	2,449,500	3,102,700	3,592,600	1,633,000	5,552,200	2,122,900	3,592,600
Blue-green							
Coccoid	+	+	+	+	+	+	+
Filamentous	1,143,100	489,900	+	816,500	653,200	163,300	326,500
Dinoflagellate	+	+	+	+	326,600	+	+
TOTAL	11,267,700	12,737,400	11,757,600	7,511,800	13,879,400	3,755,900	4,082,400



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MEAN WEEKLY DISCHARGE OF THE MISSOURI RIVER, HERMANN, MISSOURI

Figure 2.3.2-1

2.3.3 PRIMARY PRODUCTIVITY

2.3.3.1 Missouri River

Phytoplankton primary productivity, as measured by ^{14}C fixation method, is reported below:

Station	Date	CO_2 fixation $mgC/m^3/hr$
H-2	20 Jun	2.3
C-2	20 Jun	1.9
C-2	20 Jun	1.4
A-2	7 Sep	122.7
C-2	7 Sep	126.2
H-2	7 Sep	86.9

As expected, high discharge, high turbidities (95 JTU average), and low phytoplankton densities resulted in low productivity values for the June sample. The September study yielded values, consistent with findings of lowered turbidities, decreased flow, and high phytoplankton densities.

2.3.3.2 Logan Creek

The ^{14}C primary productivity study in Logan Creek yielded the following:

Station	Date	CO_2 fixation $mgC/m^3/hr$
D	20 Jun	5.1
E	20 Jun	40.1
D	7 Sep	8.4
E	7 Sep	4.6

June productivity in the creek was, as expected, higher than that observed for the river (Section 2.3.3.1). Turbidity in the creek was low, and phytoplankton densities were moderately high. However, productivity differences between sampling stations show a direct, rather than inverse, relationship with turbidity. For example, turbidity and productivity were both highest at Station E in June, while a similar relationship existed at Station D in September. Moreover, September productivity did not reflect the high diatom counts observed in the creek (Section 2.3.2.2).

There are several possible explanations for the above observed phenomena. First, many of the diatoms in the phytoplankton samples may be dead frustrules washed from the bottom by earlier rains. These diatoms would not contribute to primary productivity but would increase phytoplankton counts. The predominance of benthic diatoms in Logan Creek samples attests to the fact that benthic diatoms are suspended in the water column. Secondly, a high percentage of the carbon assimilated during photosynthesis may be excreted into surrounding water in soluble form, resulting in an underestimation of primary productivity (Gieskes and Bennekom, 1973). Thirdly, if nutrients become depleted, maximum phytoplankton biomass would be reached, and productivity would decline. Chu (1942) reports that algae are likely to suffer a nutrient deficiency when nitrogen concentration is below 0.2 mg/l and phosphorus below 0.05 mg/l. During the September study, nutrient levels were somewhat below these limits. However, nutrient depletion is related to flow rates. Nutrients that may be limiting in lentic waters are not as important in lotic waters because flow continually renews the aquatic medium (Odum, 1956). Hence, no real nutrient deficit can build up as long as adequate flow is maintained. Once flow is reduced, nutrients can become limiting.

2.3.4 ZOOPLANKTON

2.3.4.1 Missouri River

Rotifers, characteristically the predominant zooplankter in most major river systems (Williams, 1966), were the most abundant component of the net zooplankton samples in the present study (Tables 2.3.4-1 and 2.3.4-2). Earlier collections at the study site were also dominated by rotifers (Union Electric Company, 1974).

The September 1974 collections contained greater net zooplankter densities and taxa diversity than did the June 1974 collections (Tables 2.3.4-1 and 2.3.4-2). Densities averaged 68.4 organisms/l in September and 34.2/l in July. Normally, maximum rotifer densities in large temperate rivers occur in the summer months when the water is warm and clear (Williams, 1966). However, in the present study, maximum water clarity occurred in September.

Hynes (1972) states that rotifers become common when diatom densities increase. Although phytoplankton densities in September were exceptionally high (Section 2.3.2), zooplankton densities remained moderately low. Because zooplankters feed on phytoplankton, particulate organic matter, and bacteria, maximum zooplankton densities often occur after maximum phytoplankton densities. Such a lag in zooplankton abundance was observed in the lower Missouri River by the University of Missouri-Rolla (1974) when a maximum of 2100 zooplankters/l were collected in July 1973. The low densities observed in the present study may be explained in part by this lag effect, in combination with the effects of temperature and flow. Generally, however, the lower Missouri River is considered rotifer poor (Williams, 1966).

Most of the zooplankters collected during the present study are planktonic(free floating). However, sessile rotifers were abundant in September, comprising as much as 69 percent of the total sample (Table 2.3.4-2). In addition, drift net samples taken in June contained large numbers of sessile rotifers attached to organic debris. The appearance of these organisms in both seasonal collections points to the existence of large communities of periphytic invertebrates (Aufwuchs) that become dislodged during high water.

2.3.4.2 Logan Creek

A total of 26 taxa of zooplankton, including 18 rotifers, has been reported for Logan Creek (Union Electric Company, 1974). A maximum density of 2133/l occurred in July 1973 and included 13 taxa. In the present study, 14 taxa were collected, including 7 rotifers (Tables 2.3.4-1 and 2.3.4-2). Maximum density of 34.3/l was observed in September at Station D. Rotifers were numerically predominant at both stations in June, but crustaceans were predominant at Station D in September.

Total densities of zooplankton in Logan Creek were slightly higher in June than were corresponding river collections. In September, Missouri River collections contained two to three times the density of the Logan Creek collection. However, if dislodged sessile rotifers are disregarded, both bodies of water had similar densities.

TABLE 2.3.4-1

DENSITY (organisms/liter) OF ZOOPLANKTON COLLECTED FROM THE MISSOURI RIVER AND LOGAN CREEK, JUNE 1974

Organism	Missouri River Sampling Stations				Logan Creek Sampling Stations	
	H-1	H-2	C-1	C-2	D	E
ROTIFERA						
Branchionus sp.	9.07	9.19	7.98	9.42	9.77	6.81
Filinia sp.	0.95	1.02	+	+	+	2.27
Keratella sp.	1.91	2.55	2.09	3.62	8.15	4.54
Polyarthra sp.	+	2.04	0.42	1.09	1.62	+
Trichotria sp.	+	+	+	+	1.62	+
Total Rotifer Density	11.93	14.80	10.49	14.13	21.16	13.62
CLADOCERA						
Bosmina sp.	1.43	1.53	0.84	0.72	+	+
COPEPODA						
Cyclops sp. (naupli)	1.91	2.55	2.94	1.81	3.25	6.81
Cyclops sp.	+	+	+	+	+	2.27
Cyclopoid	+	2.04	1.26	1.81	+	+
Total Crustacea Density	3.34	6.12	5.04	4.34	3.25	9.08
OTHER INVERTEBRATES						
Ostracoda	0.48	0.51	+	+	+	+
Tardigrada	1.43	+	+	0.36	+	+
TOTAL	17.18	21.43	15.53	18.83	24.41	22.70

TABLE 2.3.4.2

DENSITY (ORGANISMS/LITER) OF ZOOPLANKTON COLLECTED FROM THE MISSOURI RIVER AND LOGAN CREEK, SEPTEMBER 1974

	Missouri River Stations					Logan Creek Stations	
Organism	A-2	B-2	H-2	C-1	C-2	D	E
Rotifera							
Branchionus sp.	10.29	20.58	13.72	13.72	3.43		6.86
Filinia sp.	+	+	+	+	+	+	+
Keratella sp.	+	+	10.29	+	+	3.43	+
Polyarthra sp.	+	6.86	+	+	+	+	3.43
Sessile Rotifera	61.73	30.86	+	34.29	+	+	+
Unidentified Rotifera	+	6.86	+	+	+	+	+
Total Rotifera Density	72.02	65.16	24.01	48.01	3.43	3.43	10.29
Cladocera							
Bosmina sp.	4.12	+	6.86	3.43	+	6.86	+
Unidentified Cladocera	2.06	+	+	+	+	+	+
Copepoda							
Cyclops sp. (naupli)	+	+	6.86	6.86	+	10.29	6.86
Cyclops sp.	2.06	+	3.43	+	+	+	+
Unidentified Copepoda	2.06	+	+	+		+	+
Total Crustacea Density	10.29	+	17.15	10.29	+	17.15	6.86
Other Invertebrates							
Chironomidae	+	3.43	3.43	3.43	+	+	
Ephemeroptera	+	+	+	3.43	+	+	+
Ostracoda	6.17	+	3.43	3.43	+	3.43	+
TOTAL	88.48	68.59	48.02	68.59	3.43	24.01	17.15

2.3.5 VASCULAR HYDROPHYTES

2.3.5.1 Missouri River

During the present study, no vascular hydrophytes were observed in the Missouri River near the site. However, a few hydrophytes, mainly Potamogeton sp., were seen in an isolated chute near Station B-2 in September. This chute, closed off by silt deposits and dikes, provided the lentic conditions necessary for establishment of vascular hydrophytes. Ordinarily, physical conditions in the river are too harsh for rooted aquatic plants. Berner (1951) observed no rooted aquatic plants in the river channels, chutes, or backwaters. Likewise, none have been observed previously in the vicinity of the Callaway Plant, Units 1 and 2 (Union Electric Company, 1974).

2.3.5.2 Logan Creek

Dames & Moore reported the occurrence of water primrose (Jussiaea sp.), water willow (Dianthera sp.), duckweed (Lemma sp.), and sedges (Carex spp.) at Station E during earlier studies, but no vascular hydrophytes were observed at Station D. During the present study, two submergent vascular hydrophytes were observed at Station E in September. The plants are tentatively identified as a filiform pondweed (Pontamogeton sp.) and a water plantain, probably Alisma sp.. Lack of fruiting bodies made specific identification impossible. No vascular hydrophytes were observed in Logan Creek in June, and none were seen at any time at Station D.

2.3.6 BENTHIC MACROINVERTEBRATES

2.3.6.1 Missouri River

Benthic communities in the Missouri River are normally composed of oligochaetes, burrowing mayflies, and dipters--mainly chironomidae (Union Electric Company, 1974; University of Missouri, 1972; Berner, 1949). Densities, biomass, and species diversity are generally low, being restricted by spates (excessive currents) and unstable substrate (Union Electric Company, 1974).

June 1974 grab samples contained only 11 species, dominated by oligochaetes (97.1 to 100 percent, Table 2.3.6-1). Densities also were low, with a mean of $1169/m^2$ (Table 2.3.6-2). A combination of two factors could account for the unusual species composition and low densities. First, high water (maximum of 278,000 cfs) in late May and early June eliminated all but those forms suited to burrowing, such as mayflies, chironomids, and oligochaetes (Figure 2.4-1). Secondly, the burrowing mayflies and most chironomids had probably emerged prior to sampling.

September 1974 grab samples showed an increase in species numbers and densities over the June samples (Table 2.3.6-3). This was a result of stable river flows prior to sampling and reappearance of burrowing mayflies and chironomids (Figure 2.4-1). Species numbers increased to 19, and mean densities (from all stations) reached $1347/m^2$. Oligochaete dominance was still high, ranging from 76.4 to 91.7 percent.

An increase in species numbers and densities after the spring high water period (normally April) to a high during the winter period has been noted in the Missouri River (Union Electric Company, 1974). High winter densities are common for both lotic and lentic environments (Hynes, 1972) and are generally considered a result of decreased predation, improved water quality, and life cycle patterns of individual benthic species.

Wet-weight biomass showed a fall increase, as did densities (Table 2.3.6-4). The average biomass for north shore stations in June was 1698 mg/m^2 and 3268 mg/m^2 for September. The mayflies and dragonflies, with their greater weight per individual, accounted for almost a doubling of biomass in September, with only a 20 percent increase in densities. The September 1974 average biomass is exceeded only by the December 1973 Station C-2 biomass of 5797 mg/m^2 (Union Electric Company, 1974). These values are greater than the 241 mg/m^2 maximum reported by Berner (1951). However, even the high winter biomass does not approximate the biomass of 29,000 mg/m^2 reported for an unchannelized portion of the Illinois River between Chillicothe and Grafton (Berner, 1951).

Species diversity indices increased from June to September 1974 as follows:

Station	June	September
A-2	0.67	0.92
B-2	0.89	0.98
H-2	0.22	1.45
C-2	0.64	1.64

Generally, diversity in the Missouri River increases during the winter (Union Electric Company, 1974). According to Wilhm and Dorris (1968), diversities below 2.0 indicate gross pollution and between 2.0 and 3.0, moderate pollution. In the case of the Missouri River at the site, gross pollution would be attributed to physical stress from spates and shifting substrate, which are the result of river channelization. In this sense, channelization could be considered a form of pollution to the bottom fauna.

In addition to grab samples, drift samples were also taken. In contrast to observations by Berner (1949), species composition in drift samples varied greatly from that observed in the grab samples (Tables 2.3.6-5 and 2.3.6-6). Also, the number of drift organisms averaged much lower for both June ($0.0547/m^2$) and September ($0.546/m^2$), than that observed by Berner ($0.7593/m^2$) at Boonville, Missouri on April 18, 1946. Similar low values for the Ohio River were indicated by Philip A. Lewis (personal communication, November 18, 1974, biologist, E.P.A., Cincinnati, Ohio). Drift density seemed to increase from upstream Station B-2 to downstream Station C-2. There is greater dike and revetment surface area upriver from Station C-2 than Station B-2, which could be the source of most drift organisms.

Random samples (rocks and logs removed from a revetment) taken in September at Station B-2 confirm the use of revetments by benthic species not associated with the shifting sand (grab samples). The rocks and logs had a combined surface area of 0.05 square meters and contained the following:

Taxon	Calculated density	Number collected
Turbellaria	$3100/m^2$	(155)
Oligochaeta	$60/m^2$	(3)
Amphipoda	$320/m^2$	(16)
Chironomidae	$4280/m^2$	(214)
Trichoptera	$40,180/m^2$	(2009)
Ephemoptera	$80/m^2$	(4)
Total	$48,020/m^2$	(2401)

Even taking into account the small area sampled to yield numbers per m^2, the values are very high. These values far surpass previously reported values for this and other rivers (Hynes, 1972; Needham and Needham, 1962; University of Missouri, 1972), where a major source of organic enrichment does not exist. This random sample of the revetment indicated a larger benthic food base than previously expected. However, this is an artificial substrate of sorts and would compare better with values for basket samplers. For example, basket samplers in the Wabash River near New Harmony, Indiana (August 25, 1966), yielded densities of $167,600/m^2$ (Mason, et al., 1971).

2.3.6.2 Logan Creek

Historical data concerning Logan Creek benthic fauna are apparently lacking, except for the study by Dames & Moore. Dames & Moore characterized the creek as similar to the Missouri River in species composition, with slightly higher densities, biomass, and diversity.

June 1974 samples at Station D contained 94.1 percent oligochaetes (Table 2.3.6-1), with chironomids and nematodes comprising the remainder for a total density of $3292/m^2$ (Table 2.3.6-2). Ninety-nine percent of the wet-weight biomass of $15,268/m^2$ was contributed by Branchiura sowerbyi. Species diversity was also low at 1.23.

In September, the benthos population at Station D was still dominated by oligochaetes (99.1 percent), as noted previously. Wet-weight biomass was slightly higher at 3806 mg/m^2. However, Branchiura sowerbyi dominance was replaced by Limnodrilus sp. (65.0 percent). A reduction in diversity of fauna after the June sampling resulted in a species diversity of 1.03, the lowest recorded in 2 years of study by Dames & Moore. This reduction in diversity may be the result of a toxic pollutant, such as a pesticide. Saether (1970) noted that oligochaetes are more tolerant of pesticides than chironomids. If pesticides were responsible, the effect was local because the upstream Station E had a normal assemblage of chironomids.

Another factor that may have contributed to the low diversity at Station D is the Missouri River backwater, which deposits a thick layer of ooze in the lower creek. Thick ooze of this nature often becomes anerobic and is a poor substrate for most benthic macroinvertebrates. Only chironomids and oligochaetes, which feed in the ooze and respire through anal gills exposed to the water, can survive (Brinckhurst, 1973). Also, Station D is subject to constant scouring action which limits invertebrate diversity (Hynes, 1972).

The June 1974 samples at Station E contained 79.0 percent oligochaetes and 19.2 percent chironomids (Table 2.3.6-1). Density was $892/m^2$, with a wet-weight biomass of 518 mg/m^2. Diversity increased from 1.23 at Station D to 1.70 at Station E. The greater distance of Station E, as noted above, from the confluence of Logan Creek with the Missouri River probably accounts for the major differences in diversity. Duplicate (2.5-hour sampling periods) drift nets yielded two mayflies and one midge larvae (Table 2.3.6-7). This limited catch reflects the low flows during the June sampling. Random samples in June at Station E revealed the presence of a moderately dense population of mussels, mainly Amblema sp. and Uniomerus sp.. An estimation of their density was $0.5/m^2$. Also, a limited number of Palaemonetes kadrakensis green shrimp and immature crayfish was collected in seine hauls.

September grab samples at Station E indicated an oligochaete dominance of 69.8 percent with chironomids contributing 25.6 percent. Population densities were $868/m^2$ and biomass was $946/m^2$. Species diversity increased from 1.23 in June to 2.39 in September. Station E seems to be receiving mild organic pollution: both nutrients and fecal coliforms have been reported as moderate to high (Table 2.3.1-2). The dominance of benthic fauna by oligochaetes and diversities below 2.5 support possibilities of mild pollution. The pollution source could be agricultural runoff (including cattle waste in the creek), septic tank field lines, or a combination of both. Intermittent flow, as noted by Dames & Moore (1974), could also be a limiting factor.

A summary of the benthic macroinvertebrate species collected in Logan Creek and the Missouri River is presented in Table 2.3.6-8 for the fall 1974 survey, the baseline survey, and the preconstruction survey.

TABLE 2.3.6-1

BENTHIC MACROINVERTEBRATES COLLECTED FROM THE MISSOURI RIVER AND LOGAN CREEK, JUNE 1974

Organism	Missouri River Sampling Stations				Logan Creek Sampling Stations	
	A-2	B-2	H-2	C-2	D	E
Nematoda						
Unknown sp.	P[a]	+	+	P	E[b]	E
Annelida						
Oligochaeta						
Dero sp.	P	+	+	P	E	+
Tubifex sp.	P	+	P	P	E	E
Limnodrilus sp.	P	P	P	P	E	E
Branchiura sowerbyi	+	P	+	+	E	E
Lumbriculus sp.	P	+	+	P	+	+
Crustacea						
Copepoda	+	+	+	+	+	+
Calanoida	P	P	+	R[c]	+	+
Cyclopoid	+	+	+	R	E	E
Cladocera	+	+	+	P	+	+
Amphipoda						
Crangonyx sp.	+	+	+	R	+	+
Decapoda						
Palaemonetes kadiakensis	+	+	+	+	+	R
Astacidae (immature)	+	+	+	+	+	R
Diptera						
Chironomidae						
Ablabesmyia sp.	+	+	+	+	+	R
Chironomus sp.	+	+	+	P,R	E	E
Chironomus sp. B	+	R	+	+	+	+
Cryptochironomus sp.	P	+	+	+	+	+
Tribelos sp.	+	+	+	+	+	E
Polypedilum sp.	+	+	+	R	+	+
Microtendipes sp.	+	+	+	+	+	E
Culicidae						
Chaeborus sp.	+	+	+	R	+	+
Trichoptera						
Hydropsyche sp.	+	R	+	R	+	+
Chematopsyche sp.	+	R	+	+	+	+
Ephemoptera						
Centroptilum sp.	+	R	+	+	R	+
Stenonema sp.	+	R	+	R	+	R
Paraleptophlebia sp.	+	+	+	R	+	+
Isonychia sp.	+	R	+	+	+	+
Caenis sp.	R	+	+	+	+	+

TABLE 2.3.6-1 (continued)

Organism	Missouri River Sampling Stations				Logan Creek Sampling Stations	
	A-2	B-2	H-2	C-2	D	E
Odonata						
Zygoptera	+	+	+	+	+	+
Argia sp.	R	+	+	+	+	+
Anisoptera						
Gomphus sp.	+	+	+	P	R	+
Macromia sp.	+	+	+	+	+	R
Mollusca						
Amblema sp.	+	+	+	+	+	R
Uniomeras sp.	+	+	+	+	+	R

[a] Ponar grabs

[b] Ekman grabs

[c] Random samples

TABLE 2.3.6-2

WET-WEIGHT BENTHIC MACROINVERTEBRATE BIOMASS AND DENSITIES FOR MISSOURI RIVER AND LOGAN CREEK, JUNE 1974[a]

Stations	Nematoda	Oligochaeta	Crustacea	Diptera	Odonota	Total Wet-Weight
A-2	(10) 1	(1720) 1919	(10) 5	(19) 14	+	1939
B-2	+	(912) 899	(10) 5	+	+	904
C-2	(19) 1	(1159) 1744	+	(10) 5	(10) 1938	[illegible]87
D	(43) 2	(3099) 15136	+	(150) 130	+	15268
E	(21) 1	(705) 280	+	(171) 237	+	518
H-2	+	(808) 262	+	+	+	262

[a] (number of organisms) wet-weight in mg/m^2

TABLE 2.3.6-3

BENTHIC MACROINVERTEBRATES COLLECTED FROM THE MISSOURI RIVER AND LOGAN CREEK, SEPTEMBER 1974

Organism	Missouri River Sampling Stations				Logan Creek Sampling Stations	
	A-2	B-2	H-2	C-2	D	E
Platyhelminthes						
Turbellaria	P[a]	R[b]	+	+	+	+
Annelida						
Oligochaeta						
Branchiura sowerbyi	P	P	P	P	E[c]	E
Limnodrilus sp.	P	P	P	P	E	E
Lumbriculus sp.	+	+	+	+	+	E
Crustacea						
Amphipoda						
Craygonyx sp.	+	R	+	+	+	+
Decapoda						
Astacidae (immature)	+	+	+	+	+	R
Palaemonetes kadiakensis	+	+	+	+	+	R
Diptera						
Chironomidae						
Ablabesmyia sp.	+	P	+	P	+	E
Chironomus sp.	+	P	P	P	+	E
Coelotanypus sp.	+	P	P	P	+	+
Cryptochironomus sp.	+	P	+	P	E	E
Glyptotendipes sp.	+	+	+	+	+	E
Microtendipes sp.	+	+	+	+	+	E
Pentaneurini	+	+	P	+	+	+
Procladias sp.	+	+	P	P	+	E
Polypedilum sp.	+	R	P	+	+	E
Psectrocladius sp.	+	R	+	+	+	+
Pseudochironomus sp.	+	+	+	+	+	E
Tanypodinae	P	R	+	+	+	+

TABLE 2.3.6-3 (continued)

Organism	Missouri River Sampling Stations				Logan Creek Sampling Stations	
	A-2	B-2	H-2	C-2	D	E
Tanytarsini	+	+	+	+	+	E
Tanytarsus sp.	+	R	+	+	+	+
Culicidae						
Chaoborus sp.	+	R	P	+	+	+
Tipulidae	+	+	+	+	+	R
Tabanidae						
Tabanus sp.	+	+	+	+	+	R
Trichoptera						
Chematopsyche sp.	P	R	P	+	+	+
Hydropsyche sp.	+	P	+	+	+	+
Lype sp.	+	R	+	+	+	+
Ephemoptera						
Caenis sp.	+	R	+	+	+	E
Centroptilum sp.	+	R	+	R	+	+
Hexagenia sp.	+	P	P	P	+	+
Stenonema sp.	+	R	+	R	+	+
Megaloptera						
Sialis sp.	+	+	+	+	+	E
Odonata						
Gomphus sp.	P	P	+	+	+	+
Hemiptera						
Buenoa sp.	+	+	+	R	+	+
Gyretes sp.	+	+	+	R	E	+
Coleoptera						
Stenelmis sp.	+	+	+	R	+	+
Mollusca						
Lasmigona sp.	P	+	+	+	+	+

TABLE 2.3.6-3 (continued)

Organism	Missouri River Sampling Stations A-2	B-2	H-2	C-2	Logan Creek Sampling Stations D	E
Pisidium (cyclocalyx) adamsi	P	P	+	+	+	+
Shaerium (musculium) partiumeium	P	+	+	+	+	+

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[a]Ponar grab sample

[b]Random sample

[c]Ekman Dredge Sample

TABLE 2.3.6-4

WET-WEIGHT BENTHIC MACROINVERTEBRATE BIOMASS AND DENSITIES FOR MISSOURI RIVER AND LOGAN CREEK, SEPTEMBER 1974[a]

Groups	Stations					
	A-2	B-2	H-2	C-2	D	E
Oligochaeta	(886)1.007	(2219)3.309	(848)0.889	(743)0.893	(3057)3.656	(606)0.594
Diptera	(10)0.005	(48)0.024	(124)0.071	(162)0.081	(14)0.007	(222)0.111
Trichoptera	(10)0.005	(48)0.135	(10)0.042	+	+	+
Ephemoptera	+	(86)0.632	(19)0.322	(67)2.295	+	(10)0.008
Odonata	(10)0.430	(10)0.134	+	+	+	+
Coleoptera	+	+	+	+	(14)0.143	+
Mollusca	(67)1.710	(10)1.086	+	+	+	+
Other	(10)0.005	+	+	+	+	(10)0.233
Total/m^2	(993)3.162	(2421)5.320	(1001)1.324	(972)3.269	(3085)3.805	(868)0.946

[a](number of organisms) wet-weight in mg/m^2

TABLE 2.3.6-5

NUMBER OF BENTHIC MACROINVERTEBRATES COLLECTED
IN A METERED LARVAL NET IN THE
MISSOURI RIVER,
JUNE 23, 1974

Organism	Station B	Station C
Crustacea		
Amphipoda		
Crangonyx sp.	+	1
Diptera		
Chironomidae		
Chironomus sp.	1	1
Chironomus sp. B	1	+
Polypedilum sp.	+	1
Culicidae		
Chaoborus sp.	+	1
Trichoptera		
Hydropsyche sp.	1	1
Chematopsyche sp.	1	+
Ephemoptera		
Centroptilum sp.	3	+
Stenonema sp.	10	13
Paraleptophleba sp.	+	1
Tsonychia sp.	2	+
Caenis sp.	2	+
Odonata		
Gomphus sp.	+	1
TOTAL	20	20
DENSITY	$0.0503/m^3$	$0.0568/m^3$

TABLE 2.3.6-6

NUMBER OF BENTHIC MACROINVERTEBRATES COLLECTED IN A METERED LARVAL NET IN THE MISSOURI RIVER JUNE 23 AND SEPTEMBER 8, 1974

Organism	June 23		September 8	
	Station B	Station C	Station B	Station C
Annelida				
Oligocheate				
Limnodrilus sp.	+	+	+	1
Crustacea				
Amphipoda				
Crangonyx sp.	+	1	1	+
Diptera				
Chironomidae				
Chironomus sp.	1	1	+	+
Chironomus sp. B	1	+	+	+
Polypedilum sp.	+	1	1	3
Tanypodinae (unknown)	+	+	1	1
Culicidae				
Chaoborus sp.	+	1	4	3
Trichoptera				
Chematopsyche sp.	1	+	+	+
Hydropsyche sp.	1	1	2	6
Lype sp.	+	+	1	+
Ephemoptera				
Caenis sp.	2	+	+	+
Caenidae (unknown)	+	+	+	2
Centroptilum sp.	3	+	+	+
Hexagenia sp.	+	+	5	4
Isonychia sp.	2	+	+	+
Paraleptophleba sp.	+	1	+	+
Stenonema sp.	10	13	1	2
Odonata				
Gomphus sp.	+	1	+	+

TABLE 2.3.6-6 (continued)

Organism	June 23		September 8	
	Station B	Station C	Station B	Station C
Hemiptera				
Buenoa sp.	+	+	+	1
Coleoptera				
Stenelmis sp.	+	+	+	1
TOTAL	21	20	16	24
DENSITY	$0.0527/m^3$	$0.0568/m^3$	$0.0490/m^3$	$0.0603/m^3$

TABLE 2.3.6-7

NUMBER OF BENTHIC MACROINVERTEBRATES COLLECTED IN DRIFT NETS[a] IN LOGAN CREEK, JUNE 22, 1974

Organism	Station D	Station E
Crustacea		
Copepoda		
Cyclopoid	6	38
Diptera		
Chironomidae		
Ablabesmyia sp.	+	1
Ephemoptera		
Stenonema sp.	+	1
Centroptilum sp.	1	+

[a] 0.135-m^2 nets

TABLE 2.3.6-8

BENTHIC MACROINVERTEBRATES COLLECTED FROM THE MISSOURI RIVER AND LOGAN CREEK DURING JULY (J-3), SEPTEMBER (S-3), DECEMBER (D-3), 1973, AND FEBRUARY (F-4), JUNE (J-4), AND SEPTEMBER (S-4), 1974

Organism	Missouri River						Logan Creek					
	J-3	S-3	D-3	F-4	J-4	S-4	J-3	S-3	D-3	F-4	J-4	S-4
Platyhelminthes												
Turbellaria						x						
Nematoda												
unknown sp.					x						x	
Annelida												
Oligochaeta												
Enchytraeidae												
unknown sp.			x	x						x		
Lumbriculidae												
Lumbriculus sp.					x							x
unknown sp.									x			
Tubificidae												
Aulodrilus pigneti									x	x		
Branchiura sowerbyi	x	x	x	x	x	x	x	x	x	x	x	x
Ilyodrilus templetoni				x								
Limnodrilus ceruix			x	x					x	x		
L. claparedeanus			x	x					x	x		
L. hoffmeisteri			x	x					x	x		
L. sp.	x	x	x	x	x	x	x	x	x	x	x	x
L. udekemianus	x		x	x					x	x		
Peloscolex sp.		x										
Tubifex sp.		x			x						x	
unknown sp.	x	x	x	x			x	x	x	x		
Naididae												
Aulophorus sp.								x				
Dero digitata			x	x					x	x		
Dero sp.					x						x	
Nais elinguis			x	x								
N. sp.										x		

TABLE 2.3.6-8 (continued)

Organism	Missouri River						Logan Creek					
	J-3	S-3	D-3	F-4	J-4	S-4	J-3	S-3	D-3	F-4	J-4	S-4
Paranais frici			x	x								
Crustacea												
Amphipoda												
Crangonyx sp.					x	x						
Hyallella azteca		x										
Decapoda												
Astacidae (immature)											x	x
Palaemonetes kadiakensis											x	x
Diptera												
Chironomidae												
Ablabesmyia janta			x									
Ablabesmyia sp.						x					x	x
Chiroromus sp.		x	x	x	x	x	x	x	x	x	x	x
Coelotanypus sp.			x			x						
Conchapelopia sp.			x									
Cricotopus exilis			x	x						x		
Cryptochironomus blarina			x									
Cryptochironomus fuluus			x	x			x		x	x		
Cryptochironomus sp.	x	x			x			x				x
Dicrotendipes sp.		x	x	x			x	x	x			
Glyptotendipes lobiferus			x							x		
Glyptotendipes senilis							x					
Glyptotendipes sp.				x				x				x
Microtendipes sp.											x	x
Orthocladius sp.				x								
Paracladopelma sp.				x					x			
Paralauterborneilla sp.	x	x	x									
Paratendipes sp.		x	x				x					
Pentaneurini (unknown)						x						
Polypedilum halterale				x					x			
Polypedilum scalaenum							x					
Polypedilum sp.		x		x	x	x	x	x				x

Organism	Missouri River J-3	S-3	D-3	F-4	J-4	S-4	Logan Creek J-3	S-3	D-3	F-4	J-4	S-4
Procladius adumbratus			x	x					x	x		
Procladius riparius	x		x	x			x		x	x		
Procladius sp.	x					x						x
Psectrocladius sp.						x						
Pseudochironomus sp.		x						x	x			x
Rheotanytarsus sp.		x	x	x			x	x				
Stictochironomus sp.				x			x			x		
Tanypodinae						x						
Tanytarsini												x
Tanytarsus sp.						x						
Tendipedini		x	x									
Tribelos sp.											x	
Trichocladius sp.		x										
Trissocladius sp.			x	x					x	x		
Zavrelimyia sp.	x						x					
Culicidae												
Chaoborus punctipennis				x						x		
Chaoborus sp.		x	x		x	x		x				
Ceratopogonidae												
Bezzia sp.							x					
Unidentified sp.			x	x						x		
Psychodidae												
Psychoda sp.				x								
Tipulidae												x
Tabanidae												
Tabanus sp.												x
Trichoptera												
Chematopsyche sp.			x	x	x	x						
Hydropsyche orris			x	x								
Hydropsyche sp.					x	x						
Lype sp.						x						
Neureclipsis sp.			x									
Unidentified sp.	x											

TABLE 2.3.6-8 (continued)

Organism	Missouri River						Logan Creek					
	J-3	S-3	D-3	F-4	J-4	S-4	J-3	S-3	D-3	F-4	J-4	S-4
Ephemoptera												
Caenis sp.	x			x	x							x
Centroptilum sp.					x	x					x	
Ephemerella frisoni		x						x				
Hexagenia sp.			x			x						
Paraleptophlebia sp.					x							
Isonychia sp.					x							
Pentagenia vittigena		x										
Pentagenia sp.	x		x									
Stenonema femoratum		x						x				
Megaloptera												
Sialis sp.												x
Odonata												
Argia sp.			x									
Gomphus sp.				x	x						x	x
Macromia sp.											x	
Hemiptera												
Buenoa sp.						x						
Gyretes sp.						x						x
Coleoptera												
Dubiraphia sp.	x			x								
Stenelmis sp.						x						
Mollusca												
Gastropoda												
Ferrisia sp.			x									
Pelecypoda												
Amblema sp.											x	
Corbicula sp.		x										
Lasmigona sp.						x						
Pisidium adamsi						x						
Shaeriidae unknown				x								
Shaerium partumeium						x						
Uniomeras sp.											x	

2.3.7 FISH

2.3.7.1 Missouri River

Pflieger (1971) summarized fish collection data from 1853 to 1969 in Missouri. From these data he produced maps that note collection sites for each species of fish reported from Missouri. A tentative species list for the Callaway Plant site has been constructed from these maps (Table 2.3.7-1). The table includes 34 species known to occur in the Missouri River and 32 species in tributaries of the area. Thus, a total ichthyofauna of 67 species has occurred historically near the site.

None of the Dames & Moore collections confirmed the presence of nine species reported by Pflieger (1971). All of these species were minnows, with the exception of the black redhorse (Moxostoma duquesnei). Many minnows species in Missouri are limited to certain parts of the Missouri River. Some, for example, are restricted to the upper and others to the extreme lower parts of the river. Because no collections had previously been made between the Osage and Gasconade Rivers (Pflieger, 1971), where the flow differs significantly, it is logical to assume that the Callaway Plant site might have a slightly different assemblage of minnows than those reported by Pflieger.

The present study consisted of two trips, with 35 species being collected from Missouri River (Table 2.3.7-1). Twelve species collected had not been recorded by Pflieger (1971). However, five had been collected previously by Dames & Moore. Their presence reaffirms Pflieger's classification of these species as wide ranging. The remaining seven species had been reported only from tributaries by Pflieger (1971). Low summer flows probably account for their presence in the river.

During the June sampling period, 13 species of fish were captured in gill and fyke nets set in quiet waters behind dikes and revetments (Table 2.3.7-2). Greatest numbers and diversity were obtained from Transect C, which intersects the river near the mouth of Logan Creek. Although there were no clear trends in catch among stations, white crappie, freshwater drum, gar, river carpsucker, and carp were most abundant in the catch. Sport fish such as white crappie, sauger, and northern pike were captured only at Transect C. Commercially important blue catfish and flathead catfish were captured only at Transect A. Smallmouth buffalo, reported to be the second most abundant fish in commercial catches (Robinson, 1973), were not collected.

Electroshocking was conducted in June along the north and south shoreline for a period of about 4 hours but was largely unsuccessful, as only 11 fish were collected (Table 2.3.7-3). High turbidity and high river currents reduced the effectiveness of the electroshocker. Other workers have encountered similar problems with this type of gear in the Missouri River (Minter, 1972).

The September gill and fyke net collections yielded 15 species (Table 2.3.7-4). Most abundant were freshwater drum, smallmouth buffalo, goldeye, and white crappie. Northern pike, black bullheads, and sauger, all collected in June, were not present in the September collections. However, paddlefish, goldeye, smallmouth buffalo, and white bass were present only in September. Most of the seasonal differences in species composition are from species that are classed as wide-ranging (Pflieger, 1971); therefore, their ephemeral appearance in the catch is not unusual.

To put the present (June and September 1974) fish collections in perspective, a discussion by species is in order. For clarity, they will be discussed by family in phylogenetic order.

The lamprey family (Petromyzonidae) has only one representative in the Missouri River, the chestnut lamprey. Dames & Moore collected five specimens in December 1973; during the present study, none were collected. Pflieger (1971) suggests that populations are decreasing because of reduction in spawning areas.

Two of the three species belonging to the sturgeon family (Acipenseridae) in Missouri are considered rare, the lake sturgeon (Acipenser fulvenscens) and pallid sturgeon (Scaphirhynchus albus). Their presence has never been reported at the Callaway Plant site. However, the other species, the shovelnose sturgeon (Scaphirhynchus platyrhynchus), occurs at the site (Table 2.3.7-1).

The collection in September 1974 of the single member of the paddlefish family (Polydontidae) confirms the presence of paddlefish in the lower Missouri River (below confluence of the Osage River), where they have not been reported previously (Pflieger, 1971).

The gar family (Lepisosteidae) is represented by the longnose (Lepisosteus osseus) and shortnose gar (L. platostomus). Similar to findings of Pflieger (1971) and University of Missouri-Rolla (1974), the present study showed that the shortnose gar was more abundant than the longnose gar. This was true in both spring and fall collections.

The eel family (Anguillidae) is represented by the American eel (Anguilla rostrata) in Missouri. Its presence at the Callaway Plant site has not been confirmed by this or previous Dames & Moore studies. Pflieger (1971) reports collections containing eels at several up-river sites. The catadromous nature of this species predicts its presence, at least seasonally, at the Callaway plant site.

The shad family (Clupeidae) contains the gizzard shad (Dorosoma cepedianum), one of the most abundant fish in the Missouri River. Dames & Moore collections in 1973-74 confirmed its abundance at the site. Another species, skipjack herring (Alosa chrysochloris), not normally considered a resident of the lower Missouri River, has been collected both in 1973 and 1974 by Dames & Moore, although it was not collected during the present study. Pflieger (1971) characterizes the species as inhabiting open waters of large rivers and being intolerant of extreme turbidity. Its presence in the lower Missouri River may indicate a reduction in excessive turbidity.

The present collection contained one species of the mooneye family (Hiodontidae), the more common goldeye (Hiodon alosoides). Previous collections (Dames & Moore, 1974; University of Missouri-Rolla, 1974) in the area have contained the mooneye (Hiodon tergisus), which is considered rare in Missouri by Pflieger (1971).

The pike family (Esoxidae) was represented by the northern pike (Esox lucius). There is a question as to whether E. lucius has a natural population in Missouri or is present because of northern intrusion. Pflieger (1971) states that there is a possibility of a self-sustaining population in the Osage River. This is probably the source of the single specimen collected in June 1974.

The minnow family (Cyprinidae) is more diverse than any other family in the Missouri River. During the present study, 10 species were collected, including the common carp (Cyprinus carpio). It was moderate in abundance and accounted for 10 percent of the June net collection and 8 percent of the September net collection (Table 2.3.7-2 and 2.3.7-4). This species, with its granivorous nature and high fecundity (Berner, 1951), is well suited to the Missouri River.

The other minnows collected corresponded closely to those reported by University of Missouri-Rolla (1974). The emerald shiner, Notropis athernoides, was the most abundant for both spring and fall surveys. Second in abundance for the spring survey was the silver chub, Hybopsis storeriana, and for the fall the western silvery minnow, Hybognathus argyritis (Tables 2.3.7-5 and 2.3.7-6). (H. argyrtis is considered a subspecies of H. nuchalis, silvery minnow, by Bailey, et al. [1970].).

The sucker family (Catostomidae) is ecologically well suited to most large river systems. Their use of detritus, an abundant food source, and touch-taste feeding mechanism reduce effects of high turbidities (Hynes, 1972) normally associated with large rivers. At the Callaway Plant site, this family is represented by five species. All three species of the carpsucker genus, Carpiodes, have been collected. The river carpsucker (C. carpio) is by far the most prevalent species of this genus in the Missouri River (Pfleiger, 1971). The other two Carpiodes species were collected during the June 1974 survey.

The remaining sucker species, smallmouth and largemouth buffalo, found at the site are both in the same genus (Ictiobus). Pflieger (1971) and University of Missouri-Rolla (1974) both stated that the largemouth buffalo (I. cyprinellus) is the most common buffalo species in the Missouri River. However, at the site the smallmouth buffalo (I. bubalus) is more common (Union Electric Company, 1974). During the present study, the smallmouth buffalo was the only buffalo species collected.

The catfish family (Ictaluridae) is represented by four species at the site. In order of decreasing abundance, they are as follows: flathead (Pylodictis olivaris), blue catfish (Ictalurus furcatus), channel catfish (I. punctatus), and black bullhead (I. melas). Dominance of blue catfish is higher at the site than previously reported by Pflieger (1971) and University of Missouri-Rolla (1972, 1974) for the Missouri River; conversations with local fisherman support Dames & Moore's findings.

The temperate bass family (Percichthyidae) was represented by a single species, the white bass (Morone chrysops). Several authors have indicated that reduction in turbidity could account for appearance of this species.

The sunfish family (Centrarchidae) was better represented in Logan Creek than in the Missouri River. Only one species of sunfish, the bluegill (Lepomis macrochirus), was collected from the river. However, both largemouth and smallmouth bass (Microptrus salmoides, M. dolomieui) were collected in the river. Dames & Moore's collection of smallmouth bass from the river represents only the third such collection. The remaining sunfish species, white crappie (Pomoxis annualris), was quite abundant behind revetments and at the mouth of Logan Creek. It accounted for 10.2 percent of the fall and 16.2 percent of the spring net catch.

The perch family (Percidae) was represented by the sauger (Stizostedion canadense) and orangethroat darter (Etheostoma spectabile). Several young-of-the-year sauger were collected both in the spring and fall. However, adults were taken only during the spring survey. This indicates low abundance of this species or possible migration of the adults upstream during the spring.

The drum family (Sciaenidae) was represented at almost every station during both surveys by freshwater drum (Aplodinotus grunniens). This species is also common in commercial catches, being taken by net or seasonally by trotline (Robinson, 1973).

Although the fish fauna of the Missouri River is diverse, standing crops and growth rates are reported by several authors as low (Berner, 1951; Carlander, 1969; Gammon, 1970; and Robinson, 1973). Gammon (1970) attributed low productivity resulting from high turbidity as part of the cause. Berner (1951) states that channelization also lowered productivity by reducing backwater where plankton production occurs.

To aid in assessing production potential, food availability, and general suitability of the aquatic environment, condition factor (K) was calculated for the five most abundant species collected during both sampling periods (Table 2.3.7-7). Condition factors for four of the five species were either lower than values reported by Carlander (1969) or as low. [The condition factor for white crappie in the Missouri River is about equal to that attained by this species in rivers of other states, such as in Oklahoma (Houser and Bross, 1963).] This species is able to eat anything from plankton to small fish. It also is not greatly affected by turbidity or mud bottom. Therefore, it is well suited to backwater areas of the Missouri River, as its condition factor illustrates.

The other species with a near average condition factor was the carp. Berner (1951) indicated carp are seed and detritus eaters. The fluctuating water level in the river results in good seed supply at least part of the year. Gizzard shad and river carpsucker, which have a low condition factor, do not selectively eat seeds and rely mainly on detritus.

Drum condition was lower than that of either white crappie or carp. The drum has a more restricted diet than white crappie. It is not able to use plankton and must generally utilize larger food types such as fish and invertebrates.

An age and growth study was conducted on gizzard shad collected in the Missouri River during the present study. Back calculated lengths at age (Table 2.3.7-10) are slightly below the median growths reported by Carlander (1968) for Missouri, Illinois, Kentucky, Tennessee, and North Carolina. Because gizzard shad probably are able to directly derive energy, they utilize organic detritus (Baker and Schmitz 1971).

In an effort to assess the food base of the river, seining was conducted along sand bars and in backwater areas. Seine hauls in June 1974 were dominated by shiners (<u>Notropis</u> spp.) and chubs (<u>Hybognathus</u> spp.). Most abundant in all catches was the emerald shiner, reported to be the most abundant minnow in the Missouri River. The spring sample also contained numerous young-of-the-year gizzard shad, white bass, white crappie, sauger, and others. Sauger, gizzard shad, bluntnose minnow, and brook silverside were collected exclusively at night.

September 1974 seine hauls were also dominated by both adult and juvenile shiners and chubs. The western silvery minnow (<u>Hybognathus argyntis</u>) appeared for the first time. In addition, juveniles of several species were collected, including river carpsucker, channel catfish, largemouth bass, white bass, and sauger. Berner's (1951) seine collections contained fewer minnows and were dominated by <u>Hybognathus</u> spp. and <u>Hybopsis</u> spp.

For both fall and spring periods, approximately 300 fish were collected per 15-m haul of a 7.5-m minnow seine. This abundant population can be explained by the food habits of the collected species. They are able to utilize particulate organic matter (detritus), which is the major energy source for the river's aquatic organisms.

Larval fish data were collected during both spring and fall surveys; a metered net was used for sampling. These data serve a two-fold purpose. First, they indicate spawning use of the Missouri River and, secondly, they document the presence of possible entrainable fauna.

Results of the larval fish sampling, conducted in the spring (June 23), showed that larvae of several species were suspended in the water column and that reproduction had occurred only a short time earlier (Table 2.3.7-8). Some egg-sac larvae were less than 4mm long. Densities of fish larvae and eggs were calculated to be $0.201/m^3$ at Transect B and $0.270/m^3$ at Transect C. The difference in densities probably reflects contributions from Logan Creek and associated backwaters at Transect C. Fish eggs were collected only at Transect C.

In the fall (September 5), no larval fish were collected at Transect B, but two carp about 20 mm long were taken at Transect C. They represent a density of $0.005/m^3$.

2.3.7.2 Logan Creek

Logan Creek does not support the same species diversity as other tributaries in the area. Dames & Moore, in four collecting periods, reported 26 species from two stations, whereas Pflieger (1971) found a more diverse ichthyofauna in tributaries adjacent to the Callaway Plant site. He indicated that 32 species occur only in these tributaries. The creek's small size may account for its moderately low diversity. One of the environmental factors limiting Logan Creek diversity is its periodically low flow. During low flow periods, pools are formed where water temperatures and dissolved oxygen can become limiting to fish survival. Rapid water level change is another stress factor. The short and narrow drainage basin reduces seepage and increases volume and speed of runoff. Station D on Logan Creek suffers from additional stress of heavy silt deposits (50 to 80 cm). This silt is deposited by flood waters of the river. Because of the low gradient and current at Station D, these deposits are removed quite slowly.

Seining at Station D in June 1974 yielded a total of 10 species of fish (Table 2.3.7-5). Five of these (Shortnose gar, gizzard shad, emerald shiner, smallmouth bass, and freshwater drum) were age 0 juveniles and three (channel catfish, bluegill, and white crappie) were probably age 1 juveniles. Juvenile smallmouth are of interest because they have not been previously collected in the creek, though local fisherman catch adults. Adult smallmouth bass have also been collected from the river near Hermann, Missouri (Minter, 1972).

In September 1974 the number of species collected by seining at Station D increased from 10 to 17 (Table 2.3.7-9). Intrusion of river species into the creek accounted for most of the increase. Warmouth (Lepomis gulosus), one of the river species collected, has never been reported in collections from lower Missouri tributaries (Pflieger, 1971).

Sampling was conducted at Station E on May 30 and June 22, 1974. The May sampling yielded seven species, mainly bluegills and green sunfish (Table 2.3.7-5). Green sunfish were absent in June when

13 fish species were collected. In all, 16 species were collected at Station E in the spring of 1974.

Standing crop biomass estimates were made at Station E on both May 30th and June 22nd. During the May sampling, a 30-meter section of the creek was blocked off with minnow seines and sampled with a backpack D. C. electroshocker until the catch per unit effort was reduced sufficiently to allow a population estimate. The same procedure was used in June, with the exception that a 14.1-meter section of the stream was sampled with a minnow seine. A total of 60 fish were collected from the blocked-off area on May 30th. Regression of catch per unit effort on cumulative catch resulted in an X-intercept of 68 fish. Total biomass, extrapolated from the catch, is estimated at 2,469 g, or 24.18 kg/ha. Standing crop biomass, estimated from the regression obtained from 28 fish collected on June 22nd, was 9.265 kg/ha. The difference in the two estimates is due primarily to the large number of green sunfish present in the May sample. The June sample contained fewer sunfish and a greater diversity of smaller fish, such as minnows and gizzard shad.

On September 6th, 1974, an 18-meter section at Station E was blocked and seined. A biomass estimate of 4.342 kg/ha was calculated from the X-intercept of 68 fish. The presence of numerous juvenile fish in the sample accounted for the increase in fish numbers without a corresponding biomass increase.

Biomass at Station D was estimated by use of a beach haul seine. One-half of the seine was strung out directly across to the opposite bank. The other end was played out along the near bank. Then the near bank side of the net was seined across so as to encircle a given area. Two seine hauls sampled an area equal to about $360m^2$. Estimated biomass was 9.678 kg/ha, which almost equals the biomass of the second sampling period at Station E.

The growth rates for bluegill collected from Logan Creek during the present study are very low (Table 2.3.7-10). For example, back calculated length at age are slightly above the lowest reported for Oklahoma during the period 1952 to 1963 (Houser and Bross, 1963).

In general, the number of species and standing crop at Station E is lower that at Station D. Wide-ranging river species frequent Station D and account for most of the difference.

Summary

In summary, the water quality of the Missouri River is influenced primarily by surface drainage from undisturbed and cultivated lands, high discharge rates, and industrial and municipal pollution. Variation in most water quality parameters measured during the present, as well as earlier, studies was a function of discharge rate and the presence of suspended solids. Coliform bacteria counts increased during periods of high runoff and often exceeded state standards. Chronic pesticide contamination does not exist, though chlorinated pesticides have been detected in spring water samples. Copper concentration, earlier suggested as a possible aquatic toxicant (Union Electric Company, 1974), was found to be associated more with the concentration of suspended particulate matter than with total dissolved solids. Therefore, toxicity of copper to most aquatic organisms is not likely. Cadmium, however, is probably a component of the total dissolved solids.

Data from the present study support the contention that water quality is higher in Logan Creek than in the Missouri River. Dissolved solids, suspended solids, turbidity and coliform bacteria levels are generally lower in the creek than in the river. Dissolved oxygen is generally higher in the creek than in the river, though Station D in Logan Creek may, because of its close proximity to the river, have dissolved oxygen levels more characteristic of the river than the creek. Diurnal depletion of dissolved oxygen may occur in the lower reaches of the creek due to respiration of organically enriched bottom muds.

Low phytoplankton and zooplankton densities generally found in the river are related to excessive turbidities and lack of adjoining lentic waters. However, in the present study, seasonal fluctuations, density, and productivity of phytoplankton were unusually great. Phytoplankton densities in September were over 100 times greater than those in June and as much as 8 times greater than the highest densities reported for the lower Missouri River. Primary productivity in September, as measured by uptake of ^{14}C, was also moderately high, indicating that active photosynthesis was occurring. During the summer, river discharge rates dropped below 44,000 cfs, thus reducing turbidity and creating quiet water areas behind revetments. Prior to the September study, discharge increased from 44,000 to 89,000 cfs. Apparently, this water level increase flooded the revetments and washed phytoplankton into the river channel, thus producing the high densities observed in September. Turbidity, which was still moderately low, permitted photosynthesis to continue both in the river channel and behind revetments.

Phytoplankton densities in Logan Creek during the September study were also high, though lower than Missouri River densities. Primary productivity, however, was low at both sampling stations. It appears that the presence of large numbers of dead diatom frustrules accounted for high densities and low productivity measured in the study, though other factors, such as nutrient depletion, may be responsible for this anomaly.

Variation in benthic macroinvertebrate density, diversity, and biomass was found to be a function of river discharge and unstable substrate. High spring water levels plus the normal emergence of mayflies and chironomids resulted in low diversities and densities and the predominance of oligochaete worms in the June river samples. September samples contained a more diverse and dense assemblage of macroinvertebrates as a result of improved water quality, lower predation, and normal life cycle patterns.

Macroinvertebrate drift samples taken in the river yielded a species composition different from that found in the bottom grab samples. The source for many of the drift organisms may be channel modification structures such as dikes and revetments. Samples of rocks and logs taken from a revetment revealed the presence of species not associated with other bottom substrata. Caddis flies, chironomids, flat worms, amphipods, mayflies, and oligochaete worms were present in densities greater than 48,000/m^2.

Logan Creek benthic macroinvertebrates are similar in species composition to those in the Missouri River but usually have higher densities, biomass, and diversity. Seasonal variation in benthic macroinvertebrate diversity, biomass, and density was similar to that observed in the river and was largely influenced by the same physical and biological factors. Variation between stations is primarily related to differences in water quality and substrate. Low diversity observed previously at Station D was also noted in the present study and was the lowest recorded in 2 years of study. The most important factors affecting benthic invertebrates in the lower creek are those related to flooding and silt deposit by the river, though pesticide contamination may also play a role.

During the present study, 35 species of fish were collected in the Missouri River. Seven of these species had not been collected in the area previously but are reported as tributary species. Freshwater drum, white crappie, and river carpsucker were constantly abundant in all collections. Seasonal variation in catch was due largely to the appearance of wide-ranging species. Seine collections on sand bars and backwater areas were dominated by the emerald shiner. Numerous juvenile fish were collected, including gizzard shad, white bass, white crappie, sauger, freshwater drum, largemouth bass, and others.

Results of the larval fish sampling in June indicate that larvae of at least eight species were suspended in the water column. Densities of fish larvae and eggs were estimated at 0.201/m^3. at Transect C, suggesting that Logan Creek and associated backwaters at Transect C contributed to the catch. The September sampling yielded only two larval carp.

Seining and electroshocking in Logan Creek yielded a total of 26 species, including 12 species of juveniles. The eight species of juveniles present in the creek in May and June were mostly river species. A greater number of minnows and sunfish made up the nine species of juvenile fish present in September.

Standing crop biomass estimates from collections made at Station E in May, June, and September are 24 18 kg/ha, 9.265 kg/ha, and 4.342 kg/ha, respectively. Biomass from collections at Station D in September is estimated at 9.678 kg/ha. The appearance of wide-ranging river species at Station D accounts for the observed difference in biomass in September.

Condition factors of the five most abundant fish species collected in the Missouri River were calculated. Condition factors for carp and white crappie were about average when compared to those from other states. Gizzard shad, river carpsucker, and freshwater drum exhibited below-average condition factors.

TABLE 2.3.7-1

SPECIES OF FISH COLLECTED IN THE MISSOURI RIVER AND LOGAN CREEK

Family Species	Common Name	Collection Dates					
		Missouri River				Logan Creek	
		1853-1969[a]	1972[b]	1973[c]	1974[d]	1973-74[e]	1974[f]
Petromyzontidae							
Ichthyomyzon castaneus	Chestnut lamprey	R	x	x			
Acipenseridae							
Scaphirhynchus platorynchus	Shovelnose sturgeon	R		x	x		
Polydontidae							
Polyodon spathula	Paddlefish			x[g]	x		x
Lepisostheidae							
Lepisosteus osseus	Longnose gar	R		x	x		
Lepisosteus platostomus	Shortnose gar	P	x	x	x		x
Clupeidae							
Dorosoma cepedianum	Gizzard shad	R	x	x	x	x	x
Alosa chrysochloris	Skipjack herring			x	x		
Hiodontidae							
Hiodon alosoides	Goldeye	R	x	x	x	x	
Hiodon tergisus	Mooneye			x			
Esocidae							
Esox lucius	Northern pike			x	x		
Cyprinidae							
Cyprinus carpio	Carp	R	x	x	x	x	
Semotilus atromaculatus	Creek chub	R					
Hybopsis storeriana	Silver chub	R			x		
Hybopsis x-punctata	Gravel chub	R					
Hybopsis gracilis	Flathead chub	R			x		

TABLE 2.3.7-1 (continued)

Family Species	Common Name	Collection Dates: Missouri River 1853-1969[a]	Missouri River 1972[b]	Missouri River 1973[c]	Missouri River 1974[d]	Logan Creek 1973-74[e]	Logan Creek 1974[f]
Cyprinidae (continued)							
Hybopsis meeki	Sicklefin chub	R					
Phenacobius mirabilis	Suckermouth minnow	R					
Notropis atherinoides	Emerald shiner	R	x	x	x		x
Notropis rubellus	Rosyface shiner	T					
Notropis umbratilis	Redfin shiner	R		x	x	x	x
Notropis shumardi	Silverband shiner	R					
Notropis zonatus	Bleeding shiner	T					
Notropis cornutus	Common shiner	T					
Notropis boops	Bigeye shiner	T					
Notropis lutrensis	Red shiner	R			x	x	x
Notropis stramineus	Sand shiner	R			x	x	x
Notropis topeka	Topeka shiner	T					
Notropis heterolepis	Blacknose shiner	T					
Notropis volucellus	Mimic shiner	R	x				
Notropis buchanani	Ghost shiner	R					
Dionda nubila	Ozark minnow	T					
Phoxinus erythrogaster	Southern redbelly dace	T				x	
Hybognathus argyritis	Western silvery minnow	T			x		
Hybognathus placitus	Plains minnow	R	x				
Pimephales notatus	Bluntnose minnow	T			x	x	x
Pimephales promelas	Flathead minnow	T					
Campostoma anomalum	Stoneroller	T			x	x	x
Catostomidae							
Carpiodes carpio	River carpsucker	R	x	x	x	x	x
Carpiodes cyprinus	Quillback	R		x	x	x	x
Carpiodes velifer	High-finned carpsucker			x	x		
Catostomus commersoni	White sucker	R		x			
Catostomus catostomus	Longnose sucker			x			

TABLE 2.3.7-1 (continued)

Family Species	Common Name	Collection Dates Missouri River 1853-1969[a]	 1972[b]	 1973[c]	 1974[d]	 Logan Creek 1973-74[e]	 1974[f]
Catostomidae (continued)							
Hypentilium nigricans	Northern hog sucker	T					
Ictiobus cyprinellus	Largemouth buffalo			x			
Ictiobus bubalus	Smallmouth buffalo	R		x	x		x
Moxostoma duquesnei	Black redhorse	R					
Moxostoma erythrurum	Golden redhorse	T	x				
Moxostoma macrolepidotum	Northern redhorse	T					
Ictaluridae							
Ictalurus furcatus	Blue catfish	R		x	x		
Ictalurus melas	Black bullhead	T			x		x
Ictalurus natalis	Yellow bullhead	T			x	x	x
Ictalurus nebulosus	Brown bullhead					x	
Ictalurus punctatus	Channel catfish	R	x	x	x		x
Plyodictis olivaris	Flathead catfish	R	x	x	x		
Noturus exilis	Slender madtom	T					
Cyprinodontidae							
Fundulus catenatus	Northern studfish	T					
Fundulus olivaceus	Blackspotted topminnow	T					
Fundulus notatus	Blackstripe topminnow	T			x	x	x
Poeciliidae							
Gambusia affinis	Mosquitofish	T			x	x	x
Atherinidae							
Labidesthes sicculus	Brook silverside	T			x	x	x
Percichthyidae							
Morone chrysops	White bass		x	x	x		

TABLE 2.3.7-1 (continued)

Family Species	Common Name	Collection Dates Missouri River 1853-1969[a]	1972[b]	1973[c]	1974[d]	Logan Creek 1973-74[e]	1974[f]
Centrarchidae							
Micropterus dolomieui	Smallmouth bass	T	x		x		x
Micropterus salmoides	Largemouth bass	R		x	x	x	x
Lepomis gulosus	Warmouth						x
Lepomis cyanellus	Green sunfish	T			x	x	x
Lepomis humilus	Orangespotted sunfish	T					
Lepomis megalotis	Longear sunfish	T			x	x	x
Lepomis macrochirus	Bluegill	R	x	x	x	x	x
Pomoxis annularis	White crappie	R	x	x	x	x	x
Percidae							
Stizosteidon canadense	Sauger	R	x	x	x		
Percina phoxocephala	Slenderhead darter	T					
Percina caprodes	Logperch	T				x	
Etheostoma nigrum	Johnny darter	T				x	
Etheostoma spectabile	Orangethroat darter	T			x		x
Etheostoma flabellare	Fantail darter	T					
Etheostoma punctulatum	Stippled darter					x	
Etheostoma exile	Iowa darter					x	
Sciaenidae							
Aplodinotus grunniens	Freshwater drum	R	x	x	x	x	x

[a]River (R) and tributary (T) collections reported by Pflieger (1971).

[b]Collected from one station at Hermann, Missouri (Missouri River Environmental Inventory, 1972). An unidentified *Notropis* species was also collected near Hermann, but has not been included in the table.

[c]Collected from five stations near the site area by Dames & Moore, July, September, and December, 1973.

[d]Collected from six stations by Dames & Moore, June, 1974.

[e]Collected from two stations by Dames & Moore, July, September and December, 1973 and February, 1974.

[f]Collected from two stations by Dames & Moore, June and September, 1974.

[g]Observed during the survey, but not collected.

TABLE 2.3.7-2

TOTAL NUMBER AND LENGTH RANGE OF FISHES COLLECTED WITH GILL AND FYKE NETS FROM THE MISSOURI RIVER, JUNE 1974[a]

Common Name	Station A-North End		Station A-South End		Station B-South End		Station B-North End	
	Number	Length	Number	Length	Number	Length	Number	Length
Shovelnose sturgeon	+	+	2	430(467)490	+	+	+	+
Longnose gar	+	+	1	615	+	+	1	605
Shortnose gar	+	+	+	+	+	+	+	+
Gizzard shad	+	+	+	+	+	+	+	+
Northern pike	+	+	+	+	+	+	+	+
Carp	+	+	2	300(385)470	+	+	2	248(337)425
River carpsucker	+	+	+	+	1	377	+	+
Blue catfish	1	210	1	805	+	+	+	+
Black bullhead	1	200	+	+	+	+	+	+
Flathead catfish	+	+	1	705	+	+	+	+
White crappie	+	+	+	+	+	+	+	+
Sauger	+	+	+	+	+	+	+	+
Freshwater drum	+	+	+	+	+	+	3	225(267)309

Common Name	Station H-South End		Station C-North End		Station C-South End	
	Number	Length	Number	Length	Number	Length
Shovelnose sturgeon	+	+	+	+	1	530
Longnose gar	+	+	+	+	1	965
Shortnose gar	+	+	+	+	4	525(562)570
Gizzard shad	+	+	+	+	2	282(287)292
Northern pike	+	+	1	666	+	+
Carp	+	+	+	+	+	+
River carpsucker	1	377	+	+	2	401(412)422
Blue catfish	+	+	+	+	+	+
Black bullhead	+	+	+	+	+	+
Flathead catfish	+	+	+	+	+	+
White crappie	+	+	1	185	5	178(210)250
Sauger	+	+	1	308	1	423
Freshwater drum	+	+	+	+	3	114(204)340

[a]Total length range (mm) with mean length in parentheses.

TABLE 2.3.7-3

TOTAL NUMBER AND LENGTH RANGE OF FISHES COLLECTED WITH A BOOM ELECTROSHOCKER IN THE MISSOURI RIVER, JUNE 1974[a]

Common Name	Station B-North End Number	Length	Station C-North End Number	Length
Shortnose gar	2	490;517	3	565(582)618
Gizzard shad	+	+	2	210;214
Carp	+	+	1	432
White crappie	+	+	1	185
Freshwater drum	+	+	2	231;234

[a]Total length range (mm) with mean length in parentheses.

TABLE 2.3.7-4

TOTAL NUMBER AND LENGTH RANGE OF FISHES COLLECTED WITH GILL AND FYKE NETS FROM THE MISSOURI RIVER, SEPTEMBER 1974[a]

Common Name	Station A-South End Number	Station A-South End Length	Station B-South End Number	Station B-South End Length	Station B-North End Number	Station B-North End Length	Station H-North End Number	Station H-North End Length	Station C-North End Number	Station C-North End Length
Shovelnose sturgeon	1	430	+	+	+	+	+	+	+	+
Paddlefish	+	+	+	+	+	+	1	910	+	+
Longnose gar	+	+	1	1366	1	630	2	550(553)555	+	+
Shortnose gar	+	+	+	+	3	484(556)604	5	415(508)649	+	+
Gizzard shad	+	+	1	306	+	+	10	320(342)374	2	457(494)530
Goldeye	+	+	1	263	16	260(277)300	1	259	12	71(170)329
Carp	+	+	1	485	4	450(493)534	5	320(397)450	+	+
River carpsucker	+	+	1	420	+	+	7	391(405)415	+	+
Smallmouth buffalo	+	+	+	+	12	275(373)427	1	340	1	77
Blue catfish	2	460(465)470	+	+	+	+	+	+	+	+
Channel catfish	+	+	+	+	1	163	1	540	+	+
Flathead catfish	+	+	+	+	1	91	+	+	+	+
White bass	+	+	+	+	+	+	+	+	1	130
White crappie	+	+	+	+	1	320	+	+	12	77(206)261
Freshwater drum	+	+	+	+	13	65(134)395	4	66(79)90	2	84(102)119

[a]Total length range (mm) with mean length in parentheses.

TABLE 2.3.7-5

TOTAL NUMBER AND LENGTH RANGE OF FISHES COLLECTED WITH SEINES IN THE MISSOURI RIVER AND LOGAN CREEK, JUNE 1974[a]

Common Name	Station B June 22 Number	Station B June 22 Length	Station B-South June 23 Number	Station B-South June 23 Length	Station H June 22 Number	Station H June 22 Length	Station D June 22 Number	Station D June 22 Length	Station E June 22 Number	Station E June 22 Length	Station E May 30 Number	Station E May 30 Length
Longnose gar	+	+	1	57	+	+	+	+	+	+	+	+
Shortnose gar	+	+	+	+	+	+	1	59	+	+	+	+
Skipjack herring	+	+	7	16(28)35	+	+	+	+	+	+	+	+
Gizzard shad	18	21(27)40	13	22(30)65	1	27	2	33(34)35	9	131(186)322	1	244
Stoneroller	14	35(54)64	2	46-60	+	+	+	+	+	+	+	+
Flathead chub	1	95	+	-	+	+	+	+	+	+	+	+
Silver chub	+	+	46	18(25)34	+	+	+	+	+	+	+	+
Emerald shiner	96	19(30)60	368	17(22)30	47	19(21)27	4	23(25)27	13	36(50)62	1	61
[illegible]d s[illegible]iner	+	+	+	+	+	+	+	+	1	70	+	+
Redfin shiner	+	+	+	+	+	+	+	+	5	54(58)61	+	+
Bluntnose minnow	21	17(22)30	+	+	+	+	+	+	46	15(27)62	+	+
Quillback	+	+	+	+	+	+	+	+	2	139(145)151	+	+
Smallmouth buffalo	+	+	2[b]	21(22)23	2[b]	20(23)26	+	+	1	287	+	+
Channel catfish	+	+	+	+	+	+	5	85(98)137	+	+	+	+
Black bullhead	+	+	+	+	+	+	+	+	+	+	1	95
Blackstripe topminnow	+	+	+	+	+	+	+	+	4	54(59)65	9	51(60)75
Mosquitofish	+	+	+	+	+	+	1	30	1	31	+	+
Brook silverside	3	18(22)25	+	+	+	+	+	+	+	+	+	+
White bass	1	22	13	18(27)35	2	19(23)26	+	+	+	+	+	+
Green sunfish	+	+	+	+	+	+	+	+	+	+	16	61(131)170
Longear sunfish	+	+	+	+	+	+	+	+	25	61(103)129	3	98(107)112
Bluegill	+	+	+	+	+	+	1	56	21	78(109)132	32	91(116)175
Sunfish hybrid	+	+	+	+	+	+	+	+	1	98	+	+
Smallmouth bass	+	+	1	37	+	+	5	27(43)58	1	33	+	+
White crappie	+	+	2	18(22)25	+	+	2	87(100)112	3	164(168)174	+	+
Orangethroat darter	+	+	+	+	+	+	1	22	+	+	+	+
Sauger	7	44(61)91	+	+	1	67	+	+	+	+	+	+
Freshwater drum	+	+	4	27(29)30	+	+	4	22(25)27	+	+	+	+

[a]Total length range (mm) with mean length in parentheses.

[b]May be *Carpiodes* sp.

[+]Not observed.

TABLE 2.3.7-6

TOTAL NUMBER AND LENGTH RANGE OF FISHES COLLECTED WITH SEINES IN MISSOURI RIVER,
SEPTEMBER 5, 1974

Common Name	Station B		Station B-South		Station H	
	Number	Length	Number	Length	Number	Length
Skipjack herring	1	75	+	+	+	+
Gizzard shad	3	66(71)80	11	71(145)278	24	33(101)275
Flathead chub	2	42(58)73	+	+	+	+
Silver chub	+	+	15	28(45)62	3	61(65)70
Emerald shiner	77	[illegible]7(43)72	330	24(36)42	88	23(45)64
Red shiner	+	+	41	28(40)47	+	+
Silvery minnow	22	27(48)80	+	+	+	+
Bluntnose minnow	+	+	8	28(45)62	+	+
River carpsucker	32	45(59)67	8	45(48)51	3	30(32)33
Channel catfish	3	57(59)62	+	+	+	+
Mosquitofish	+	+	2	25(26)26	+	+
White bass	+	+	1	65	2	95(100)104
Bluegill	1	43	6	25(36)48	2	20(24)28
Largemouth bass	+	+	4	25(36)48	+	+
White crappie	+	+	+	+	4	56(71)100
Orangethroat darter	+	+	+	+	2	30(31)31
Sauger	+	+	+	+	1	72
Freshwater drum	2	88(99)109	+	+	+	+

TABLE 2.3.7-7

CONDITION FACTOR AND LENGTH-WEIGHT REGRESSIONS FOR FIVE SPECIES OF MISSOURI RIVER FISH COLLECTED, JUNE AND SEPTEMBER 1974

Species	Condition Factor		Length-Weight Regressions
Gizzard shad (male)	(19)[a]	0.929	log W = -4.87 +2.93 log L
Gizzard shad (female)	(19)	0.971	log W = -5.42 +3.16 log L
Gizzard shad (combined)	(38)	0.950	log W + -5.32 +3.12 log L
Carp	(15)	1.353	log W + -4.83 +2.98 log L
River carpsucker	(21)	1.217	log W + -4.46 +2.82 log L
White crappie (male)	(9)	1.560	log W = -2.15 +1.82 log L
White crappie (female)	(7)	1.654	log W = -4.76 +2.98 log L
White crappie (combined)	(22)	1.546	log W = -2,77 +1.34 log L
Freshwater drum	(12)	1.352	log W = -5.73 +3.36 log L

[a]Number of specimens used for calculation.

TABLE 2.3.7-8

LARVAL FISH COLLECTED WITH A METERED TOW NET FROM THE MISSOURI RIVER, JUNE 23, 1974

Species	Transect B			Transect C		
	Number	Total Length (mm)	No./m^3	Number	Total Length (mm)	No./m^3
Alosa chrysochloris	4	10-15	0.010	2	20-24	0.006
Dorosoma cepedianum	15	6-13	0.377	39	4-12	0.111
Micropterus spp.	2	6-7	0.005	12	6-9	0.034
Notropis spp.	12	4-10	0.030	28	4-7	0.079
Cyprinus carpio	2	22-27	0.005	+	+	+
Morone chrysops	3	6-8	0.007	+	+	+
Centrarchidae species	3	<4	0.007	+	+	+
Unidentified species	39	<4	0.098	14	<4	0.040
Unidentified fish eggs	+	+	+	3	+	(0.008)
TOTAL	80		0.201	98		0.270

TABLE 2.3.7-9

TOTAL NUMBER AND RANGE OF FISHES COLLECTED WITH SEINES IN LOGAN CREEK, SEPTEMBER 6, 1974

Common Name	Station D		Station E	
	Number	Length	Number	Length
Shortnose gar	1	515	1	
Gizzard shad	8	75(162)265	+	331
Stoneroller	+	+	4	45(51)67
Silver chub	9	29(37)52	+	+
Emerald shiner	34	31(39)65	+	+
Red shiner	1	60	+	+
Redfin shiner	7	53(60)67	+	+
Sand shiner	8	30(37)47	6	27(35)49
Bluntnose minnow	+	+	7	33(35)38
Carpiodes spp.	5	44(52)62	+	+
Smallmouth buffalo	1	186	+	+
Carp	2	216(241)266	+	+
Channel catfish	1	75	+	+
Blackstripe topminnow	+	+	4	30(44)72
Mosquitofish	4	29(30)32	+	+
Green sunfish	+	+	6	25(42)69
Longear sunfish	+	+	1	97
Bluegill	15	30(55)108	4	30(49)103
Largemouth bass	1	228	+	+
Warmouth	1	142	+	+
White crappie	10	129(155)187	+	+
Orangethroat darter	+	+	2	38(39)41
Freshwater drum	6	57(79)97	+	+

TABLE 2.3.7-10

MEAN BACK-CALCULATED TOTAL LENGTH (mm) AT END OF EACH YEAR OF LIFE OF BLUEGILL AND GIZZARD SHAD COLLECTED IN 1974

Bluegill

Year Class	Number of Fish	Age 1	2	3	4
1973	4	84			
1972	31	63	91		
1971	9	62	95	111	
1970	5	55	85	122	137
mean length		66	90	116	137
mean increment		66	30	26	21

Gizzard Shad

Year Class	Number of fish	Age 1	2	3	4
1973	6	126			
1972	10	148	218		
1971	25	142	208	260	
1970	1	104	170	268	317
mean length		130	199	264	317
mean increment		130	68	75	53

2.4 ECOLOGICAL SUMMARY

Abundance and diversity of aquatic biota near the Callaway Plant site have been characterized as limited by excessive turbidity, high discharge rates, and lack of quiet backwater area. The following discussion highlights some of the more important features of the aquatic ecosystem as they are related to these limiting factors.

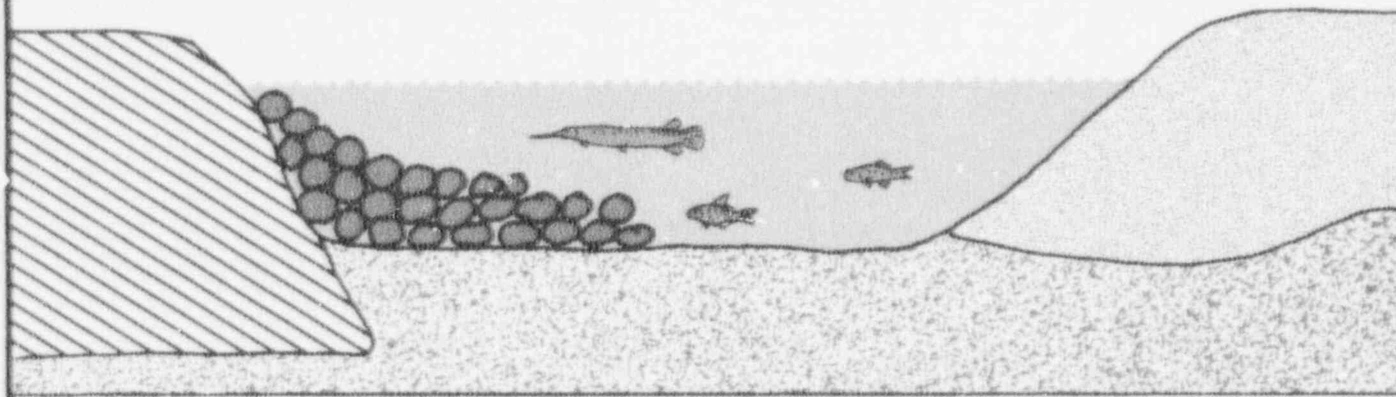
Low primary productivity in the Missouri River has resulted from heavy silt loads, which reduce the amount of light available for photosynthesis by planktonic and periphytic algae. Because primary productivity is low, the major source of energy available to the aquatic community is from terrestrial plant and animal materials in the watershed. This energy source, available directly to both invertebrates (zooplankton, benthic invertebrates) and to vertebrates (fish) can result in short food chains. For example, several of the minnows that provide forage to other fishes can utilize organic detritus directly. Bottom feeders such as the carp probably derive a portion of their energy from detritus.

The single most important feature of the lower Missouri River near the site is its physical nature, resulting from channelization. The channel modification structure blocks side channels and backwater areas and increases the flow. Nearly every aspect of the aquatic ecosystem is subsequently affected. Quiet backwaters, important as plankton-producing areas, spawning sites for fish, and nursery areas for fish larvae are eliminated. As a result, tributary streams such as Logan Creek likely receive increased pressure as a substitute for lost lentic areas. The importance of Logan Creek as a spawning area was shown in this study. That lentic areas are important for plankton production is illustrated by the findings of the present study with regard to phytoplankton production behind revetments. Moreover, high flow rates, siltation, and fluctuating water level resulting from channelization limit the production of bottom-dwelling organisms.

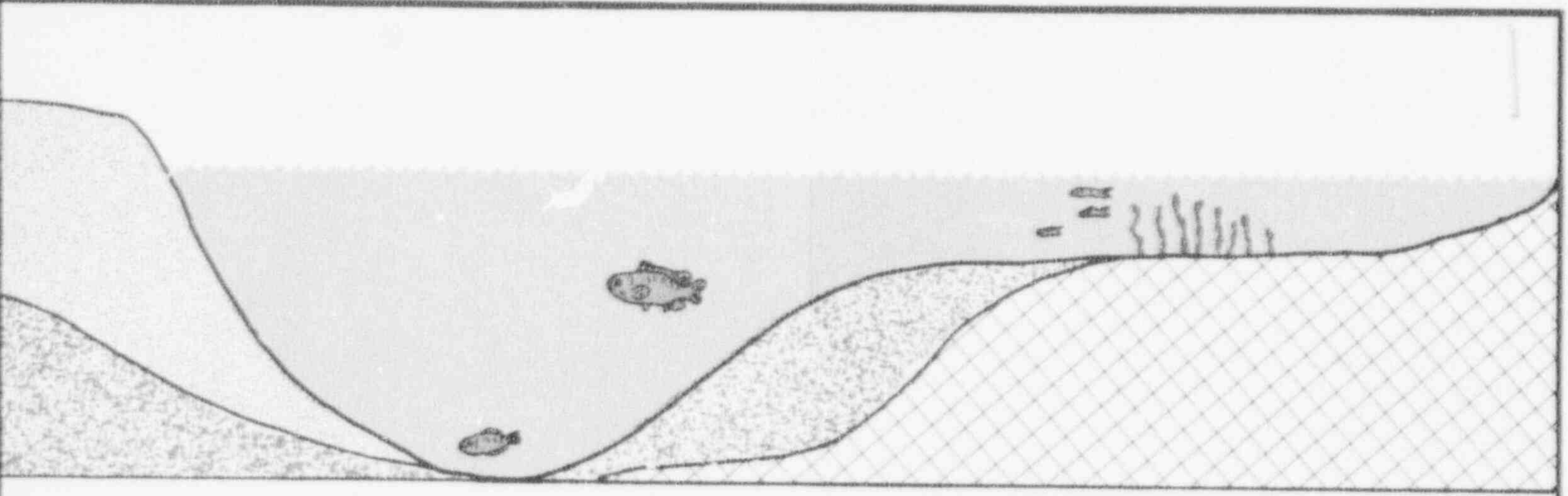
At the Callaway Plant site study area, several L-head dikes and revetments exist on both sides of the river. Different aquatic habitats such as open river channels, sand bars, reveted areas, and creek can be distinguished on the basis of associated biota as well as by physical features. The major components of these associations are presented in Figure 2.4-1. Logan Creek, being less physically stressed, has, for example, a proportionately different assemblage of benthic macroinvertebrates than has the river. The creek also has resident populations of fish, dominated by sunfish and minnows. The energy source to the Logan Creek biota is also largely from terrestrial sources, although phytoplankton productivity is undoubtedly higher as a result of low turbidities.

Numerous minnows were collected on the sand bars and quiet water areas closed off by the bars. Juvenile fish of several species were also collected and a diurnal difference in catch was noted. Several species probably move to the shallows at night to feed.

The revetments were found to contain high densities of macroinvertebrates of a species composition different from that found on the river bottom. These macroinvertebrates are probably the source of a portion of the drift organisms collected in the open channel. Also, the organisms found on the revetment probably are a food source to several species of fish. During the winter months of low flow, the dikes and revetments provide protective areas where fish are known to congregate. Commercial fishermen near the study site take advantage of this phenomenon to increase their catches.



DIKES AND REVETMENTS	SAND BARS
PHYTOPLANKTON	
(NO COLLECTIONS)	(NO COLLECTIONS)
ZOOPLANKTON	
SESSILE ROTIFERS	(NO COLLECTIONS)
HYDROPHYTES	
NONE	NONE
BENTHIC MACRO-INVERTABRATES	
CADDIS FLY LARVAE MIDGE FLY LARVAE FLAT WORMS AMPHIPODS MAYFLIES OLIGOCHAETE WORMS	(NO COLLECTIONS)
FISH	
SHORTNOSE GAR LONGNOSE GAR GIZZARD SHAD RIVER CARPSUCKER FRESHWATER DRUM CARP	EMERALD SHINER SILVER CHUB GIZZARD SHAD FRESHWATER DRUM RIVER CARPSUCKER SILVERY MINNOW



2.5 CONCLUSIONS AND RECOMMENDATIONS

The results of this report, though they add substantially to the data base collected at the site, do not contradict the conclusions regarding the potential impact of the plant put forth in the Callaway Plant Units 1 and 2, Environmental Baseline Inventory, Annual Report. To reiterate, major factors influencing the aquatic system near the site appear to be channelization, turbidity, and surface run-off. Turbidity and water quality changes from surface run-off are directly related to channelization. Channelization results in a more immediate transport of run-off water downstream and prevents normal modification of water quality. Channelized water, having a greater velocity, reduces the possibility of suspended particles settling out of the water column and increases the erosional potential that results in higher turbidities. Channelization also has resulted in elimination of productive backwaters and marshy habitats. Because of this, tributaries to the Missouri River have become increasingly important as aquatic habitats, especially if they provide spawning and nursery sites for fish.

The plant intake and discharge structures were located so as to minimize any of the Callaway Plant's adverse ecological effects, especially with regard to Logan Creek. The intake structure was designed to reduce impingement of fish and the discharge effluent to meet water quality standards. Because of these construction and operational considerations, and the already limited biota production in this section of the Missouri River, no major impacts are anticipated.

Since Logan Creek may be an important spawning creek, it is recommended that sampling frequency during spawning be increased over that in the first year of the preoperational monitoring program. The recommended program for determining spawning intensity in Logan Creek is as follows: When the temperature of Logan Creek reaches about 60° F (late April), the first of two samples to be taken during a 2-week period will be made to measure early spawning activities. For measuring late spawning activities, a second sample will be made about 2 weeks following the first sample. Allowing time for sampling, spawning intensity will have been measured over a time period of about 6 weeks. During the second sampling period, routine data on benthos and fish will be collected. This sampling period coincides with 1973 and 1974 samples. Thus the sampling for the aquatic program should consist of a winter, spring and early summer, and fall sampling.

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3. TERRESTRIAL ECOLOGY

3.1 INTRODUCTION

The Callaway Plant site is located on the Coates Plateau in Auxvasse Township (T-46-N, R-8-W), the southeastern portion of Callaway County, Missouri. The small town of Reform, centrally located within the plant site, is about 350 feet higher than and 5.75 miles south of the Missouri River. The plant site, primarily the northeastern and southwestern sectors, is variously dissected by drainageways. Site topography is rolling to steeply rolling in character. In general, the rougher terrain supports forest vegetation, some of which is grazed, and the more level areas have been or are being utilized as pasture and for production of annual agricultural crops.

A broad-based environmental baseline inventory of the Callaway Plant site was conducted in 1973-74. The objectives of this investigation were:

a. to record and describe "important" species of flora and fauna in the site area during all four seasons of the year

b. to provide baseline data that could be used to develop a monitoring program for detecting impacts of plant construction and operation on the environment

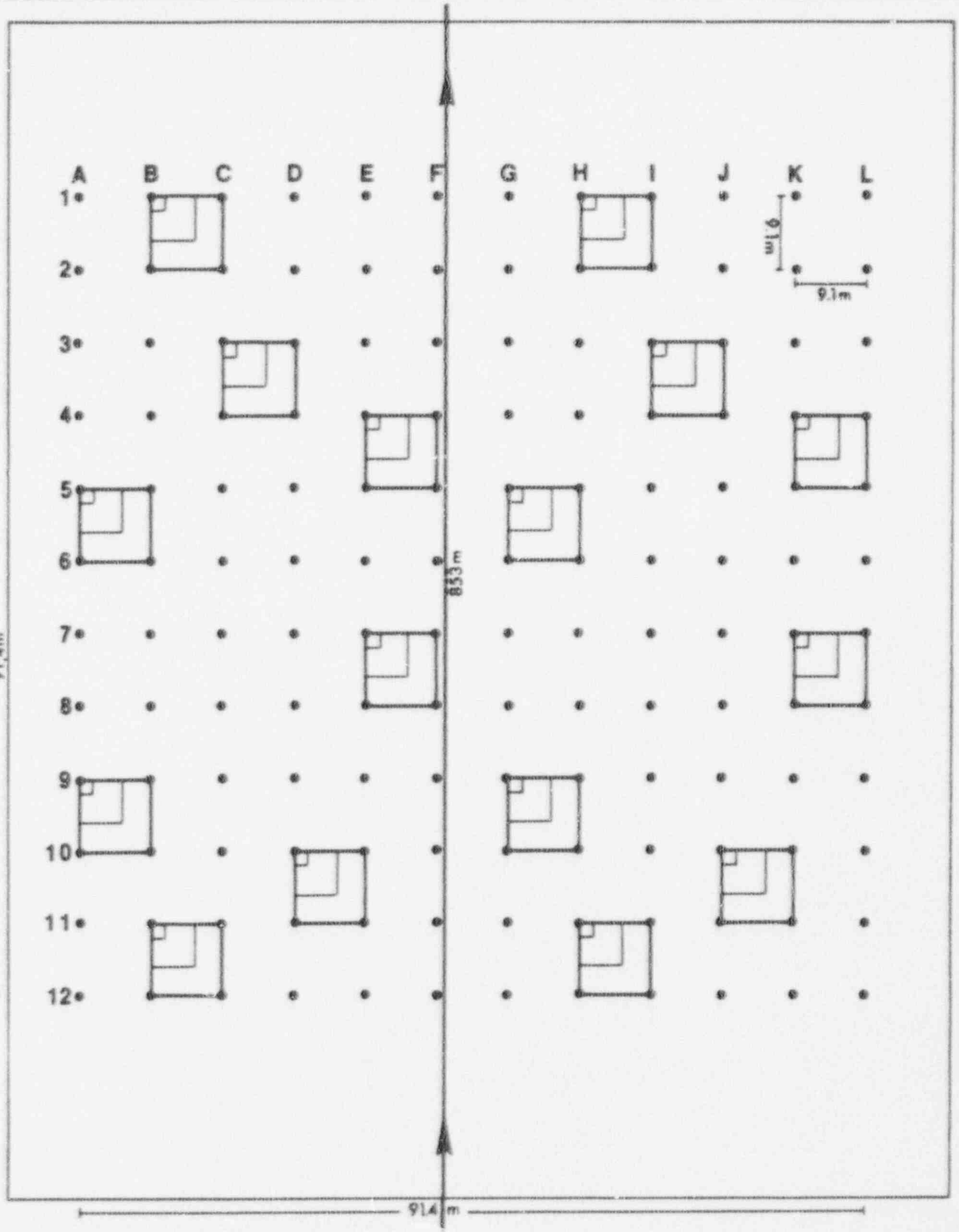
c. to offer recommendations to the Union Electric Company concerning effects of construction on any "unique or unusual" habitat, animals, or a combination of these two life forms found within zones of direct impact

The terrestrial sampling for the preconstruction phase of the environmental monitoring program was initiated at the Callaway Power Plant site in spring, midsummer, and fall of 1974.

The objectives of the monitoring program are generally complementary to those of the previously completed baseline studies. However, the orientation of investigation differs. Whereas the baseline study was a broad-based investigation to characterize the factors or components of the plant site environment, the focus of monitoring studies is to intensively document ecological relationships of selected, permanent sampling stations for the purpose of detecting changes in the natural system. The stations were strategically located at varying distances and bearings from, and outside of, the area to be directly impacted by site development.

The data collected in the three samples ar presented and summarized in this report. The purpose of this report is to determine the suitability of the sampling design for achieving the monitoring program objectives and to discuss the ecological relationships among the major environmental components.

This part of the report is organized into six major sections: Introduction, Methods and Materials, Results and Discussions, Terrestrial Ecological Summary, Conclusions and Recommendations, and References. Most major sections are divided into subsections, the number of which depends on the complexity of the subject matter. The Methods and the Results and Discussions are subdivided by broad terrestrial parameters (Vegetation, Mammals, Birds, Amphibians and Reptiles, and Invertebrates). The text ends with a Conclusion and Recommendations section that attempts to relate survey data to potential environmental impact from plant construction and operation.



LEGEND:

- SMALL MAMMAL TRAP
- VEGETATION QUADRANTS
- AVIAN TRANSECT

UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

DESIGN OF THE 2.5 ACRES TERRESTRIAL STUDY PLOT

Figure 3.2-2

1. Total Density (plants/acre) = $\frac{43{,}560 \text{ sq ft (1 acre)}}{\text{mean area (ft}^2\text{) of plants}}$

2. Relative Density = $\frac{\text{Number of individuals/species}}{\text{Number of individuals of all species}} \times 100$

3. Frequency of Species = $\frac{\text{Number of times individual species occurs}}{\text{Total number of times all species occur}}$

4. Relative Frequency = $\frac{\text{Frequency of individual species}}{\text{Sum of frequencies of all species}} \times 100$

5. Basal Area per Tree = $\frac{\text{Total basal area}}{\text{Number of trees}}$ (overstory only)

6. Relative Dominance = $\frac{\text{Total basal area of one species}}{\text{Total basal area of all species}} \times 100$ (overstory only)

7. Total Basal Area = Mean area x density (overstory only)

8. Importance Value = (Relative density + relative dominance + relative frequency)
(adapted from Curtis and Cottam, 1956)

In addition to the overstory and understory sampling conducted during the fall 1973 field effort, increment core samples were taken of the major overstory species.

At the laboratory, the core was mounted in a position to vertically expose the vascular structures. Once mounted, the core was macroscopically and microscopically viewed, aged, and characterized by observing any "signatures" of cyclic or unique occurrences indicating the prehistory of the site. This data was then tabulated to further characterize each of the sampled locations.

The general layer vegetation for each of the eight sampling stations was surveyed in the spring, summer (early August) and fall (early September). Ground layer vegetation surveying was limited to herbaceous species and woody plants of less than 20 inches in height.

The sampling procedure (for spring and fall samples) consisted of clipping all ground layer vegetation from quadrats located within vegetation survey subplots as shown in Figure 3.2-1. The area of the clipped quadrats used to sample forest habitat was 0.25 milacres (3.3 x 3.3 feet) and for prairie vegetation, 0.125 milacres in size. Clipped vegetation was sorted and packaged by species. Individual bags were coded in accord with field identification, with subplot and sampling station numbers. Matching voucher specimens of species occurring in subplots were collected in the immediate area. The specimens were placed in press and later forwarded to Dr. D. B. Dunn of the University of Missouri for identification.

Clipped vegetation was transported to the Dames & Moore Laboratory in Cincinnati, Ohio, where the materials were oven dried and weighed. Net oven dry weights were recorded in grams according to species and the subplot and sampling station from which the species were collected.

For the midsummer (August 1974) vegetation sampling, incidental species not previously identified or collected during the spring sampling period were collected. This was done by walking transects through each plot and collecting plants not observed during the spring survey.

Relative frequency and relative dominance based on proportional dry weights were calculated for each species occurring at a given sampling station. Relative frequency and dry weight values were summed to provide a quantitative estimate of the importance (importance values) of individual species in the compositions of ground layer vegetation of respective forest and prairie communities. These values are also shown in the above-mentioned appendices. Species percent frequency, dry weights and importance values were further utilized to characterize and compare ground layer vegetation of the sampling stations as will be made apparent in following discussion.

As part of the monitoring program, certain soil chemical properties were examined. At each sample location, samples were collected at a depth of 3-4 inches with a soil auger. The chemical analysis procedures are similar to those recommended by the Environmental Protection Agency; the analyses were conducted at Dames and Moore's Environmental Laboratory (Cincinnati, Ohio).

The following chemical properties of the soil were determined: ph, total nitrogen, available phosphorus, potassium, calcium, sodium and magnesium; the following heavy metals were also determined: arsenic, cadmium, chromium, copper, lead, mercury, and manganese. An analysis for herbicide and pesticide residues in the soil was also performed. The herbicide and pesticide analyses were performed by abc Analytical Bio Chemistry Laboratories, Inc., Columbia, Missouri.

3.2.2 MAMMALS

Rodents were censused by the trap-and-recapture methods described by Smith, Jorgensen, and Tolley (1972) and Smith and Jorgensen (1974). Trapping grids were established on each of eight permanent sampling stations--four in deciduous forest habitats and four in grassland habitats. Each trapping grid entailed use of 144 Sherman live traps; one trap was placed near each of 144 wooden stakes located at right angles to and 30 feet apart from one another. Stakes were arranged in a geometric square, 12 stakes to a side, encompassing 2.5 acres (Figure 3.2-2). The sampling area of each grid extended one-half trap distance (15 feet) beyond the staked perimeter; thus, the effective trapping area was 2.98 acres per grid. Traps were set for 6 consecutive nights during each of the two sampling periods, spring and fall. Thus, for each sampling period and permanent sampling station, a total of 864 trap nights occurred; and for each major habitat type (prairie and forest), trap nights were 3,456 (864 x 4). During the spring survey, trapping occurred from May 31 to June 5, and for the fall survey from September 18 to September 23.

All traps were baited daily with a mixture of peanut butter and oatmeal. Traps in forest habitats were checked for captures and baited each morning, while traps in grassland habitats were baited each evening and checked for captures each morning. Captured animals were marked by toe clipping, and species, sex, age class, reproductive condition, and capture location on the grid were recorded. When sufficient captures permitted, 10 animals of each species were anesthetized with methoxyfluorane (Richins, Smith, and Jorgensen, 1974), and total tail, ear, and hind foot length measurements were recorded. These measurements were compared to published data to verify field identifications.

A computer program (Smith, Jorgensen, and Tolley, 1972) was used to derive small mammal population estimates from the data obtained from the trap-and-recapture program for each of the eight permanent sampling stations. Population estimates were then converted to density estimates by the following formula:

$$\text{Population density} = \frac{\text{population estimate}}{\text{effective trapping area}}$$

Population density estimates are herein expressed as numbers/acre for each species. Age class - sex relationship of species occurring within each permanent sampling station are also estimated.

Thirty snap-traps, baited with a peanut butter and oatmeal mixture, were set in prairie habitat for four nights (June 5, 1974 to June 9, 1974) to obtain voucher specimens to aid in identification.

Because the cottontail rabbit is a naturally-occurring primary consumer as well as an important prey species for a variety of predators, the status of the rabbit population is particularly relevant to a monitoring program. An automobile survey of about 13 miles on local roads was used to survey the cottontail rabbit. The survey techniques are similar to those described by Lord (1959). The locations of the census route and the schedule of route surveys was adopted to correspond with time and travel requirements of investigators conducting small mammal surveys at the various permanent sampling stations previously discussed. The rabbit survey extended over a four-day period during each sampling period--June 2, 1974 to June 5, 1974 during the spring survey and September 17, 1974 to September 21, 1974 during the fall survey. Results of the survey were used to estimate the relative abundance of cottontail rabbits. The estimated mean relative abundance is expressed as the ratio of number of rabbits/mile traveled.

A 20-mile nighttime census route to inventory larger mammals was established along existing roads in the vicinity of Reform, Missouri. Spotlighting was used to supplement observations made with auto headlights. The surveys began approximately 1 hour after sunset; the numbers and kinds of mammals seen were recorded. The surveys were conducted for three nights during the spring and fall surveys.. Lord's (1959) techniques were used to derive an estimate of relative abundance of the various mammal species observed.

3.2.3 AVIFAUNA

The spring avifauna survey of the Callaway Plant site was conducted during the height of the breeding and nesting period, May 25 to June 11, 1974. A similar survey during the fall coincided with the migration period, September 21 to 30, 1974.

The eight permanent sampling stations selected for intensive investigation of vegetation and small mammal populations were the focal point for the spring avian studies. Walking transects for observing bird activities were established so that a portion of the transect route traversed the permanent sampling stations. Portions of the transect route exterior to the sampling stations were located in habitat conditions very similar to those prevailing within the perimeter of the sampling stations.

The technique described by Emlen (1971) was modified to estimate avian densities within and immediate to the permanent sampling stations. The investigator walked along each transect and recorded all birds observed or heard within a strip of established width and 100 yards ahead. A strip width of 200 feet was adopted for survey of prairie habitats; a 400-foot width was used for forest habitats. The visibility of birds, the disturbing effect of the investigator's movements, and the density of vegetation were important factors determining width selection. This method differs from Emlen (1971) in that coefficients of detection in each study area were estimated rather than mathematically determined. This was necessary because the continuity of habitat required by Emlen (1971) was not present on the Callaway Plant site.

The areas sampled for each transect were as follows:

Pr-1	8.82 acres
Pr-2	6.17 acres
Pr-3	5.29 acres
Pr-4	9.70 acres
F-1	21.16 acres
F-2	21.16 acres
F-3	28.20 acres
F-4	21.16 acres

Species of birds recorded were identified either by sight or song. The plots were not surveyed in order; instead, a random sampling was used to keep the consistency of the data equal for all the plots. Every plot was visited at least twice for each sampling time to provide data consistency throughout the study.

Breeding bird densities were computed by the following formula:

$$\frac{\text{Number of Birds} \times 2 \text{ (breeding pairs)}}{\text{Area of coverage (acres)}} = \text{Birds/acre}$$

The area of coverage acreage was computed for each transect route by multiplying the strip width by transect length (feet) and subsequent conversion to acres. The length of each transect was measured from an aerial photograph (scale 1" = 1920'); no adjustment was made for distance as influenced by topographic variation.

Each transect route was traversed three times during the spring sampling period, and the surveys were conducted at approximately the same time each day. Hence, an average density of birds, as calculated for each transect route, provides a valid basis for comparisons between and within habitat types. A Students "t" test was used to compare means and to test for significant difference between avian densities at the various sampled areas. This test provides a method of substantiating the similarity or dissimilarity of plots on the basis of data obtained in field surveys.

During the fall survey, transect sampling methodology was modified to give a more accurate accounting of birds using the permanent sampling plots during the migration period. Each plot (Figure 3.2-1) was sampled by an investigator who walked a series of transects the length of the plots and 100 feet apart. In addition, he would walk a transect 100 feet from the outer perimeter and completely around it. The area sampled for each plot remained constant at 6.45 acres each.

The formula for computing avian densities for the fall survey therefore is:

$$\frac{\text{Number of Birds}}{\text{6.45 (area of coverage in acres)}} = \text{Birds/acre}$$

The avian densities thus derived are subject to several unavoidable modifying constraints, such as the flocking behavior of migrating birds, the decreased visibility of birds in post-breeding plumage, and the disturbing effects of the investigator's movements. These modifying constraints tend to increase variance in the results. Each plot was sampled four times in a random sequence at varying times of day to yield more accurate estimates of avian density as this relates to activity patterns and time of day.

3.2.4 AMPHIBIANS AND REPTILES

Amphibians and reptiles were recorded whenever encountered at each of the permanent sampling stations established on the Callaway Plant site. A variety of suitable habitats were searched to detect the presence of reptiles and amphibians; for example, pond banks were investigated, and logs and large stones were upturned and then replaced. Care was taken to disrupt the habitat only momentarily to ensure the reliability of subsequent reptile and amphibian surveys. The total survey also included areas adjacent to the primary sampling locations.

Amphibians collected within the permanent sampling areas during the spring survey (June 6-8, 1974) were marked by toe clipping (Woodbury, 1953). Reptiles were usually collected for voucher specimens. The exception was turtles; an identification number and date was carved on the plastron of captured species.

During the fall survey (September 13-15, 1974), herpetofauna were marked by code to indicate the permanent plot nearest their point of capture and released. The code is as follows:

1) Lizards, frogs, toads, and salamanders:

   A toe was cut off in a manner to indicate the nearest plot - left front foot for forest plots, right front foot for prairie plots (1, 2, 3, or 4), starting with the inside toe.

2) Turtles:

   A notch was filed in the marginal scutes (through to the bone) according to the same code.

3) Snakes:

   Subcaudals were clipped by the same code as the snake was held venter up (meaning a reversal of the actual side).

Voucher specimens of each species encountered were collected for later study to assure positive identification, as necessary. Identification and nomenclature follow Blair, Blair, Brodkorb, Cagle, and Moore (1968) and Conant (1958). Whenever possible, identifications were made in the field.

3.2.5 INVERTEBRATES

Invertebrates of the vegetative stratum were sampled at permanent sampling stations established on the Callaway Plant Units 1 and 2 site. The sampled areas were Stations F-1 and F-4 in forest habitats and Stations Pr-1 and Pr-4 in prairie habitats. Station locations are shown in Figure 3.2-1. Sampling dates for the spring survey were June 10 and 11, 1974. Fall samples were taken on September 13, 1974.

An aerial sweepnet with a 38-cm diameter, heavy-duty muslin bag and a 90-cm-long handle was used for collecting the invertebrates. The sampling technique consisted of making 50 sweeps over a distance of 50 paces along three randomly selected transects within each of the four 2.5-acre sampling stations. In both the prairie and the forest communities, some vegetation was collected in the net along with the invertebrates. This necessitated transferring the contents into a 1-gallon ZIPLOC[R] bag after the first 25 sweeps and again after the second 25 sweeps along a given transect. Both plant and animal contents from each sample were carefully transferred into the bag, which was then sealed and immediately placed on ice in a large ice chest in the field. On arrival at the laboratory, the samples were transferred to a freezer, where they were stored until each sample was processed for identification and counting. Plant parts collected in the sweepnet were examined in the laboratory for invertebrates that might have adhered to them. Organisms were appropriately pinned, pointed, preserved in ethyl alcohol, or mounted on microscope slides for identification (USDA, 1967). This procedure proved highly satisfactory for the majority of organisms collected.

3.3 RESULTS AND DISCUSSION

3.3.1 VEGETATION AND SOILS

3.3.1.1 Vegetation

Prairie Vegetation Type

The Prairie Sampling Stations Pr-1 through Pr-4 were composed of two predominant floristic strata: the ground layer and the understory vegetation. These two strata will be considered separately in the following discussion, which presents species composition and seasonal diversity. The ground layer and understory will, however, be considered as an integral unit in the discussion of successional trends and directions.

Prairie Sampling Station Pr-1 exhibited a moderate diversity, with 17 species present in the fall 1974 sampling. Based on dry weight and presence, several ground layer species held dominant positions within the subplots. Meadow fescue (Festuca elatior L.) was by far the most dominant, having a relative frequency of 100 percent and an importance value of 132.94 (Appendix A-1). Cinquefoil (Potentilla simplex Michx.) and the graminoid (Panicum lanuginosum Ell.) were the second and third most frequent species, both having relative frequencies of 31.25 percent and importance values of 10.83 and 10.75, respectively (Appendix A-1). Subdominants falling within the ground layer strata of Sampling Station Pr-1 having importance values below 10 included Japanese lespedeza (Lespedeza striata (Thunb.) H. & A.), a carex (Carex glaucodea Tuckerm.), a moss species, and Korean clover (Lespedeza stipulacea Maxim.) [Appendix A-1]). The remaining ground layer vegetation (10 species) had importance values less than 4.25, based on relative frequency and relative dry weights.

Dry weight, utilized as an indicator of presence in this study, was an important parameter; it allowed distinctions to be made among the ground layer plots on the basis of species composition. The estimated dry weight based on 3,044.76 grams per 0.125 milacre for Pr-1 was 1,522,380 grams/acre (3,356.84 pounds/acre), shown in Table 3.3.1-1. This sampling station showed an overall increase in production of 261,490 grams (576.84 pounds) of dry weight plant material over the weights obtained during the spring sampling period (Table 3.3.1-2).

Seasonal comparison of the dominant ground layer species from Station Pr-1 indicated that reed fescue (Festuca arundinaceae Schreb.) had phased out, while meadow fescue (Festuca elatior L.) remained the prominent grass species. Spring subdominants, carex (Carex glaucodea Tuckerm.) and orchard grass (Dactylis glomerata L.) (Appendix A-2) were replaced in prominence in the fall by the cinquefoil and a species of panicum (Appendix A-1). There was a pronounced change in the species within the supportive community of the ground layer as the season progressed from spring to fall. Twenty-three species were recorded for the spring sample, while only 17 species were recorded in the fall sample. There were eight carryover species found in both samples; however, 15 species recorded in the spring failed to occur in the subsequent fall sample. Within the fall sample, nine new species were tallied that had not occurred in the spring sample. Thus, a total of 34 distinct species were recorded for the ground layer.

The understory vegetation of Prairie Sampling Station Pr-1 displayed a considerable diversity in species composition during the fall 1974 sampling program. The fall sampling period was the first instance data were obtained on understory vegetation present within the Callaway Plant site. Woody species predominated; persimmon (Diospyros virginiana L.) was the most frequent species encountered, with a density of 21 trees and an importance value of 64.2 overall (Appendix A-3). Subdominants of the understory included snowberry (Symphoricarpos sp. Duham.), pasture rose (Rosa carolina L.), and white ash (Fraxinus americana L.) with importance values of 37.1, 29.2, and 11.6, respectively (Appendix A-3).

The subdominant species of the understory found within Prairie Sampling Station Pr-1 all held importance values less than 10 (Appendix A-3). Evidence of regeneration is present in the understory of Station Pr-1 in that the species composition includes black oak (Quercus velutina Lam.), post oak (Quercus stellata Wang.), hickory (Carya sp. Nutt.), slippery elm (Ulmus rubra Muhl.), and white ash mentioned previously. All of these species are elements of the forested sites discussed in detail later within this section and indicate that regeneration of overstory species was not a successional possibility within Station Pr-1. On the average, there were 3.2 understory trees or shrubs in each quadrat, yielding 518.4 trees and/or shrubs per acre within the prairie vegetation type.

The second Prairie Sampling Station, Pr-2, showed an extremely high diversity and composition of various ground layer species. A total of 42 distinct species were recorded during the fall 1974 sampling program. The major dominant ground layer species was redtop (Agrostis alba L.) with a relative frequency of 93.75 percent and an importance value of 39.91 (Appendix A-4). Canada blue grass (Poa compressa L.) was second in prominence with a frequency of 100 percent and an importance value of 24.23 (Appendix A-4). A disparity seemed to exist between redtop, frequency 93.75 percent, and Canada blue grass, frequency 100 percent. This was easily explained when the dry weights of the two species were compared. Redtop accounted for 642.80 grams of dry weight, while Canada blue grass accounted for 314.00 grams of dry weight, roughly half the total for the dominant species, redtop (Appendix A-4). The third, fourth, and fifth species were the graminoid (Panicum lanuginosum Ell.), prairie threeawn grass (Aristida oligantha Michx.), and Japanese lespedeza (Lespedeza striata (Thunb.) H. & A) with frequencies of 87.50 percent, 37.50 percent, and 93.75 percent, and showing importance values of 12.45, 11.78, and 11.66, respectively (Appendix A-4). Ground layer vegetation having importance values less than 10.0 amounted to 37 additional species

(Appendix A-4). Eighteen of the species collected during the fall 1974 sampling period consisted of graminoid types, including sedges, carices, and rushes.

Plot clipping performed during the fall 1974 sampling to obtain herbage dry weight revealed a general increase in vegetative production. This increased biomass was reflected in the total fall sample weight of 1,012,950 grams (2233.55 pounds) per acre (based on 2025.9 grams per 0.125 milacre). Specifically, the fall sample showed an increase of 76,825 grams (169.42 pounds) per acre of dry weight plant material (Table 3.3.1-1).

The dominant ground layer vegetation of Sampling Station Pr-2 showed a remarkable change in structure from the spring to the fall sampling period. In the spring, the dominant species was Kentucky blue grass (Poa pratensis L.); however, in the fall, redtop had replaced the blue grass (Appendix A-5). Kentucky blue grass descended from a spring importance value of 28.57 to a fall importance value of only 9.75, which is explained by the fact that Kentucky blue grass is primarily a "cool season" grass that fades out during the August-September period. In the spring, redtop was number two, with an importance value of 27.05, which rose in the fall to 39.91. Timothy (Phleum pratense L.), was third in importance in the spring, with an importance value of 21.63, but fell to a low of 8.35 in the fall sample. Hairy chess (Bromus racemosa L.) held fourth position in the spring, with an importance value of 11.39, but was not recorded in the fall sample. Finally, a carex (Carex bushii Mack.), holding fifth position in the spring with an importance value of 10.37, was not recorded during the fall period.

This general "replacement" of species is believed to be attributable to the seasonal composition changes brought about by elimination of the heat-intolerant "cool season" grasses. These are replaced by the "warm season" heat-tolerant and xerophytic species that are more adapted to periods of elevated temperature typically associated with the late summer-fall time period. To further illustrate the seasonal species phase change: in the spring sampling period, a total of 49 ground layer species were recorded, while in the fall period, 42 species were recorded. Of these recorded species, only 23 carryover species were found to be concurrent for spring and fall. Overall, 68 individual species were recorded for the ground layer of Station Pr-2.

The understory stratum of Sampling Station Pr-2 was limited to only five species, all of which held importance values greater than 10.0. The most important and most frequent tree species found within the understory stratum of Prairie Station Pr-2 was the woody species persimmon, with a relative frequency of 12 percent, a relative density of 77 percent, and an importance value of 129.2 (Appendix A-6). Subdominant supportive elements of the understory included dewberry (Rubus flagellaris Willd.), white ash, snowberry, and slippery elm, having importance values of 27.5, 23.1, 10.1, and 10.1, in order. Sampling Station Pr-2 did not exhibit the understory species evident of understory-overstory regeneration. White ash and slippery elm were present, but the density data for these species indicated only a sparse representation. This fact suggests that succession within Pr-2 exhibited no well-defined trend other than a general shift to more woody-shrubby composition. Generally, the understory was characterized by 8.7 trees or shrubs per quadrat, extrapolated to 1,409.4 trees and/or shrubs per acre.

Prairie Station Pr-3 had a moderate species diversity within the ground layer stratum during the fall 1974 sampling program. Specifically, 35 species were recorded for Pr-3 during the survey. Canada blue grass was, by a considerable margin, the most dominant species tallied; its importance value was 45.42 (Appendix A-7). Furthermore, Canada blue grass had a relative frequency of 93.80 percent and a density based on dry weight of 657.10 grams (Appendix A-7). Redtop was the species holding secondary importance within Pr-3, with an importance value of 32.04 (Appendix A-7). Kentucky blue grass and a panicum were also grass species and held importance values of 15.52 and 10.51, respectively (Appendix A-7). Japanese lespedeza was the fifth and final species having an importance value over 10 (Appendix A-7). There were 30 additional species recorded having importance values lower than 10. Nineteen of the total 35 species recorded were graminoid species including the allied sedges, carices, and rushes.

Dry weight determined from plot clipping of Station Pr-3 during the fall 1974 sampling revealed a generalized decline in production of herbage from the dry weights obtained during the spring sampling period. This reduction in biomass production was noticeable when weights from both spring and fall were compared. In the spring, the sample station yielded 1,156,205 grams (2.549 pounds) per acre. The fall data yielded figures of 940,500 grams (2,073.80 pounds) per acre, showing a net loss in production of 215.705 grams (475.20 pounds) per acre. A possible explanation of this marked decline in production is that compositional changes occurred from spring to fall, or that the edaphic-climatic regime of the Pr-3 station affected its productivity.

Although the composition of the Pr-3 station changed, fall composition was not radically dissimilar to spring composition. The spring dominant was Kentucky blue grass, with an importance value of 38.76 (Appendix A-8); this dominance was phased out by Canada blue grass (with a value of 45.42) during the fall sampling. Redtop, the second in importance during the spring survey, was also second in the fall survey. The third species in order of importance during the spring was timothy, while Kentucky blue grass was third in the fall period. Hairy chess and a carex were respectively fourth and fifth during the spring, but were displaced by a panicum and Japanese lespedeza in the fall.

Comparison of species diversity of the ground layer between spring and fall reveals that 35 species were recorded from both the spring and fall sampling periods. A total of 16 carryover species were recorded for both sampling periods. The total species diversity of the spring and fall periods from the ground layer of Station Pr-3 was 54 distinct species.

Sampling Station Pr-3 displayed a sparse understory stratum characterized by only three species. The predominant species was snowberry, with a relative frequency of 1.0 percent, a relative density of 4.0 percent, and an importance value of 100 (Appendix A-9). The two remaining species, slippery elm and honey locust (Gleditsia triacanthos L.) were present in equal numbers, both having importance values of 50 (Appendix A-9). If importance values of 100 and 50 seem excessively high, it should be borne in mind that, from all sixteen 6.25-milacre plots, only 6 individual trees or shrubs were tallied. This sparsity of undersotry was reflected in the trees or shrubs per quadrat value 0.4, which indicates a meager stratum. Extrapolation of the quadrat density data yielded 64.8 trees per acre for the understory of Sampling Station Pr-3.

Analysis of the understory from the viewpoint of succession yielded no trend information. The absence of dense, regenerating woody species indicated that succession to the stage of predominant understory had not taken place, but rather that Prairie Station Pr-3 was still in the "grass" stage and was just beginning to experience invading species.

Vegetation comprising the ground cover of Prairie Station Pr-4 exhibited the least diversity of any of the other three prairie stations. The fall 1974 sampling recorded only 13 species in the subplots of this station. Far above all other species in importance was meadow fescue, with a relative frequency of 100 percent, an importance value of 136.20, and a yield of 2,517.35 grams of the total 2,542.55 grams recorded for the station (Appendix A-10). White sweet clover (Melilotus alba Desr.) was second in importance in the fall sampling, with an importance value of 14.25 (Appendix A-10). The third species of prominence was Korean lespedeza, with an importance value of 14.14 (Appendix A-10). The remaining 10 species of the ground cover vegetation had importance values less than 10 (Appendix A-10).

Production of biomass within the ground layer was determined from dry weights of herbage. This dry weight served as an indicator of species presence. For Prairie Station Pr-4, the estimated dry weight per acre was based on 2,542.44 grams per 0.125-milacre (equivalent to 1,271,275 grams (2,803.16 pounds) per acre (Table 3.3.1-1). A comparison of this production data to that obtained during the spring sample indicates an increase in biomass production. The total increase in dry weight per acre was 397,320 grams (877.16 pounds). Therefore, though there are relatively few species comprising the Pr-4 station subplots, the production has increased, the increment almost entirely due to the species meadow fescue. Indeed, from the standpoint of fall production, Pr-4 may be considered as monotypic, owing to the overwhelming influence of meadow fescue.

Spring (Appendix A-11) and fall composition comparisons of predominant ground layer species at Pr-4 are similar to comparisons for Pr-1, in that reed fescue, a dominant in the spring, was overshadowed by meadow fescue, also present in the spring but more widespread in the fall. Horse nettle (Solanum carolinense L.) ranked third in the spring, dropped to an importance value of 13.04, and then increased its presence to an importance value of 14.14 in the fall period. A total of 22 species was recorded from the spring survey, and only 13 species in the fall, with 7 carryover species from spring to fall. A total of 28 distinct ground layer species was tallied for Pr-4.

The understory of Pr-4 was exclusively one species. Dewberry had a relative frequency of 2.0 percent, a relative density of 3.0 percent, and an importance value of 200 (Appendix A-12). Site statistics indicated 0.2 trees or shrubs per quadrat and 32.4 trees or shrubs per acre. Because of the growth form of dewberry, it was conjectured that the primary reason for lack of an established understory was the intensive competition created by meadow fescue within the subplots. Man-induced stress from cultivation and/or chemical application was also thought to be a possible explanation of the relatively early successional stage found at Prairie Station Pr-4. Generally, the prairie stations reflect the regional vegetation discussed by Kucera (1973), though the site contains none of the unique floras cited by him.

Prairie vegetation Sampling Stations Pr-1 through Pr-4 were composed principally of ground cover, with a representation of understory vegetation present in varying degrees. The composition, both area-wide and seasonal, by species, of these four sampling areas varied considerably, as evidenced in Appendix A-1 through Appendix A-12. The prairie sampling stations may be grouped in several ways according to their individual properties. The spring and fall species composition of Pr-1 and Pr-4 are most similar, with reed fescue and meadow fescue being the predominating species in each area during both seasons. The Prairie Sampling Stations Pr-2 and Pr-3 showed the highest species diversity, Pr-2 having 49 (spring) and 42 (fall), and Pr-3 having 35 (spring and fall) species, respectively. Considering production of biomass as a parameter, Pr-1, Pr-2, and Pr-4 showed moderate gains in herbage yield during the fall sample, while Pr-3 showed a general decline in production during the same time interval.

Structurally, the ground layer vegetation exhibited substantial difference at the various sampling locations, based on the species-area curve (Cain, 1938). On the basis of distribution in the species-area curve (Appendices A-1, A-4, A-7, and A-10), redtop, timothy, Kentucky blue grass, and Canada blue grass are the dominant ground layer species. Japanese lespedeza, Korean lespedeza, hairy chess, a carex, and a panicum were the predominant members of the supportive community.

The distinct seasonal "phasing" of the grass species was also evident. The "cool season" grasses, such as meadow foxtail, redtop, timothy, brome, and orchard grass diminished in importance at the time of the fall survey. "Warm season" grasses, including meadow fescue, panicum, and blue grass increased in prominence during the fall sampling. This natural variation is a normal seasonal occurrence and must not be misconstrued as a successional trend.

Vegetation of the understory, present at all of the prairie sampling stations, showed a considerable individual differentiation at each station. Species diversity for the understory included Pr-1 (10 species), Pr-2 (5 species), Pr-3 (3 species), and Pr-4 (1 species).

Overall, the dominant understory species averaged from all stations included persimmon, snowberry, and dewberry. White ash, slippery elm, honey locust, and pasture rose comprised the supportive elements.

Succession was evident generally throughout the prairie sampling stations, where both the ground layer and the understory vegetation indicated the evolving trend. This successional progression was well documented for Callaway County (Drew, 1942), particularly with respect to revegetation of abandoned land and the ensuing "rebound" or reinvasion by characteristic species. Drew (1942), and Cox et al. (1972) considered several periods of years as indicators of the general trend. These trends include:

1. First year: The dominant species, while reflecting the last grown crop, include primarily panic grasses, crab grass, common ragweed, trailing wild bean, plantain, and horseweed. Generally, the first year is composed of low-value grass species, composites and some legumes.

2. Second year: The composition remains ostensibly the same; however, goldenrods and asters are increasing in importance.

3. Third year: Compositional change alters abruptly from the previous year. The formerly dominant annual grasses and composites evidence a decline. An increase in perennial species is noted, with goldenrods, asters, and broomsedge showing an upsurge in absolute numbers.

4. Fifth year: The perennial species have taken hold by this time, with goldenrod and asters at an almost dominant position. Wire grasses are first noted at this stage. The important species of the first and second year are almost totally absent from the area.

5. Fifth to Twentieth year: The vegetation composition attained at the five-year period remains almost in equilibrium throughout this period, experiencing only minor changes. Subtle additions include development of dewberry, cinquefoil, legumes, and broomsedge. Introduction of woody species commences and is customarily well developed by the twentieth year. Competition between shade-tolerant and shade-intolerant species is pronounced at this time.

6. Twentieth to Thirty-fifth year: Increasing evidence of woody trees and shrubs is found, with a rapidly growing overstory eliminating all but shade-tolerant species. Species within this category include muhlenbergia, goldenrods, snakeroot, and meadow violet.

Subsequent to the thirty-fifth year, the woody species are generally well developed. As the woody species mature, they become important as regeneration seed sources. In transition areas (ecotones) between forests and pastures or oldfields, the presence of oaks, hickories, maples, elms, ashes, red cedars, sassafras, and persimmon was noted. These species served as excellent seed sources for the pastures and oldfields, which they adjoin. It is worthy of note that regeneration of these seed sources was evident during the fall sampling data (Appendix A-1 through Appendix A-12) for Stations Pr-1 through Pr-4.

Several of the understory species are considered to be transgressive, that is, transitional between the oldfield and the immature forest (Buzzaz, 1968). Species falling within this category include red cedar, sassafras, black oak, honey locust, and slippery elm. A listing of invader species, "Transitional Species Preferring Disturbed Sites" prepared by Dr. Dunn, is included (Appendix A-13). Buzzaz (1968) additionally considers the dissemination of propagules (seeds) of different species on old or abandoned fields to be of primary importance. Further, the success and viability of these vegetative species is responsible in large measure for an increase in the animal populations of the area (Johnson and Odum, 1956; Pearson, 1959).

Comparisons of similarity for the ground layer prairie vegetation based on importance values (Table 3.3.1-3) elicited some interesting conclusions. Prairie Stations Pr-2 and Pr-3 evidenced the highest similarity based principally on the mutual occurrence of redtop, a panicum, Canada blue grass, and Japanese lespedeza, with an index of similarity of 84.80 percent (Table 3.3.1-3). Prairie Stations Pr-1 and Pr-4 were also found to be most similar to one another, but here the reason for the similarity was the pervasive presence of meadow fescue based on an index of similarity of 83.76 percent (Table 3.3.1-3). The most dissimilar of the prairie stations were Pr-2 and Pr-4 with an index of similarity of 12.18 percent. Overall, distinct differences in composition were found to occur throughout the prairie ground layer sampling stations based on species composition and presence. Spring comparisons are presented in Table 3.3.1-4.

Similarity comparisons for the understory stratum of the prairie sampling stations (Table 3.3.1-5), indicated that Station Pr-1 and Pr-2 were most similar with an index of similarity of 80.5 percent. Prairie plots Pr-2 and Pr-4 were second in overall importance with an index of similarity of 56.9 percent. The most dissimilar plots were Pr-1 and Pr-4, with a second group Pr-3 and Pr-4 all having indexes of similarity of 0.00 percent (Table 3.3.1-5). These determinations indicated a homogeneity of composition between Pr-1 and Pr-2 which was not found for any other combination of plots.

Succession is influenced by many natural and induced factors. However, within the Callaway site specifically, it is felt that several factors are of paramount importance in regulating the speed of succession. These factors include climatic conditions favorable to seed production and plant growth, vigor of seedlings established in the prairie areas, availability of fertile seed sources, distance of the seed source from the field, size and general morphology of the seeds of various species, and finally, the occurrence of good seed production years. These natural factors, in concert with seasonal composition changes, serve to direct the successional trend of the Callaway Plant site both in composition and in time of development. A complete species table for prairie and forest vegetation was prepared (Appendix A-14).

Generally, the prairie sampling stations, both from the standpoint of ground layer and understory, will progress toward a woody shrub-dominated cover type in the foreseeable future. If undisturbed by man, fire or infestation, these sites potentially would develop into the oak-hickory forest associations characteristic of the vicinity of the Callaway Plant site.

Forest Vegetation Type

In this section, the vegetation of each of three strata--ground layer, understory, and overstory--is described for each of four forest sampling stations.

Generally, the upland central hardwood types were predominantly white oak, black oak, and red oak. On the more moist sites, such as those found in Callaway County, Missouri, codominants or subordinates usually were found to include along with the oaks, white ash, black cherry, sugar maple, slippery elm, Ohio buckeye, shagbark, and bitternut hickory, with flowering dogwood and sassafras the most numerous understory species. Locally common species included shadbush and hop-hornbeam on the drier sites and redbud and hornbeam on the more moist sites. Usually, these overstory and understory species occurred on residual soils developed from sandstone and shale but were also found on shallow limestone soils and areas covered with varying depths of loess.

At the conclusion of the discussion of each of the four sampling stations, an overall discussion of conclusions will be presented.

Forest Sampling Station F-1 showed remarkable diversity in floristic composition of the ground layer, with 41 distinct species present in the fall 1974 sampling. Several ground layer species were found to hold dominant positions in the F-1 sampling area. Fragrant sumac was the dominant, with a relative frequency of 33.3 percent, a relative dry weight of 21.82 percent, and an importance value of 25.15 (Appendix A-15). White oak and a carex (Carex rosea Schk.) were the second and third most frequent species, with relative frequencies of 6.66 and 7.77 percent, respectively (Appendix A-15). White oak had an importance value of 22.46 and the carex value was 16.56 (Appendix A-15). White ash and Virginia creeper (Parthenocissus quinquefolia L. Planch.) were fourth and fifth, with respective importance values of 16.34 and 12.41 (Appendix A-15). The remaining ground layer vegetation (36 species) had importance values lower than 10.

Dry weight, an important indicator of species presence during the spring and fall sampling programs, was utilized for Forest Station F-1. The estimated dry weight per acre, based on 162.63 grams per 0.25 milacre, was 40,657.50 grams (89.64 pounds per acre), as shown in Table 3.3.1-1. The Fall F-1 sampling station showed an overall decline in production of 28,707.5 grams (63.36 pounds) per acre.

Seasonal analysis of the dominant ground layer from Station F-1 indicated that the spring dominant was Virginia creeper (Appendix A-16). Both the spring and fall samples recorded 41 distinct species, with only 19 carryover species found during both surveys. A total of 63 distinct species was recorded from the ground layer of F-1.

The ground layer vegetation, as mentioned previously, exhibited a remarkable diversity in both spring and fall periods. This diversity was in part due to the open nature of the overstory and understory strata, discussed in the following section. The decline in herbage yield of the ground layer of Station F-1 was thought to be due in part to the lack of moisture available to the vegetation during the midsummer and fall of 1974. The ground layer vegetation is the most susceptible strata to moisture deficit. It was believed that succession within the ground layer is in the incipient or early pioneer stage and has not been taken over by the customary goldenrod-broomsedge cover type.

The understory of F-1 exhibited a surprising diversity of vegetative composition, with 24 distinct species represented. The predominant species of the understory in the vicinity of Forest Station F-1, both in importance and frequency, was flowering dogwood (Cornus florida L.). Flowering dogwood comprised 14.1 percent of the understory, on the basis of relative frequency, with an importance value of 35.3 (Appendix A-17). White oak and hickory (Carya sp. Nutt.) were also dominant in the understory, with relative frequencies of 10.1 percent and 12.1 percent, respectively (Appendix A-17). Though the hickory had a higher relative frequency than the white oak, the white oak had a much higher density (45.0) than the hickory (37.0) (Appendix A-17). Subdominant species included white ash, fragrant sumac (Rhus aromatica Ait.), hop-hornbeam (Ostrya virginiana (Mill.) K. Koch.), and black oak, with importance values of 19.6, 19.5, 14.9, and 12.1, respectively (Appendix A-17). The remaining understory species included shadbush (Amelzanchier arborea (Michx. F.) Fern.), slippery elm, red cedar (Juniperus virginiana L.), red oak, winter grape (Vitis vulpina L.), dewberry (Rubus flagellaris Willd.), poison ivy (Rhus radicans L.), red mulberry (Morus rubra L.), summer grape (Vitis aestivalis Michx.), hackberry (Celtis occidentalis L.), Ohio buckeye (Aesculus glabra Willd.), virburnum (Viburnum sp. L.), black cherry (Prunus serotina Ehrh.), hawthorn (Crataegus sp. L.), sassafras (Sassafras albidum (Nutt.) Neew.), sugar maple (Aceor saccharum Marsh.), and grayback grape (Vitis cinerea Engelm.) (Appendix A-17). The vegetation of the understory amounted to an average of 23.0 trees and/or shrubs per quadrat, and by extension, 3,726 trees and/or shrubs per acre.

The great diversity of species within the understory of Forest Station F-1 was explained by the fact that the overstory consisted of an open canopy that permitted the shade-intolerant understory species to flourish and become well established. It was also noted that many of the understory species within range of Station F-1, such as the grapes, ivy, cherry, sassafras, viburnum, mulberry, and dewberry provide outstanding forage sources as well as cover, concealment, and habitat for wildlife species.

Overstory in the Forest Sampling Station F-1 area was dominated by white oak (including species and varieties) with a cumulative basal area of 4,337.4 square inches. White oak held a relative frequency of 25.5 percent, a relative density of 28.8 percent, and an overall importance value of 132.8 (Appendix A-18). Two species of secondary importance included flowering dogwood and black oak, with importance values of 43.8 and 34.2, respectively. The flowering dogwood had a relative frequency of 16.4 percent and a relative density of 25.2 percent, while black oak had a relative frequency of 14.5 percent and a relative density of 17.1 percent. Shagbark hickory and post oak were additional subdominant species having importance values in excess of 15.0, namely 18.7 and 16.1, respectively. The remaining species tallied for Forest Station F-1 included shadbush, black hickory, hop-hornbeam, red oak, slippery elm, red cedar, mockernut hickory and white ash. Statistically, there were 6.9 trees per quadrat, a total of 279.5 trees per acre. The basal area per quadrat was 348.5 square inches, which was equivalent to 14,114.3 square inches per acre.

Structurally, the overstory exhibited substantial stratification, partially due to the open canopy condition. Support for this conclusion, in addition to the sample data, were the increment cores taken and analyzed from the F-1 station. The cores evidenced an age spread from 15 years for a slippery elm and flowering dogwood specimen, to 135 years for a hybrid oak specimen (Appendix A-19). Further support for the uneven-aged nature of the stand was found in the diameter classes of the increment core study. Three distinct groups were evident: a 2.0 to 2.5-inch class, a 4.00- to 7.00-inch class, and a 12.01- to 17.00-inch class. The larger diameter class was composed chiefly of white and hybrid oaks. This size class differentiation indicated that the stand, though diverse, had not attained maturity, evidenced by the "regenerative" nature of the 2.0-inch diameter species. A mature, even-aged stand was not expected to display such diversity; therefore, it was felt that Station F-1, though showing several over-mature specimens, was not a mature, climax oak-hickory forest stand. Succession, if allowed to proceed undisturbed for Station F-1, would be expected to evolve to a closed canopy oak-hickory forest characteristically found within the region.

The ground layer of Forest Sampling Station F-2 had a high species diversity. A total of 38 distinct species was tallied during the fall 1974 sampling program. The dominant species of the ground layer at F-2 during the fall was fragrant sumac, which had a relative frequency of 5.81 percent and an importance value of 21.18 (Appendix A-20). Virginia creeper was second in overall prominence, with a relative frequency of 9.30 percent and an importance value of 16.38 (Appendix A-20). The fragrant sumac was dominant, though its relative frequency was less than Virginia creeper, because its dry weight (19.30 grams) was greater than that of the Virginia creeper (8.90 grams). The third and fourth species in order were white oak and elegant bedstraw (Galium cocinnum Torr. & Gray), with importance values of 15.44 and 13.94, respectively (Appendix A-20). The remaining species with importance values greater than 10 were a carex (Carex rosea Schk.) (13.52), wild bean (Strophostyles helvola L. Britt.) (13.10), and hop-hornbeam (10.52) (Appendix A-20). Ground layer vegetation with importance values less than 10 included 31 species (Appendix A-20).

Clippings from forest subplots during the fall 1974 sampling revealed a general decline in production of herbage from the dry weights obtained during the spring sampling period. This reduction in biomass was reflected in a comparison of the total weights, both spring and fall. In the spring, the sample station yielded 65,725 grams (145 pounds) per acre. The fall sampling yielded a production of 31,387.5 grams (69.20 pounds) per acre for a net loss of 4,337.5 grams (75.8 pounds) per acre of slightly greater than a 50 percent decline in production. It was felt that this decline in production of herbage was due to a particularly dry summer-fall period of 1974 that caused some of the species to be "phased out" due to lack of moisture.

The composition of Forest Station F-2 did not change radically. The spring dominant was Virginia creeper (Appendix A-21), while the fall dominant was fragrant sumac. In the spring, the second species of importance was the fragrant sumac and in the fall Virginia creeper was of second importance. By virtue of the large number of species (54) collected in the spring sample, no individuals other than those already mentioned had importance values above 10 (Appendix A-20). In the fall, species with importance values greater than 10 included white oak, elegant bedstraw, a carex, wild bean, and hop-hornbeam.

Comparison of the species diversity of the ground layer between the spring and fall indicated that 54 separate species were recorded from the spring sampling and 38 species were recorded for the fall sample. A total of 19 carryover species were recorded for both sampling periods. The total species diversity for spring and fall from the ground layer of Station F-2 was 73 distinct species.

Understory at Forest Sampling Station F-2 had the broadest species diversity found to exist at any of the four stations. A total of 30 distinct species were recorded in the fall 1974 sampling program. The most important species, from the standpoint of importance value and relative density, was fragrant sumac, with figures of 25.9 and 18.3 percent, respectively (Appendix A-22). It was interesting to note, however, that flowering dogwood, white oak, and white ash each had greater relative frequency than fragrant sumac, with 9.0 percent, 8.3 percent, and 9.7 percent opposed to the value for sumac, which was 7.6 percent (Appendix A-22). Though these species were more numerous than fragrant sumac, their relative densities were much lower. That is to say, the density of fragrant sumac was higher in those subplots where it was found. This suggests that fragrant sumac had a clustered distribution rather than a random heterogeneous distribution within the sampled quadrats. The importance values of the subdominant species were flowering dogwood (22.8), white oak (18.6), and white ash (15.2) (Appendix A-22). The remaining species found in the subdominant category was sugar maple, with a relative frequency at 4.8 percent and an importance index of 11.5 (Appendix A-22). The remaining species recorded at Station F-2 had importance values less than 10 and included in order, hickory, snowberry, black oak, pasture rose, poison ivy, shadbush, slippery elm, black haw (Viburnum prunifolium L.), wild plum (Prunus americana Marsh.), red cedar, black cherry, prickly ash (Zanthoxylum sp. L.), sassafras, persimmon, bittersweet (Celastrus sp. L.), winter grape, grayback grape, black raspberry (Rubus occidentalis L.), hop-hornbeam, hawthorn, red oak, American bittersweet (Celastrus scandens L.), red mulberry, wahoo (Euonymus atropurpureus Jacq.), and catbrier (Smilax sp. L.). Statistically, Sampling Station F-2 had 39.9 trees and/or shrubs per each 6.25-milacre plot. This density was equivalent to 6,463.8 trees and/or shrubs per acre (Appendix A-22).

Forest Station F-2, with such a rich and interesting diversity of species, was an open canopy overstory. The open canopy permitted a wide variety of shade-intolerant species to prosper, species which in a closed canopy situation would not likely have survived. Successionally, competition among dominants in this sampling area was still in the preliminary stages, judging from the closely bracketed densities of the species comprising the understory at F-2. Forage species were abundant in the Sampling Station F-2 area. Species of importance included fragrant sumac, shadbush, black haw. black cherry, sassafras, persimmon, bittersweet, grapes, black raspberry, red mulberry, and catbrier. The F-2 understory was an excellent area for cover and concealment for wildlife species and met all the requirements for a good habitat with considerable carrying capacity.

Overstory vegetation within Forest Sampling Station F-2 was dominated by 13 species, of which white oak (including the species and varieties) was most dominant. White oak was by far the most ubiquitous species, with an importance value of 134.9 (Appendix A-23). White oak, further, had a relative frequency of 25.0 percent, a relative density of 46.7 percent and a cumulative basal area of 2,859.7 square inches (Appendix A-23). Shagbark hickory was the subdominant species, having second position in the stand with an importance value of 43.5 (Appendix A-23). Black hickory and red oak were the next prominent species in the stand, with importance values of 26.4 and 23.5, respectively. It was interesting to note that although red oak was fourth based on importance value, it ranked second based on basal area (515.9 square inches), which indicated that though red oak had a relative frequency of only 8.3 percent, those specimens tallied were all of a more mature diameter class than the other species of the stand. The remaining species having an importance value greater than 15.0 were black oak (22.2) and flowering dogwood (20.5) (Appendix A-23). The remaining components of the overstory from Station F-2 included, in order, shadbush, mockernut hickory, sassafras, post oak, black cherry, red mulberry, and persimmon. The overstory components amounted to 9.8 trees per quadrat or 396.8 trees per acre with basal areas of 282.7 square inches per quadrat and 11,449.4 square inches per acre.

The overstory of Station F-2 demonstrated stratification, though in this sampling area, the strata were not found to be as distinct as observed for Stations F-1, F-3, or F-4. The oaks and hickories displayed similar dominance of the overstory of F-2, supported by shadbush, dogwood, black cherry, and red mulberry. The lack of observable distinct strata within the sampling area was further related to a lack of refined diameter classes taken for increment core aging (Appendix A-19). The size classes ran from 2.16 through 8.00 inches, with fairly uniform representation throughout. One separate class (11.18 inches) was found for a single white oak specimen. The age classes ran from 17 to 62 years without major breaks. Though this age and diameter class information indicated that forest stand F-2 was an uneven aged stand, the marked absence of clean-cut size and age classes indicated that this stand was becoming a distinct oak-hickory forest. The prominence of the understory vegetation (30 distinct species), coupled with the density, led to the observation that the young overstory stand supported a rich understory flora by virtue of its open canopy. Shade tolerance and species competition were among the prime factors noted serving to shape the Forest Station F-2. If undisturbed, succession will be expected to lead this stand toward the climax oak-hickory forest type characteristic of the area.

Forest Sampling Station F-3 exhibited a moderate species diversity within the ground layer stratum during the fall 1974 sampling. Specifically, 28 separate species were recorded for F-3 in the fall. Fragrant sumac was the most dominant species recorded, with an importance value of 26.73 (Appendix 24), a relative frequency of 6.32 percent and a density based on dry weight of 22.17 grams (Appendix A-24). A carex (Carex rosea Schk.) was the species of secondary importance in Station F-3, with an importance value of 25.31 (Appendix A-24). The third and fourth species, Virginia creeper and tick trefoil (Desmodium nudiflorum L. D.C.), held importance values of 25.26 and 19.93, respectively (Appendix A-24). Wild bean and horse-mint (Monarda russeliana Nutt.) were the fifth and sixth species of importance, with values of 15.09 and 12.26 in order. There were 22 additional species recorded having importance values lower than 10 (Appendix A-24).

Determination of dry weight values from plot clipping at Forest Station F-3 during the fall 1974 sampling revealed a marked decline in production of herbage from the dry weights obtained during the spring sampling period. This decline in biomass was noted in comparison of total weights for both spring and fall. During the spring, Station F-3 yielded 44,300 grams (98.00 pounds) per acre. Data from the fall sample indicated production to be 27,145 grams (59.85 pounds) per acre based on 108.58 grams per 0.25-milacre quadrat. The net loss in production was a total of 17,155 grams (38.15 pounds) per acre. This decline in production was thought to be due largely to the general dry period from midsummer to fall 1974, in the vicinity of the F-3 site.

Species diversity comparisons of the ground layer between the spring and fall demonstrated that 38 species were recorded from the spring sample (Appendix A-25) and 28 species from the fall. A total of 17 carryover species were noted during the 1974 sampling effort. Total species diversity for the ground layer of Forest Station F-3 was 49 separate species. Spring and fall comparisons of species revealed that fragrant sumac remained the dominant species throughout the year. In the spring, Virginia creeper, wild bean, tick trefoil, wild licorice (Galium circaezans Michx.), and grayback grape held the dominant positions. In the fall, a carex (Carex rosea Schk.), Virginia creeper, tick trefoil, wild bean, and horse-mint were the dominant species. This information indicates a stable ground layer vegetation.

The understory vegetation of Forest Sampling Station F-3 exhibited considerable diversity in species composition. Twenty-four species were present and were recorded during the fall 1974 sampling program. The dominant species recorded was fragrant sumac, which had an importance value of 70.7 (Appendix A-26). Flowering dogwood was the next most important species, with an importance value of 22.6 (Appendix A-26). Flowering dogwood had greater relative frequency (13.2 percent) than fragrant sumac (12.3 percent), which indicates that the sumac had a non-random grouped (clonal) distribution (Appendix A-26). Subdominant species with importance values greater than 10 included black cherry (14.7), black oak (13.4), hickory (13.1), and white oak including the varieties (10.8) (Appendix A-26). The supportive species also found within subplots at F-3 included, in order, sugar maple, sassafras, red oak, winter grape, pasture rose, dewberry, grayback grape, wild plum, red mulberry, red cedar, snowberry, hawthorn, white ash, summer grape, shadbush, hackberry, persimmon, and black haw. In total, there were 39.9 trees and/or shrubs per quadrat and 6,463.8 trees and/or shrubs per acre within Forest Station F-3.

The density and importance value of fragrant sumac (Appendix A-26) establish it as the dominant species in Forest Station F-3. Once again, however, as in F-1 and F-2, the open canopy had permitted many species of the understory strata to compete for light and space. This, then, was the reason why the flora of F-3 was so varied. Forage sources were available and considerable in quantity at F-3 and should provide excellent habitat for wildlife.

Overstory vegetation in the F-3 area was composed of 13 distinct species and was dominated by white oak (including species and varieties). White oak had a relative frequency of 26.9 percent, a relative density of 57.0 percent, a relative dominance of 58.3 percent, and an importance value of 142.2 (Appendix A-27). White oak had a cumulative basal area of 3,175.1 square inches, which was more than 2.5 times greater than that of black oak, the next forest dominant, with a basal area of 1,296.3 (Appendix A-27). Black oak had an importance value of 54.5, which would have been a respectable figure were it not for the pervasive size and frequency of the white oak component of the stand. Additional elements of the overstory included flowering dogwood, black hickory (<u>Carya</u> <u>texana</u> Buckl.), and post oak, with respective importance values of 25.2, 23.2, and 16.5 (Appendix A-27). The relative frequencies of these species were: flowering dogwood (17.3 percent), black hickory (11.5 percent), and post oak (7.7 percent) (Appendix A-27). The remaining elements of the overstory with importance values less than 15.0 were red oak (14.5), shagbark hickory (8.7), sugar maple (6.9), mockernut hickory (3.1), red mulberry (2.6), and grayback grape (2.6) (Appendix A-27). There were a total of 10.8 trees per quadrat, or 437.4 trees per acre having a basal area per quadrat of 333.2 square inches and a basal area per acre of 13,494.6 square inches.

The physiognomy of the overstory exhibited considerable stratification, the oaks being the highest within the strata, subtended by the hickories, maple, and red mulberry. This stratification is further supported from the increment core data (Appendix A-19), which show that for Sampling Station F-3, the oaks generally are older species, ranging from 38 to 50+ years, whereas most of the hickories range from 10 to 35 years, with one notable exception being a black hickory 61 years old. The diameters also indicated that this was an uneven-aged stand by virtue of the three size classes observed, namely 2 to 2.5 inches, 3 to 7 inches, and 8 to 13 inches. The oaks were well represented in the largest diameter class and the supportive community in the small and medium-size classes. Probably, then, this oak-hickory stand was not yet mature, judging from diameter classes and strata of the overstory, combined with the wide diversity of the understory species. Reproduction of selected overstory species was noted for the understory, indicating that the overstory was reproductively active and had not gone into the regenerative "stagnation" noted for some mature and overmature forests of the oak-hickory type. This forest in the future will develop into a closed-canopy oak forest type with mixed hickory interspersed. This successional trend is believed to be correct if no detrimental external influences interrupt the direction of the advancing stand development.

Forest Sampling Station F-4 demonstrated considerable diversity of ground layer species, possessing 29 separate species at the time of the fall sampling. Dominance was held by fragrant sumac, which had a relative frequency of 10.6 percent, a relative dry weight of 24.04 percent, and an importance value of 34.64 (Appendix A-28). Wild bean and sunflower (Helianthus strumosus L.) were second and third most frequent species, with relative frequencies of 9.09 percent and 3.03 percent, respectively (Appendix A-28). The importance value of wild bean was 14.85 and for sunflower, 13.33 (Appendix A-28). Pasture rose and black oak were fourth and fifth in order, with importance values of 13.27 and 11.93 (Appendix A-28). A carex (Carex rosea Schk.) and elm-leaf goldenrod (Solidago ulmifolia Muhl.) were the last species having importance values greater than 10.0, namely, 10.33 and 10.3, in order. The remaining vegetation (22 species) of the ground layer had importance values less than 10.0.

Dry weight, utilized in this study, was an important indicator of species presence, both in spring and fall samples. For F-4, the estimated dry weight based on 167.40 grams per 0.25 milacre was 41,850 grams (92.27 pounds) per acre, as shown in Table 3.3.1-1. An overall decline in productivity was noted for Station F-4. This reduction in biomass was 24,270 grams (53.73 pounds) per acre.

Changes in seasonal composition of the dominant flora of F-4 were noted. The spring dominant, Sampson's snake root (Psoralea psoralioids [Walt.] Corry var. elandulosa [Ell.] Freeman) (Appendix A-29) was replaced by fragrant sumac in the fall sampling. The spring subdominants fragrant sumac, black-jack oak, bur oak hybrid (Quercus macrocarpa Michx. V Q. marilandica), and the pasture rose shifted importance with the fall sample subdominants, wild bean, sunflower, pasture rose, black oak, a carex (Carex rosea Schk.), and elm-leaf goldenrod. The spring sample recorded 44 distinct species, with 20 carry-over species to the fall sample, which comprised 29 species. Totally, 53 species were present for the spring and fall samples at Station F-4.

The vegetation composing the ground layer at F-4 exhibited a moderate diversity, somewhat greater in the spring than in the fall. The understory and overstory of F-4 support the contention that there was an open canopy condition existing within the F-4 area. The "openness" of the canopy was not as pronounced as that found at F-1 or F-2, which explains why the diversity of species based on shade intolerance was less at Sampling Station F-4. The marked decline in biomass production recorded for F-1 through F-4 supported the belief that the extensive dry midsummer and fall of 1974 caused loss of herbage through wilt and lack of growth generally. The ground layer vegetation was most subject to moisture changes and by virtue of that fact reflected the moisture deficit in terms of reduced or arrested production. Successionally, F-4 will continue to proceed toward the woody perennial stage if left undisturbed.

Vegetation comprising the understory at Forest Sampling Station F-4 demonstrated a wide diversity in composition, with 25 distinct species represented. The most predominant species in the understory of F-4 recorded during the fall 1974 sampling was fragrant sumac, which had an importance value of 44.9 (Appendix A-39). Fragrant sumac had a relative frequency of 13.5 percent and a relative density of 31.4 percent (Appendix A-30). Three other species comprised the supporting subdominants having importance values greater than 10. Black oak was second in prominence, with an importance value of 31.7. White oak and flowering dogwood were third and fourth in rank, with respective importance values of 27.0 and 11.8. The remainder of the species recorded for Station F-4 had importance values less than 10, and in order included red oak, white ash, hophornbeam, hickory, sugar maple, shadbush, black cherry, pasture rose, grayback grape, winter grape, hawthorn, persimmon, red cedar, hybrid oak, post oak, dewberry, red bud, wahoo, wild plum, sassafras, and slippery elm. The understory was developed to the point at which there were 25.7 trees and/or shrubs per quadrat and 4,163.4 trees and/or shrubs per acre.

A diversity of 25 species indicates, as in the other understory Sampling Stations F-1 through F-3, that the forest in which these species comprised the understory is not a closed canopy type. Indeed, with as much diversity as was recorded for the understory, considering density alone, the overstory was quite open, with many "breaks" in the cover. The open canopy has permitted the understory to develop to a high degree. Being highly diverse, Sampling Station F-4 had not established well-developed formal successional patterns. Discounting the dominant species somewhat, consideration was directed toward the specific vegetative components that served to form a foundation for the strata.

Species from the understory of F-4 that provided forage to wildlife populations included hickory, shadbush, black cherry, grapes, hawthorn, persimmon, oaks, dewberry, wild plum, and sassafras. These edible species provided excellent cover and concealment habitat, as well as food, to many wildlife forms.

Overstory vegetation in the area of Forest Sampling Station F-4 exhibited moderate diversity, with 11 species represented. The dominant species was white oak (including species and varieties), with an importance value of 92.7 (Appendix A-31). Black oak was the second species, having an importance value of 88.0 (Appendix A-31). However, if judged solely on basal area, black oak, with 2,115.3 square inches, would have been first, followed by white oak, with 1,241.9 square inches. White oak was more important because of its higher frequency of occurrence (28.6 percent) as opposed to that of black oak (23.8 percent). Post oak was the species holding third position, with a relative frequency of 21.40 percent, a relative density of 23.1 percent, and an importance value of 65.0 (Appendix A-31). The last species holding an overstory importance value greater than 15 was flowering dogwood, with 15.6 (Appendix A-31). The remaining species were tallied for Forest Station F-4 and included, in order, sugar maple, black-jack oak, black hickory, shagbark hickory, slippery elm, shadbush, and white ash. Physically, the overstory comprised 5.7 trees per quadrat, or 230.9 trees per acre. The basal area was 290.5 square inches per quadrat, yielding 11,765.3 square inches per acre.

The overstory of Forest Station F-4 showed a pronounced stratification, dominated by six species of oak, with a supportive strata composed of maple, dogwood, and hickories. The increment cores taken from F-4 added further insight to the stratification. Once again, three predominant diameter classes (2 to 2.5 inch, 3 to 9 inch, and 10 to 16 inch) emerged from the sampling station. The most direct correlation between age and diameter class-species relationship was observed for F-4. Three age classes (30+ years, 60 to 70 years, and over 100 years) supported the supposition that this was yet another example of an uneven-aged stand. The open canopy, the predominance of seedlings of overstory species within the understory, and the age structure data provided emphasis to this determination. The domination by oak species within this station, coupled with the age determinations of the cores, indicated that F-4 was a sub-climax oak-hickory forest type. If this stand were undisturbed, it would in time develop to a more even-aged, mature oak-hickory association with a gradual decline in supportive species such as dogwood, shadbush, and possibly white ash.

The composition by species of Forest Sampling Stations F-1 through F-4 was varied, but most widely diverse in the ground layer. Less diversity was found in the understory, with the overstory remaining fairly stable. Ground layer data were presented in Table 3.3.1-6, understory data in Table 3.3.1-7, and overstory data in Table 3.3.1-8. Species most common in the ground layer included Virginia creeper, fragrant sumac, white oak seedlings, and wild bean. For the understory, white oak, hickory, white ash, fragrant sumac, hop-hornbeam, and black oak were the most commonly occurring species. In the overstory strata, white oak was the overall dominant, with flowering dogwood, shagbark hickory, black oak, black hickory, and red oak also usually present. Comparisons of spring data for Stations F-1 through F-4 are presented in Table 3.3.1-9.

Though a seasonal "phase" change was observable for ground layer vegetation in F-1 through F-4, no such temporal relationship occurred within either the understory or overstory sampling areas. Generally, the openness of the overstory canopy was responsible for the well developed and diversified understory and ground layer vegetation. Succession, particularly in the ground layer, was difficult to describe, with stages varying from incipient oldfield to areas in which the ground layer was substantially interspersed with understory woody specimens. In the understory, however, successional pathways were more distinct, with a profusion of tree seedlings and saplings of overstory species present and usually dominant within the understory stratum. Useful indicator species for disturbance were compiled by Dr. D.B. Dunn (Appendix A-13). These species were considered transgressive or transitional species characterized as "invaders" or decreaser species that indicated a stress to the vegetation. Being highly competitive for space, these species have been found to frequent all types of disturbed sites. Particular reference in Appendix A-13 is made to species found in or among both the prairie and forest sampling locations. In addition to the table of transitional species (Appendix A-13), a complete species table for all sites and strata is included (Appendix A-14). This table identifies the species by common and scientific name, by the location of the sampling station in which it was found, and in what strata it was observed.

The understory of Forest Stations F-1 through F-4 exhibited a marked diversity of species, which was somewhat surprising considering the age of the overstory stratum. This diversity may have been a response to pyric or moisture stresses of the past in which the understory was eliminated and subsequently new species invaded the stressed area. Kucera et al. (1963) indicated that fire (and, by extension, moisture stress) could retard development of woody species growth in prairie locations. Further, subsequent to a fire (or moisture) stress, relatively high productivity was experienced. The accumulation of understory litter was responsible for developing a maximum fuel load, which would increase the effectiveness of fire in controlling woody growth of ground layer or understory species. This information added further support to the hypothesis that in areas F-1 through F-4, some environmental stress of the past brought about the remarkable diversity of species found in the forest sampling areas.

Overstory vegetation of the Callaway County area has been described in the past. Minkler (1971) has described the composition of a Missouri forest of the past as chiefly red gum, black gum, white oak, black oak, hickories, white ash, red maple, elm, hackberry, and cottonwood. His information was drawn from a site evidently more mesic than the Callaway Plant site area based on the red gum, black gum, and cottonwood species. However, the data indicated that this forest of the past had a balanced structure with a great diversity of species and age classes. Minkler (1971) stated that he considered the ability of overstory species to tolerate saturated soils and standing water to have little effect in determining species composition. He felt rather that shade tolerance and growth rate combined with past occurrences created openings in the forest. His observations were found to fit the data very well and supported the contention that some stress had occurred during the past that led to the profusion of species observed in the forest sampling stations.

The overstory was influenced by edaphic factors, as observed in the field. The Menfro soil series, a silt-loam deep loess, extended from the edges of the river bluffs and provided an excellent medium for establishment of forested stands. Based on early land records from 1816 and 1817 (Wuenscher and Valionas, 1967), the major dominant forest species in Missouri that were characteristic of this soil type were, in order of importance, white oak, sugar maple, black oak, hackberry, white ash, and assorted hickories. Specifically, for Callaway County, the dominant species and their importance values were white oak (82), black oak (37), hickory (35), sugar maple (35), and elm (24) (Wuenscher and Valionas, 1967). It was pointed out that during the distant past, the Kansan glaciation extended into Callaway County, leaving soil deposits that have, over the years, provided the edaphic foundation of the current vegetation of the county and, indeed, the Callaway Plant site specifically.

Characteristically, the overstory of the forest sampling stations was composed of white oak found on all upland sites, slopes, and ridgetops except for very xeric or shallow soil ridges (Duncan and Ellis, 1969). Associated species, according to Duncan and Ellis (1969), generally were found to include post oak, sassafras, persimmon, black cherry, and white ash including various xerophytic hickories. For the drier sites, post oak and black oak were observed to occur but because of their intolerance to competition on bottom soils, they usually were relegated to poorer sites. Duncan and Ellis (1969) noted that black oak, due to its extreme shade intolerance, usually was not found to succeed itself unless major disturbance occurs in the forest canopy. It was further illustrated that post oak-black oak stands were generally found as second growth communities following cutting or other major disturbances (Duncan and Ellis, 1967).

Successionally, it was determined that the forest stand types located at Forest Sampling Stations F-1 through F-4 were relatively young, based on diameter classes and the longevity of the dominants determined from the increment core study. Additionally, all stands were found to be uneven-aged, based on diameter class and the observed physiognomic stratification present in the subplots. Characteristic of the more mature overstory was a decrease in the diversity of the species comprising the stand. The overall direction of the forest stands, if undisturbed, is toward a mature, even-aged stand having white oak as the dominant, black oak and various hickories as subdominants, and a mixture of post oak, black jack oak, black hickory, red oak, and flowering dogwood. The canopy openings in the overstory were expected to close gradually, eliminating all but the woody shade-tolerant understory species, which gradually will "fill" the gaps in the overstory.

Comparisons were undertaken for the ground layer to determine the index of similarity for the various forest sampling stations (Table 3.3.1-6). Forest Stations F-2 and F-3 were the most similar with an importance value of 77.79 (Table 3.3.1-6). In decreasing order of similarity, the remaining groups were F-1 and F-3 (72.0 percent), F-1 and F-4 (70.46 percent), F-3 and F-4 (61.98 percent), F-2 and F-4 (61.?0 percent), and finally F-1 and F-2 (60.43 percent) (Table 3.3.1-6). The reason there was such a small spread in the indices of similarity (77.79 to 60.43 percent) was believed to be the prominence of four species, a carex (Carex rosea Schk.), fragrant sumac, wild bean, pasture rose, and, at three of the stations, Virginia creeper. The relatively clustered indices of similarity indicated that the ground layer generally was fairly representative throughout the forested sampling areas.

Index of similarity comparisons for the understory of the forest sampling stations (Table 3.3.1-7) was found to have a clustered distribution. Sampling Stations F-3 and F-4 were the most closely similar stations, with an index of similarity of 89.6 percent. Next in order of similarity were Stations F-1 and F-4, with an index of similarity of 88.9 percent (Table 3.3.1-7). The species of importance throughout the understory were fragrant sumac, flowering dogwood, white oak, and white ash. The most dissimilar sampling stations were F-1 and F-3, with an index of similarity of 78.1 percent (Table 3.3.1-7).

The dominance of white oak, as previously discussed, was common to all of the forest overstory sampling stations. Utilizing the species dominance information, an index of similarity based on frequency, density, and dominance values was developed for Stations F-1 through F-4 (Table 3.3.1-8). Based on this data, F-2 and F-3 were most similar with an index of 93.6 percent (Table 3.3.1-8). Next in order, were F-1 and F-3 (92.3 percent), F-1 and F-4 (90.3 percent), F-1 and F-2 (90.1 percent), and F-3 and F-4 (87.5 percent) (Table 3.3.1-8). The forest sampling stations with the lowest index of similarity were F-2 and F-4 (67.4 percent) (Table 3.3.1-8). The overstory vegetation common to all sampling stations included four oak species, three hickory species, sugar maple, shadbush, flowering dogwood, and hop-hornbeam.

Many factors, natural and induced, have served to alter the composition of the vegetation in Callaway County. These factors have greatly influenced the vegetation by altering the succession rates constantly at work. For the county generally, and the site specifically, the vegetation, if removed from influence by man, would develop to the characteristic oak-hickory forest association previously discussed.

3.3.1.2 Soils

The chemical analysis results of the 10 soils at the permanent sampling stations are shown in Table 3.3.1-10. In general, soils in the agricultural areas (Pr-1, Pr-2, Pr-3, and Pr-4) have a higher concentration of plant nutrients than those in the forested areas (F-1, F-2, F-3, and F-4). This is expected since forests in this area do not generally receive fertilizer applications. Concerning the heavy metals, there does not appear to be any clear relationship between vegetative type and concentration, with the possible exception of Prairie Sampling Station Pr-1. This station has a greater abundance of heavy metals, consisting predominantly of lead, chromium, and manganese, than any other permanent sampling station. In general, the chemical composition of the soils of permanent sampling stations does not appear unusual.

The results of the herbicide and pesticide residual analyses of the soils are shown in Table 3.3.1-11. Of these residuals examined, none appear to be abundant.

TABLE 3.3.1-1

SOME CHARACTERISTICS OF GROUND LAYER VEGETATION[a] BASED ON PLOT CLIPPINGS AT THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Characteristics	Sampling Stations							
	Prairie				Forest			
	PR-1	PR-2	PR-3	PR-4	F-1	F-2	F-3	F-4
Estimated Dry Weight/acre								
grams	1,522,380.00	1,012,950.00	940,500.00	1,271,275.00	40,657.50	31,387.50	27,145.00	41,850.00
pounds	3,356.84	2,233.55	2,073.80	2,803.16	89.64	69.20	59.85	92.27
Average	1,186,776.25 grams 2,616.83 pounds				35,260.00 grams 77.74 pounds			
Number of species identified in subplots (including hybrids)	17	42	35	13	41	38	28	29
Average number of species occurring in each subplot (16 subplots per station)	2.93	11.43	8.93	2.68	5.62	5.37	4.93	4.12

[a]Includes herbaceous species and woody plants of less than 20 inches in height.

TABLE 3.3.1-2

SOME CHARACTERISTICS OF GROUND LAYER VEGETATION[a] BASED ON PLOT CLIPPINGS AT SAMPLING STATIONS OF THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY - JUNE 1974

Characteristics	Sampling Stations							
	Prairie				Forest			
	Pr-1	Pr-2	Pr-3	Pr-4	F-1	F-2	F-3	F-4
Estimated Dry Weight/acre								
grams	1260890	936125	1156205	873955	69365	65725	44300	66120
pounds	2780	2064	2549	1926	153	145	98	146
Average		1056794 grams 2330 pounds				61377 grams 135 pounds		
Number of species identified in subplots (including hybrids)	23	49	35	23	42	55	39	46
Average number of species occurring in each subplot (16 subplots per station)	5.75	15.81	12.00	3.87	6.44	8.94	6.56	5.25

[a]Includes herbaceous species and woody plants of less than 20 inches in height.

TABLE 3.3.1-3

COMPARISONS WITHIN AND BETWEEN SAMPLING STATIONS BASED ON CALCULATED IMPORTANCE VALUES[a] FOR MAJOR COMPONENT SPECIES OF GROUND LAYER VEGETATION[b] OCCURRING IN SUBPLOTS OF PRAIRIE HABITATS, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Species	Sampling Stations			
	Pr-1	Pr-2	Pr-3	Pr-4
Achillea millifolium L.		1.79		
Agrostis alba L.		39.91	32.04	
Ambrosia bidentata Michx.		5.45	4.84	
Andropogon virginicus L.		2.01		
Aristida oligantha Michx.		11.78	1.55	
Aster pilosus Willd.		2.87	4.85	
Bromus sp. L.			1.50	
Carex glaucodea Tuckerm.	6.49	3.60		
Carex sp. L.		2.69		
Convolvulus sepium L.		1.26		
Croton capitatus Michx.		4.95		
Crotonopsis elliptica Willd.			1.40	
Diospyros virginiana L.		1.28		
Festuca elatior L.	132.94		4.03	136.20
Juncus tenuis Willd.		1.86	4.54	
Lespedeza stipulacea Maxim.	4.25	5.02	8.80	14.14
Lespedeza striata (Thunb.) H.&A.	8.56	11.66	10.39	7.08
Lespedeza violacea (L.) Pers.				7.00
Melilotus alba Desr.				14.25
Moss sp.	4.68		6.25	
Muhlenbergii schreberi Gmel.		3.77	6.30	
Panicum lanuginosum Ell.	10.75	12.45	10.51	
Paspalum ciliatifolium Michx.			2.97	
Paspalum laeve Michx.		3.77	5.12	
Phleum pratense L.		8.35	5.91	
Poa compressa L.		24.23	45.41	
Poa pratensis L.		9.75	15.52	
Potentilla simplex Michx.	10.83	3.58		
Prunella vulgaris L.		2.89		
Pycnanthenum tenuifolium Schrad.		5.85		

TABLE 3.3.1-3 (continued)

Species	Pr-1	Pr-2	Pr-3	Pr-4
	Sampling Stations			
Ruellia humilis Nutt.		1.86		
Solanum carolinense L.		3.67	2.24	4.74
Solidago altissima L.		7.37	4.64	
Tridens flavus (L.) Hitchc.		3.31	3.00	
Trifolium repens L.		5.93		
Vernonia baldwini Torr.		1.68		
Vernonia missurica Raf.		1.99		
TOTAL	178.50	196.58	181.81	183.41

Comparisons between Sampling Stations	Summation of Importance Values for Species Common to both Stations	Summation of Importance Values for Species Occurring at only one Station	Index of Similarity (%)[c]
Pr-1 vs. Pr-2	77.19	297.89	20.57
Pr-1 vs. Pr-3	201.16	159.15	55.82
Pr-1 vs. Pr-4	303.17	58.74	83.76
Pr-2 vs. Pr-3	320.88	57.51	84.80
Pr-2 vs. Pr-4	46.31	333.68	12.18
Pr-3 vs. Pr-4	187.62	177.60	51.37

[a] Calculated as $\frac{\text{Number of points of occurrence of the species}}{\text{Number of points of occurrence of all species}} + \frac{\text{Total dry weight of each species}}{\text{Total dry weight of all species}} \times 100$ (each sampling station)

[b] Includes all species for which the percent frequency (16 subplots) and $\frac{\text{Total dry weight of each species}}{\text{Total dry weight of all species}} \times 100$ (relative dominance) exceeded a value of 10.0

[c] Calculated as $\frac{\text{Summation of importance values for species common to any two stations}}{\text{Summation of the total importance values for the same stations}} \times 100$

TABLE 3.3.1-4

COMPARISONS WITHIN AND BETWEEN SAMPLING STATIONS BASED ON CALCULATED IMPORTANCE VALUES[a] FOR MAJOR COMPONENT SPECIES OF GROUND LAYER VEGETATION[b] OCCURRING IN SUBPLOTS OF PRAIRIE HABITATS, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY-JUNE 1974

Species[b]	Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4
Achillea millifolium L.		1.73	3.01	
Agrostis alba L.		27.05	35.69	
Ambrosia artemisiifolia L.				3.24
Ambrosia bidentata Michx.	1.10	2.85	3.18	
Aster sp.	2.25	1.41	1.63	8.09
Bromus racemosa L.		11.39	16.24	
Carex albolutescens Schwein.		0.50	1.09	
Carex bushii Mack.	3.30	10.37	10.72	
Carex glaucodea Tuckerm.	15.24	7.70	3.02	3.24
Cerastium viscosum L.	2.17	4.86	5.49	
Croton monanthogynus Michx.		2.80	0.53	
Dactylis glomerata L.	11.02			
Diospyros virginiana L.		2.10		
Eleocharis compressa Sull.			1.83	
Eleocharis tenuis (Willd.) Schutes		0.83		
Erigeron annuis (L.) Pers.		0.43	3.02	
Erigeron strigosus Muhl.		2.20	5.58	1.63
Festuca arundinacea Schreb. & F. elatior L.	111.51	0.47	0.91	123.80
Fragaria virginiana Duchesne.		3.16		
Juncus tenuis Willd.	9.17	1.39	5.66	
Lactuca canadensis L.		1.25	1.12	1.61
Lespedeza stipulacea Maxim.	1.14	5.53	5.72	13.06
Oxalis europea Jord.	4.36	0.81	0.53	1.62
Panicum lanuginosum Ell.	9.95	11.97	9.22	1.63
Panicum perlongum Nash		0.90		
Phleum pratense L.		21.63	16.61	
Plantago virginica L.	1.09	[illegible]	0.53	
Poa pratensis L.	6.19	28.57	38.76	
Potentilla simplex Michx.	8.25	0.42		1.62
Prunella vulgaris L.	3.37	4.25	0.33	
Pycnanthemum flexuosum (Wa't.) B.S.P.		9.47		
Ruellia humilis Nutt.	2.20	1.36		
Rumex acetocella L.		3.58		
Solanum carolinense L.		4.49	4.25	16.26
Solidago sp.		4.25	6.10	1.70
Strophostyles umbellata (Muhl.) Britt.		0.80	0.53	3.24
Symphoricarpos orbiculatus Moench.		1.59	0.56	
Trifolium campestre Schreb.		2.91	1.29	6.62
Trifolium pratense L.	2.22	1.52	1.70	
Trifolium repens L.	1.09	1.26	6.90	
Vernonia sp.		4.56	6.67	
Totals	195.62	194.32	197.60	187.34

Comparisons between sampling stations	Summation of importance values for species common to both stations	Summation of importance values for species occurring at only one station	Index of similarity (%)[c]
Pr-1 vs. Pr-2	271.30	118.64	69.57
Pr-1 vs. Pr-3	267.65	125.57	68.07
Pr-1 vs. Pr-4	305.74	77.22	79.84
Pr-2 vs. Pr-3	368.29	23.63	93.97
Pr-2 vs. Pr-4	228.31	153.35	59.82
Pr-3 vs. Pr-4	222.38	162.56	57.77

[a]Calculated as $\frac{\text{Number of points of occurrence of the species}}{\text{Number of points of occurrence of all species}} + \frac{\text{Total dry weight of each species}}{\text{Total dry weight of all species}} \times 100$ (each sampling station)

[b]Includes all species for which the percent frequency (16 subplots) and $\frac{\text{Total dry weight of each species}}{\text{Total dry weight of all species}} \times 100$ (relative dominance) exceeded a value of 10.0

[c]Calculated as $\frac{\text{Summation of importance values for species common to any two stations}}{\text{Summation of the total importance values for the same stations}} \times 100$

TABLE 3.3.1-5

COMPARISONS WITHIN AND BETWEEN SAMPLING STATIONS BASED ON CALCULATED IMPORTANCE VALUES[a] FOR MAJOR COMPONENT SPECIES OF UNDERSTORY LAYER VEGETATION[b] OCCURRING IN SUBPLOTS OF PRAIRIE HABITATS, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Species	Sampling Stations			
	Pr-1	Pr-2	Pr-3	Pr-4
Diospyros virginiana L.	64.2	129.2		
Fraxinus americana L.	11.6	23.1		
Gleditsia triacanthos L.			50.0	
Rosa carolina L.	29.2			
Rubus flagellaris Willd.		27.5		200.0
Symphoricarpos sp. Duham.	37.1	10.1	100.0	
Ulmus rubra Muhl.		10.1	50.0	
TOTAL	142.1	200.0	200.0	200.0

Comparisons between Sampling Stations	Summation of Importance Values for Species common to both Stations	Summation of Importance Values for Species occurring at only one Station	Index of Similarity (%)[c]
Pr-1 vs. Pr-2	275.3	66.8	80.5
Pr-1 vs. Pr-3	137.1	205.0	40.1
Pr-1 vs. Pr-4	0.0	342.0	0.0
Pr-2 vs. Pr-3	170.2	229.8	42.6
Pr-2 vs. Pr-4	227.5	172.5	56.9
Pr-3 vs. Pr-4	0.0	400.0	0.0

[a] Calculated as $\frac{\text{Number of points of occurrence of the species}}{\text{Number of points of occurrence of all species}} + \frac{\text{Total density of each species}}{\text{Total density of all species}} \times 100$ (each sampling station)

[b] Includes all species for which the percent frequency (16 subplots) and $\frac{\text{Total density of each species}}{\text{Total density of all species}} \times 100$ (relative density) exceeded a value of 10.0

[c] Calculated as $\frac{\text{Summation of importance values for species common to any two stations}}{\text{Summation of the total importance values for the same stations}} \times 100$

TABLE 3.3.1-6

COMPARISONS WITHIN AND BETWEEN SAMPLING STATIONS BASED ON CALCULATED IMPORTANCE VALUES[a] FOR MAJOR COMPONENT SPECIES OF GROUND LAYER VEGETATION[b] OCCURRING IN SUBPLOTS OF FOREST HABITATS, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Species	Sampling Stations			
	F-1	F-2	F-3	F-4
Antennaria plantaginifolia (L.) Hook.	6.36			4.13
Carex bushii Mack.	3.75	5.86	9.22	3.92
Carex glaucodea Tuckerm.	5.17			
Carex rosea Schk.	16.56	13.52	25.31	10.33
Carya ovata (Mill.) K. Koch	6.03			
Cornus florida L.	4.34		3.53	7.78
Desmodium glutinosum (Muhl.) Wood	5.72			
Desmodium nudiflorum (L.) D.C.	8.16		19.93	
Fraxinus americana L.	16.34			
Galium circaezans Michx.	3.54	3.82	4.05	
Galium concinnum Torr. & Gray	4.00	13.94	4.42	
Helianthus strumosus L.	13.33			
Heuchera sp. L.		2.48		
Lespedeza violaceae (L.) Pers.	3.20			9.19
Lysimachia lanceolata Walt.		2.94		
Monarda russeliana Nutt.	12.26			9.73
Muhlenbergia sobolifera (Muhl.) Trin.		8.80		
Ostrya virginiana (Mill.) K. Koch		10.52		
Panicum boscii Poir.	9.76			
Panicum lanuginosum Ell.	3.61			3.35
Panicum lanuginosum var. lanuginosum (Scribn.) Fern.		3.89		
Parthenocissus quinquefolia (L.) Planch.	12.41	16.38	25.26	
Potentilla simplex Michx.		4.23	3.68	5.57
Prunus virginiana L.	2.71	5.22	3.55	
Quercus alba L. and var.	22.46	15.44	3.04	3.86
Quercus imbricaria Michx.		4.31		
Quercus rubra L.	5.30			
Quercus velutina Lam.	4.79			11.93
Rhus aromatica Ait.	25.15	21.18	26.73	34.64
Rosa carolina L.	7.48	2.87	5.72	13.27
Rubus flagellaris Willd.	3.44			
Solidago ulmifolia Muhl.	3.94	7.49		10.03
Strophostyles helvola (L.) Ell.	8.38	13.10	15.09	14.85
Vitus cinera Engelm.		5.07		7.21
TOTAL	218.19	161.06	149.53	149.79

TABLE 3.3.1-6 (continued)

Comparisons between Sampling Stations	Summation of Importance Values for Species common to both Stations	Summation of Importance Values for Species occurring at only one Station	Index of Similarity (%)[c]
F-1 vs. F-2	229.20	150.05	60.43
F-1 vs. F-3	264.79	102.93	72.00
F-1 vs. F-4	259.29	108.69	70.46
F-2 vs. F-3	241.63	68.96	77.79
F-2 vs. F-4	192.44	118.41	61.90
F-3 vs. F-4	185.54	113.78	61.98

[a]Calculated as $\frac{\text{Number of points of occurrence of the species}}{\text{Number of points of occurrence of all species}} + \frac{\text{Total dry weight of each species}}{\text{Total dry weight of all species}} \times 100$ (each sampling station)

[b]Includes all species for which the percent frequency (16 subplots) and $\frac{\text{Total dry weight of each species}}{\text{Total dry weight of all species}} \times 100$ (relative dominance) exceeded a value of 10.0

[c]Calculated as $\frac{\text{Summation of importance values for species common to any two stations}}{\text{Summation of the total importance values for the same stations}} \times 100$

TABLE 3.3.1-7

COMPARISONS WITHIN AND BETWEEN SAMPLING STATIONS BASED ON CALCULATED IMPORTANCE VALUES[a] FOR MAJOR COMPONENT SPECIES OF UNDERSTORY LAYER VEGETATION[b] OCCURRING IN SUBPLOTS OF FOREST HABITATS, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Species	Sampling Stations			
	F-1	F-2	F-3	F-4
Acer saccharum Marsh		11.5	6.8	6.1
Amelanchier arborea (Michx. f.) Fern.	8.7	6.1		5.8
Carya sp. Nutt.	22.2	8.9	13.4	6.3
Celastrus sp. L.		3.4		
Cornus florida L.	35.3	22.8	22.6	11.8
Crataequis sp. L.		1.8	2.2	4.1
Diospyros virginiana L.		3.7		2.7
Fraxinus americana L.	19.6	15.2	2.2	6.8
Juniperus virginiana L.	7.3	5.2	2.4	2.7
Morus rubra L.			2.6	
Ostrya virginiana (Mill.) K. Koch	14.9	2.2		6.6
Prunus americana Marsh.		5.3	2.9	
Prunus serotina Ehrh.		4.7	14.7	5.3
Quercus alba L. and var.	22.3	18.6	10.8	27.0
Quercus x fernowi Trel. (Quercus alba x Quercus stellata)				2.7
Quercus rubra L. and var.	6.2	1.6	4.6	7.4
Quercus stellata Wang.				2.7
Quercus velutina Lam.	12.1	7.5	13.4	31.7
Rhus aromatica Ait.	19.5	25.9	70.7	44.9
Rhus radicans L.		6.6		
Rosa carolina L.		6.7	4.3	5.3
Rubus flagellaris Willd.	3.4	3.7		2.7
Rubus occidentalis L.		2.4		
Sassafras albidum (Nutt.) Nees		4.5	6.7	
Symphoricarpos sp. Duham		8.8	2.4	
Viburnum prunifolium L.		5.7		
Ulmus rubra Muhl.	7.7	5.8		
Vitis aestivalis Michx.			2.2	
Vitis cinerea Engelm.		2.7	3.4	5.1
Vitis vulpina L.	4.4	3.2	4.6	4.9
Xanthoxylum sp. L.		4.6		
TOTAL	183.6	199.1	192.9	192.[illegible]

Comparisons between Sampling Stations	Summation of Importance Values for Species common to both Stations	Summation of Importance Values for Species occurring at only one Station	Index of Similarity (%)[c]
F-1 vs. F-2	310.3	72.4	81.1
F-1 vs. F-3	293.6	82.9	78.1
F-1 vs. F-4	334.5	41.7	88.9
F-2 vs. F-3	343.0	49.0	87.5
F-2 vs. F-4	339.2	52.5	86.6
F-3 vs. F-4	345.5	40.0	89.6

TABLE 3.3.1-7 (continued)

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[a] Calculated as $\frac{\text{Number of points of occurrence of the species}}{\text{Number of points of occurrence of all species}} + \frac{\text{Total density of each species}}{\text{Total density of all species}} \times 100$ (each sampling station)

[b] Includes all species for which the percent frequency (16 subplots) and $\frac{\text{Total density of each species}}{\text{Total density of all species}} \times 100$ (relative density) exceeded a value of 10.0

[c] Calculated as $\frac{\text{Summation of importance values for species common to any two stations}}{\text{Summation of the total importance values for the same stations}} \times 100$

TABLE 3.3.1-8

COMPARISONS WITHIN AND BETWEEN SAMPLING STATIONS BASED ON CALCULATED IMPORTANCE VALUES[a] FOR MAJOR COMPONENT SPECIES OF OVERSTORY LAYER VEGETATION[b] OCCURRING IN SUBPLOTS OF FOREST HABITATS, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Species	Sampling Stations F-1	F-2	F-3	F-4
Acer saccharum Marsh.			6.9	
Amelanchier arborea (Michx. f.) Fern.	12.2	7.3		
Carya ovata (Mill.) K. Koch	18.7	43.5	8.7	
Carya texana Buckl.	11.0	26.4	23.2	
Carya tomentosa Nutt.		5.9		
Cornus florida L.	43.8	20.5	25.2	15.6
Ostrya virginiana (Mill.) K. Koch	10.4			
Quercus alba L. and var.	132.8	134.9	142.2	92.7
Quercus rubra L.		23.5	14.5	
Quercus stellata Wang.	16.1		16.5	65.0
Quercus velutina Lam.	34.2	22.4	54.5	88.0
TOTAL	279.2	284.4	291.7	261.3

Comparisons between Sampling Stations	Summation of Importance Values for Species common to both Stations	Summation of Importance Values for Species occurring at only one Station	Index of Similarity (%)[c]
F-1 vs. F-2	507.7	55.9	90.1
F-1 vs. F-3	526.9	44.0	92.3
F-1 vs. F-4	488.2	52.3	90.3
F-2 vs. F-3	539.5	36.6	93.6
F-2 vs. F-4	374.1	180.6	67.4
F-3 vs. F-4	484.1	68.9	87.5

[a] Calculated as $\frac{\text{Number of points of occurrence of the species}}{\text{Number of points of occurrence of all species}} \times 100 + \frac{\text{Density of a species}}{\text{Density of all species}} \times 100 + \frac{\text{Basal area of a species}}{\text{Basal area of all species}} \times 100$ (each sampling station)

[b] Includes all species for which the percent frequency (16 subplots) + $\frac{\text{Density of a species}}{\text{Density of all species}} \times 100 + \frac{\text{Basal area of a species}}{\text{Basal area of all species}} \times 100$ (relative dominance) exceeded a value of 15.0

[c] Calculated as $\frac{\text{Summation of importance values for species common to any two stations}}{\text{Summation of the total importance values for the same stations}} \times 100$

TABLE 3.3.1-9

COMPARISONS WITHIN AND BETWEEN SAMPLING STATIONS BASED ON CALCULATED IMPORTANCE VALUES[a] FOR MAJOR COMPONENT SPECIES OF GROUND LAYER VEGETATION[b] OCCURRING IN SUBPLOTS OF FOREST HABITATS, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY-JUNE 1974

Species[c]	Sampling Stations F-1	F-2	F-3	F-4
Amelanchier arborea (Michx.) Fern.	1.01	3.16	1.07	4.94
Anemonella thalictroides (L.) Spach.	3.00	3.64	3.07	
Antennaria r aginifolia (L.) Hook		2.95	1.04	3.20
Aster sp.	3.32	0.93	2.57	7.59
Carex bushii Mack.	6.41	9.31	9.48	4.07
Carex glaucodea		6.72	1.05	
Carex gravida Bailey	4.31		4.17	
Carex rosea Schk.	3.40	8.42	2.03	3.68
Carya ovata (Mill.) K. Koch.	5.59		1.40	
Cornus florida L.	0.99	2.53	5.24	2.46
Desmodium dillenii Darl.			6.64	6.46
Desmodium glutinosum (Muhl.) Wood		4.74		
Desmodium nudiflorum (L.) D.C.	7.01		12.12	3.42
Dioscorea villosa L.		1.48		1.25
Euonymus atropurpus Jacq.			6.56	
Fraxinus americana L.	19.06	7.02		
Galium circaezans Michx.	2.94	2.21	10.58	
Galium concinnum Torr. & Gray	4.67	6.64	1.02	
Helianthus sp.		0.86		4.61
Lespedeza violacea (L.) Pers.		1.58		2.43
Lactuca sp.		1.44	1.25	1.30
Lysimachia lanceolata Walt.		1.47		
Monarda russelliana Nutt.			4.68	
Ostrya virginiana (Mill.) K. Koch.	5.62			
Panicum lanuginosum Ell.		1.66		
Panicum linearifolium Scribn.				3.10
Panicum subvillosum Ashe.			1.03	2.41
Parthenium integrifolium Ait.				5.33
Parthenocissus quinquefolia (L.) Planch.	33.93	29.38	27.25	2.59
Podophyllum peltatum L.	0.99	4.98	2.82	
Potentilla simplex Michx.		3.85		4.91
Prunus serotina	1.35	0.72	4.48	
Psoralea psoralioides (Walt.) Corey var. eglandulosa (Ell.) Sampson				28.03
Quercus alba L. and/or hybrids	16.33	5.21	3.20	6.19
Quercus macrocarpa Michx. and/or hybrids	15.57	1.94		13.41
Quercus marilandica Muenchh. and/or hybrids	3.73	4.23		18.49
Quercus stellata Wang and/or hybrids	7.07			
Quercus velutina Lam. and/or hybrids				3.94
Rhus aromatica Ait.	13.10	15.01	39.21	20.87
Rosa carolina L.	3.96	4.19	5.43	13.09
Rubus flagellaris Willd.	2.16	0.97	2.09	
Rubus occidentalis L.	2.53	7.95		
Sassafras albidum (Nutt.) Nees.		2.47		1.27
Scutellaria parvula Michx.		1.46		
Smilacina racemosa L.	2.23	2.41	2.97	
Strophostyles helvola (L.) Britt.	5.48	5.24	16.60	3.22
Symphoricarpos orbiculatus Moench.		6.66	2.38	1.19
Tradescantia ohiensis Raf.		4.61		
Viburnum rafinesquianum Schultes.		1.85		
Viola papilionacea Pursh.		4.36		
Vitis cinerea Engelm.	1.16	8.49	10.37	2.45
Totals	177.28	182.40	191.96	172.65

Comparisons between sampling stations	Summation of importance values for species common to both stations	Summation of importance values for species occurring at only one station	Index of similarity[d]
F-1 vs. F-2	282.54	77.14	78.55
F-1 vs. F-3	290.49	79.75	78.67
F-1 vs. F-4	219.76	130.17	62.80
F-2 vs. F-3	286.43	87.93	76.51
F-2 vs. F-4	241.27	113.78	67.95
F-3 vs. F-4	231.09	133.52	63.38

[a]Calculated as $\frac{\text{Number of points of occurrence of the species}}{\text{Number of points of occurrence of all species}} + \frac{\text{Total dry weight of each species}}{\text{Total dry weight of all species}} \times 100$ (each sampling station)

[b]Includes all herbaceous species and woody plants of less than 20 inches in height

[c]Includes all species for which the percent frequency (16 subplots) and $\frac{\text{Total dry weight of each species}}{\text{Total dry weight of all species}} \times 100$ (relative dominance) exceeded a value of 10.0

[d]Calculated as $\frac{\text{Summation of importance values for species common to any two stations}}{\text{Summation of the total importance values for the same stations}} \times 100$

TABLE 3.3.1-10

CHLORINATED HYDROCARBON CONCENTRATIONS OF THE SOIL AT THE UNION ELECTRIC CALLAWAY PLANT, UNITS 1 AND 2 SITE

Parts Per Million (w/w)

	1	2	3	4	5	6	7	8
Mirex	[a]<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Toxaphene	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
PCB's	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lindane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Aldrin	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor Epoxide	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
β Chlordane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
α Chlordane	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
p,p-DDE	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Dieldrin	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Endrin	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
o,p-DDT	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
p,p-DDD	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
p,p-DDT	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

[a] <Indicates less than, if present at all.

No detectable residues of 2,4-d, 2,4,5-T and Silvex chlorophenoxy acid herbicide esters were detected at a level greater than 0.05 ppm.

TABLE 3.3.1-11

CHEMICAL CHARACTERISTICS OF THE SOIL AT THE
UNION ELECTRIC CALLAWAY PLANT, UNITS 1 AND 2 SITE [a]

	F-1	F-2	F-3	F-4	P-1	P-2	P-3	P-4
Available Calcium	255.00	255.00	255.00	300.00	840.00	660.00	1200.00	1095.00
" Magnesium	51.00	60.00	60.00	60.00	72.00	168.00	114.00	123.00
" Potassium	52.80	48.00	50.40	48.00	58.20	71.20	66.00	42.60
" Sodium	7.80	7.20	6.30	6.60	12.00	14.40	14.40	14.40
" K-Nitrogen	3.69	2.85	2.85	3.12	5.10	5.70	4.59	3.59
" Tot. Phosphorus	<.15	<.15	<.15	<.15	.21	<.15	<.15	<.15
pH (units)	5.40	4.90	5.00	5.20	6.40	5.80	6.40	6.40
Lead (Total)	110.00	110.00	60.00	15.00	110.00	13.00	60.00	[illegible]0.00
Chromium (Total)	56.00	64.00	16.00	32.00	100.00	40.00	40.00	48.00
Copper (Total)	32.00	32.00	17.00	17.00	34.00	24.00	32.00	32.00
Cadmium (Total)	1.20	1.90	1.60	1.00	2.40	1.00	1.80	1.60
Manganese (Total)	2850.00	4100.00	2200.00	900.00	3500.00	1400.00	3000.00	1500.00
Mercury (Total)	0.10	0.20	.02	.02	.02	.02	.10	.10
Arsenic (Total)	19.00	44.00	<.50	<.50	12.00	<.50	.70	12.00

[a] All results are expressed in mg/kg unless otherwise specified.

3.3.2 MAMMALS

3.3.2.1 Small Mammals

Small mammal densities determined during the spring and fall sampling periods for the four permanent sampling stations located in forest habitats are presented in Table 3.3.2-1.

Short-tailed shrews were present at all four sampling stations during the spring survey but were found only at Sampling Stations F-1, F-2, and F-3 during the fall survey. The shrew recaptures at Station F-2 during the spring survey and at Stations F-1, F-2, and F-3 during the fall survey were unusual occurrences, because shrews are not attracted by the bait used in the trapping program. However, shrews are often captured when they blunder into traps, or what is more likely, when they enter the traps to prey on insects attracted by the peanut butter/oatmeal bait. Shrews have poorly developed senses of sight and smell but well developed senses of touch and hearing (Schwartz and Schwartz, 1959).

Short-tailed shrew densities at the forested stations are probably about normal. Schwartz and Schwartz (1959) list "normal" population densities as 1.4 per acre. However, short-tailed shrew densities may exceed 25 animals per acre during periods of peak populations. In addition to preying on insects, short-tailed shrews also eat mice, which they kill with a salivary poison. Thus, they may be at least partially responsible for the low densities of white-footed mice in forest habitats.

One least shrew was captured at Sampling Station F-1 during the fall survey. Although least shrew captures in deciduous forest habitats are not unknown, they are far more common in prairie and oldfield habitats (Briese and Smith, 1974).

Permament Sampling Stations F-2 and F-3 were inhabited by white-footed mice (Table 3.3.2-1). Respective densities of 0.67/acre and 0.40/acre during the spring survey are considered to be low. No white-footed mice were captured at any sampling station during the fall survey. It is possible that the deciduous forest habitats on the Union Electric site are simply unsuitable habitat for white-footed mice; however, it is probable that the white-footed mouse population in this portion of Missouri is in one of its cyclic "lows," which occur every 3 to 5 years (Schwartz and Schwartz, 1959). This "low" has probably been reinforced by the oak mast crop failure due to early frost during the last 3 to 4 years. Acorns are among the staple foods of the white-footed mouse (Schwartz and Schwartz, 1959).

Small mammal densities during the spring and fall sampling periods for the four permanent sampling stations located in prairie habitats are presented in Table 3.3.2-2.

One short-tailed shrew was captured on Station Pr-4 during the spring survey. Although short-tailed shrews do on occasion inhabit prairie situations (Briese and Smith, 1974), their preferred habitat is wooded areas. Therefore, their occurrence on prairie sites should be regarded as an exception (Schwartz and Schwartz, 1959).

Least shrews were captured at Stations Pr-1 and Pr-4 during the spring survey and at Station Pr-4 during the fall survey. These shrews are generally abundant but are seldom caught in live traps because of their marked preference for insects, centipedes, millipedes, spiders, and similar foods. Like the short-tailed shrews, least shrews have poor senses of sight and smell and locate their prey by sound and touch. They have tremendous appetites, consuming one to three times their weight in food daily. This species may contribute to control of insect populations in an area, but the precise relationship between populations of least shrews and insects has not been scientifically established (Schwartz and Schwartz, 1959).

Western harvest mice were captured at Stations Pr-2, Pr-3, and Pr-4 during both surveys. Only at Stations Pr-2 and Pr-4 were sufficient captures made to enable calculation of denisty estimates. Population densities of 0.60/acre and 1.34/acre on Pr-2 and of 0.67/acre and 0.44/acre on Pr-3 (spring and fall surveys respectively) are low for this species and may reflect their "trap shyness" (Briese and Smith, 1974). Bancroft (1966) reported population densities of 10 to 12/acre in relatively similar grassland habitats in Kansas. Populations of western harvest mice may fluctuate rapidly in part because they breed as early as 38 days of age and may bear new litters as often as every 22 days, although this situation is not often seen in field situations (Richins, Smith, and Jorgensen, 1974). Western harvest mice are an exclusively grassland species, feeding primarily on seeds. However, they occasionally supplement their diet with insects (Schwartz and Schwartz, 1959; Bancroft, 1966).

Prairie voles are the most common and most ecologically important species occurring at the prairie stations. It is also the single most important small mammal species present on the Union Electric plant site, both in terms of trophic relationships and numbers. This species is uniquely suited for study as an indicator of environmental change since it reflects change dynamically both as a population and individually. Population densities for all four prairie stations were comparatively low during the spring survey, with the highest density occurring at Station Pr-4 (Table 3.3.2-2). Prairie vole populations generally follow a 4-year cycle of abundance, ranging from less than 15/acre at low levels to more than 250/acre at peak levels. Average population densities generally range between 15 to 50/acre, but population levels are dramatically influenced by such environmental factors as summer drought, severe winter weather, parisitism, epidemic disease, land use changes, and changing habitat suitability

(Schwartz and Schwartz, 1957; Myers and Krebs, 1974).

It would be difficult to overestimate the importance of the prairie vole in the ecology of the prairie regions. The species is preyed on by almost every predator, even bullfrogs and snapping turtles; yet the prairie vole population may increase by threefold to tenfold in a single season. One individual in captivity produced 13 litters totaling 78 offspring before reaching one year of age (Schwartz and Schwartz, 1959).

That this situation can occur in nature is apparent by the data in Table 3.3.2-2. The population density at Station Pr-1 increased approximately six times between the spring and fall samples. At Station Pr-2, the increase was about eightfold; at Pr-3 about fivefold. The vole population at Station Pr-4, however, increased little--from 8/acre to about 9.5/acre. This apparent disparity in population trends can be explained by examining the relationship of prairie vole habitat requirements and existing conditions at the four prairie sampling stations.

The spring mammal data for Prairie Stations Pr-1, Pr-2, and Pr-3 show sharply lower prairie vole densities than for Prairie Station Pr-4. This difference is probably the result of a difference in previous land use at Pr-4. Station Pr-1 is located in a hay field that was apparently harvested annually in previous times. Consequently, only limited litter accumulations were present at the ground surface, providing little habitat for prairie voles, which require litter for runways and nests. The limited habitat probably is the reason for the low spring survey densities of prairie voles.

Much of the same situation exists at Stations Pr-2 and Pr-3 except here the limited litter accumulation is the result of former pasturage rather than hay harvesting. In contrast, the area at Station Pr-4 was apparently unharvested during the previous growing season. Therefore, the litter layer is fairly thick, providing ideal nesting and runway habitat for the prairie vole.

The habitat situation on these same areas during the fall survey is quite different. Stations Pr-1, Pr-2, and Pr-3 all had been released from the restrictive ecological pressures previously imposed by grazing and hay harvesting. Therefore, a rich, thick mat of lodged grasses and litter had accumulated near the ground level. The situtaion at Pr-4, however, had not changed because the process of litter accumulation had occurred at this station approximately one year previously.

Thus population density increase shown in Table 3.3.2-2 is probably due to the response of the vole population to a substantial increase in habitat suitability, in conjunction with a normal increase due to reproductive activity. Station Pr-4 displays no dramatic population density increase because there was no significant increase in habitat suitability. The minor density increase noted at Pr-4 is probably due to normal reproductive activity.

Southern bog lemmings were captured during the spring survey only at Station Pr-4. The presence of lemmings is of questionable ecological significance because the Callaway Plant site is located within the southern distributional limits of the species. Lemmings may be locally abundant in some areas but be totally absent from others that appear to provide suitable habitat conditions. Thus, the presence of the species at Station Pr-4 is not particularly meaningful. One characteristic feature of all habitats in which the species occurs is the presence of a thick mat of vegetation and litter near or at ground level (Schwartz and Schwartz, 1959).

A summary of standard body measurements made for representative small mammals captured during the spring sampling period (May 31, 1974 to June 5, 1974) and the fall sampling period (September 18-23, 1974) is presented in Table 3.3.2-3. These data are matched in the table with the established limits for each species as published by Hall and Kelson (1959); the measured values are within the established limits for the species in every case.

The small mammal snap-trapping program conducted during the spring survey provided only limited useful information, because of the frequent and heavy rainfall that consistently set off traps or washed away bait. A single specimen of short-tailed shrew, white-footed mouse, and prairie vole were prepared, mounted, and used as an aid in validating field identification.

3.3.2.2 Large Mammals

The roadside counts of eastern cottontail were probably influenced by the frequent and heavy rainfall. Unfortunately, the extent of influence cannot be ascertained. A mean relative abundance of 8.25 cottontails/13.2 miles during the spring survey was derived for the census route. It appears that the population was undergoing a natural seasonal increase; this assumption is based on the observation that there were two distinct size classes of young rabbits. At least two litters were assumed to have been born during the current breeding season. The relative abundance of cottontails observed during the fall survey decreased to a mean of 0.25 rabbits/13.2 miles traveled. It is believed that this decrease is more apparent than real. Because the crops in the area had not been harvested, the cottontails had not been forced to utilize roadside vegetation for cover.

Data obtained by nighttime spotlighting during the spring survey indicate a mean abundance of 0.25 raccoons/20 miles of travel. This figure is considerably lower than expected, inasmuch as raccoon tracks were seen in almost every muddy area on the site.

Interviews with local residents indicated that there is a fairly large population of raccoons in the area, which substantiates track observations. However, this is contrary to results obtained by spotlight survey. During the fall survey, 0.50 raccoons/20 miles of travel were observed. This figure, while higher than the spring survey, is still lower than expected.

One fox was observed during the course of the spring spotlight survey. On two other occasions, red foxes were observed in approximately the same area. No white-tailed deer were observed during springtime night spotlighting activities; however, fawns, yearlings, and adult animals were observed during conduct of the preconstruction monitoring program. During the fall survey, an average of two white-tailed deer/per 20-mile survey were observed. One opossum and two striped skunks were also observed.

3.3.2.3 Inventory of Observed Species

Mammals observed at or immediate to the Callaway Plant site are listed in Table 3.3.2-4. Some of these -- the eastern mole and spotted skunk -- were observed only as road-killed animals. Others, such as white-tailed deer, fox squirrel, and gray squirrel were sighted directly. One observed species, the long-tailed weasel, is listed as a "rare" species by the Missouri Department of Conservation (Union Electric Company, 1974).

TABLE 3.3.2-1

ESTIMATED[a] SMALL MAMMAL DENSITIES (PER ACRE) FOR PERMANENT SAMPLING STATIONS LOCATED IN FOREST HABITAT, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, SPRING AND FALL 1974

	FOREST STATIONS							
	F-1		F-2		F-3		F-4	
Species	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Short-tail shrew	P[b]	1.68	0.37	0.34	P	1.51	P	+[c]
Adult	P	1.68	0.37	0.34	P	1.51	P	+
Male	P	0.84	P	0.34	P	0.74	P	+
Female	P	0.84	0.37	+	P	0.75	+	+
Sub-Adult	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+
Juvenile	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+
Least shrew	+	P	+	+	+	+	+	+
Adult	+	P	+	+	+	+	+	+
Male	+	P	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+
Sub-Adult	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+
Juvenile	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+
White-footed mouse	+	+	0.67	+	0.40	+	+	+
Adult	+	+	0.34	+	P	+	+	+
Male	+	+	0.34	+	P	+	+	+
Female	+	+	+	+	P	+	+	+
Sub-Adult	+	+	0.34	+	0.37	+	+	+
Male	+	+	0.34	+	0.34	+	+	+
Female	+	+	+	+	P	+	+	+
Juvenile	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+

[a] Estimates are based on the EM-2 small mammal estimator (Smith and Jorgensen, 1974) utilizing 144 live traps in a 2.98-acre grid for a total of 864 trap nights.

[b] P=Present, but in insufficient numbers for density estimate.

[c] +=Not observed.

TABLE 3.3.2-2

ESTIMATED[a] SMALL MAMMAL DENSITIES (PER ACRE) FOR PERMANENT SAMPLING STATIONS LOCATED IN PRAIRIE HABITAT, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, SPRING AND FALL 1974

	PRAIRIE STATIONS							
	Pr-1		Pr-2		Pr-3		Pr-4	
Species	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Short-tailed shrew	+[b]	+	+	+	+	+	P[c]	+
Adult	+	+	+	+	+	+	P	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	P	+
Sub-Adult	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+
Juvenile	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+
Least shrew	P	+	+	+	+	+	P	P
Adult	P	+	+	+	+	+	P	P
Male	P	+	+	+	+	+	P	+
Female	+	+	+	+	+	+	P	P
Sub-Adult	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+
Juvenile	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+
Western harvest mouse	+	+	0.60	1.34	P	P	0.67	0.44
Adult	+	+	0.60	1.01	+	P	0.67	0.44
Male	+	+	P	+	+	+	0.67	+
Female	+	+	0.34	1.01	+	P	+	0.44
Sub-Adult	+	+	+	+	P	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	P	+	+	+
Juvenile	+	+	+	0.34	+	+	+	+
Male	+	+	+	0.34	+	+	+	+
Female	+	+	+	+	+	+	+	+
Prairie vole	1.81	11.74	1.78	16.11	6.14	31.08	8.09	9.40
Adult	1.81	9.80	1.51	11.21	3.12	21.44	5.78	8.02
Male	1.81	5.64	0.67	5.00	0.44	10.54	5.20	5.65
Female	+	4.09	0.64	5.74	2.35	11.14	1.54	2.39
Sub-Adult	+	1.01	0.34	3.02	0.34	3.19	P	2.01
Male	+	+	+	2.55	0.34	1.68	+	1.01
Female	+	1.01	0.34	0.34	+	1.50	P	1.01
Juvenile	+	P	+	0.67	+	9.47	0.67	+
Male	+	P	+	P	+	4.09	+	+
Female	+	+	+	0.67	+	4.46	P	+

TABLE 3.3.2-2 (continued)

	PRAIRIE STATIONS							
	Pr-1		Pr-2		Pr-3		Pr-4	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Southern bog lemming	+	+	+	+	+	+	1.17	+
Adult	+	+	+	+	+	+	1.17	+
Male	+	+	+	+	+	+	0.67	+
Female	+	+	+	+	+	+	P	+
Sub-Adult	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+
Juvenile	+	+	+	+	+	+	+	+
Male	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	+	+	+

[a]Estimates are based on the EM-2 small mammal estimator (Smith and Jorgensen, 1974) utilizing 144 live traps in a 2.98-acre grid for a total of 864 trap nights.

[b]+=not observed.

[c]P=present, but in insufficient numbers for density estimate.

TABLE 3.3.2-3

STANDARD MEASUREMENTS OF SMALL MAMMALS CAPTURED ON THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, SPRING AND FALL 1974

	Sample Size[c]		Field Measurements[a] (mm)		Published[b]
	Spring	Fall	Spring	Fall	Measurements (mm)
Short-tailed shrew	13	7			
Total length			107.5 ± 3.5	105.4 ± 12.0	95-134
Tail length			19.8 ± 0.5	19.0 ± 1.9	17-30
Ear length			3.1 ± 0.1	---	---
Hind foot length			15.1 ± 0.1	13.1 ± 0.7	11.5-17
Least shrew	4	0			
Total length			87.5 ± 1.3	---	75-89
Tail length			15.5 ± 0.6	---	12-22
Ear length			2.0 ± 0.0	---	---
Hind foot length			11.9 ± 0.5	---	9-12
Western harvest mouse	7	8			
Total length			129.1 ± 2.6	122.6 ± 19.2	118-170
Tail length			58.4 ± 3.5	59.6 ± 9.5	55-96
Ear length			12.2 ± 0.3	---	10-16
Hind foot length			16.1 ± 0.8	15.9 ± 0.6	14-20
White-footed mouse	4	0			
Total length			160.8 ± 3.4	---	156-205
Tail length			66.1 ± 1.6	---	63-97
Ear length			15.3 ± 1.7	---	13-16
Hind foot length			23.3 ± 2.5	---	19-24
Prairie vole	20	132			
Total length			143.6 ± 2.9	133.2 ± 3.5	130-172
Tail length			30.7 ± 1.4	33.6 ± 1.1	24-41
Ear length			12.6 ± 0.4	---	11-15
Hind foot length			19.5 ± 0.7	18.2 ± 0.2	17-22
Southern bog lemming	3	0			
Total length			138.0 ±16.9	---	118-154
Tail length			15.7 ± 0.7	---	13-24
Ear length			12.6 ± 1.5	---	8-14
Hind foot length			20.0 ± 1.1	---	16-24

[a] means and confidence limits (p=95%).

[b] Hall and Kelson (1959).

[c] numbers indicate sample size from which means are derived.

TABLE 3.3.2-4

A PHYLOGENETIC[a] LISTING OF MAMMAL SPECIES OBSERVED ON OR IMMEDIATE TO THE CALLAWAY PLANT SITE DURING THE 1973-74 BASELINE SURVEY[b], THE INITIAL MONITORING SURVEY, MAY-JUNE 1974, AND THE FALL SURVEY, SEPTEMBER 1974, CALLAWAY COUNTY, MISSOURI

FAMILY Scientific Name Common Name	Baseline Survey 1973-74	Spring Survey May-June, 1974	Fall Survey September, 1974
DIDELPHIDAE			
Didelphis marsupialis virginiana			
Opossum	X	X	X
SCORICIDAE			
Blarina brevicauda carolinensis			
Short-tailed shrew		X	X
Cryptotis parva parva			
Least shrew		X	X
TALPIDAE			
Scalopus aquaticus machrinoides			
Eastern mole	X	X	
LEPORIDAE			
Sylvilagus floridanus alacer			
Eastern cottontail	X	X	X
SCIURIDAE			
Marmota monax monax			
Woodchuck	X		
Sciurus carolinensis carolinensis			
Gray squirrel	X	X	X
Sciurus niger rufiventer			
Fox squirrel	X	X	X
CRICETIDAE			
Reithrodontomys megalotis dychei			
Western harvest mouse		X	X
Peromyscus maniculatus gairdii			
Deer mouse	X		
Peromyscus leucopus noveboracensis			
White-footed mouse	X	X	
Microtus ochrogaster ochrogaster			
Prairie vole		X	X
Ondatra zibethicus zibethicus			
Muskrat	X		
Synaptomys cooperi gossii			
Southern bog lemming		X	

TABLE 3.3.2-4 (continued)

FAMILY Scientific Name Common Name	Baseline Survey 1973-74	Spring Survey May-June, 1974	Fall Survey September, 1974
CANIDAE			
Canis latrans frustror			
Coyote	X	X	X
Vulpes fulva			
Red fox		X	
PROCYONIDAE			
Procyon lotor hirtus			
Raccoon	X	X	X
MUSTELIDAE			
Mustela frenata primulina			
Long-tailed weasel	X	X	
Mephitis mephitis avia			
Striped skunk	X	X	X
CERVIDAE			
Odecoileus virginiana marcoura			
White-tailed deer	X	X	X

[a]Phylogeny and species nomenclature follow Jones, Carter, and Genoways, 1973. Subspecific nomenclature follows Hall and Kelson, 1959.

[b]Union Electric Company, 1974.

3.3.3 AVIFAUNA

As noted previously, avian survey transects were chosen to traverse relatively homogeneous habitat within or immediate to permanent sampling stations established for intensive investigation of vegetation and small mammal populations. During the course of avian surveys, it was noted that subtle differences in habitat along a given transect frequently resulted in an apparent increase or decrease in the abundance and/or diversity of birds. However, considering the high degree of mobility and wide variance in behavior of bird species, exacting species-habitat preferences cannot be locally established with unequivocal certainty.

3.3.3.1 Prairie Habitats

The average density of birds observed in three daily surveys of each prairie habitat is shown in Table 3.3.3-1. The densities are variable from one habitat to another. The high standard deviation shown for Prairie Transects Pr-1 and Pr-3 indicates there may be a broad range of variability in daily avian densities estimated from the survey (Table 3.3.3-1).

Some portion of the variability was considered to be weather-related. Because surveys of a given transect were conducted on different days, the frequent and irregular occurrence of rainfall before, during, and after a survey undoubtedly influenced bird activities as well as the investigator's ability to detect and recognize birds within the sampling area. However, Students "t" tests (see Table 3.3.3-2) suggest that there are no significant differences in the density of avifauna occurring in or otherwise utilizing the sampled prairie habitats.

The densities of breeding birds associated with the sampled transects are therefore assumed to be relatively similar.

A tally of all birds recorded during the spring survey along each transect through the four prairie habitats (Table 3.3.3-3) indicates that the bird population at Prairie Transect Pr-2 had highest diversity (11 species); that of Prairie Transect Pr-3 had lowest diversity (5 species). Table 3.3.3-3 includes species that are not common nesting inhabitants of prairie or oldfield habitats. Such species were observed flying over the strip or in nearby habitat not representative of the sampled transects. Table 3.3.3-4 includes only those birds common to the site; species uncommon to the site have been omitted. In this table, the similarity or dissimilarity of nesting birds inhabiting the four prairie habitats is more apparent. Pr-1 and Pr-2 are most similar, and Transects Pr-2 and Pr-3 are somewhat similar. Any comparison of Transect Pr-4 nesting birds with those of other transects shows a low degree of similarity.

From the standpoint of comparable habitat, Transects Pr-1 and Pr-4 (fescue grasslands) and Transects Pr-2 and Pr-3 (abandoned pasture) are most similar. Despite some disparities, the density and diversity of birds associated with Transects Pr-2 and Pr-3 were of sufficient similarity to be strongly correlated.

The transects through Prairie Stations Pr-2 and Pr-3 were comparatively short (0.18 miles). However, similar habitat conditions were not available nearby to permit increasing the length of the transects. It is likely that if the sampled areas could have been increased, the estimated nesting bird populations of the two transects would have shown even greater similarity.

In contrast, although avian density of Transects Pr-1 and Pr-4 appeared to be relatively similar, species diversity in the two transects was variable. Transects Pr-2 and Pr-3 were surveyed in sequence, whereas Transects Pr-1 and Pr-4 were the first and last, respectively. This may be an important factor in explaining the difference in nesting species associated with the Pr-1 and Pr-4 transects.

Data from the fall avian survey are not directly comparable with the data from the spring survey because of the differences in density, diversity, and distribution wrought by the factors such as migration, effect of weather on cover, and the tendency of premigratory birds to flock together by species. (Density estimates for each transect are given in Table 3.3.3-1.) With the breeding season over, many of the birds had dispersed over larger areas of territory. Also, some of the prairie nesters had already migrated from the area. Most birds observed on the transects were seen flying overhead; they were either moving to nearby wooded areas or migrating south. Meadowlarks were by far the most abundant of the birds using the prairie areas for feeding and roosting. These birds also seemed to be the most abundant in the areas around Pr-2 and Pr-3, which abounded in short grass preferred by the meadowlarks.

The only other prairie nesters seen feeding or roosting on the prairie areas were field sparrows, bobwhite quail, and mourning dove. These birds were observed feeding either early in the morning or late in the evening; after being flushed, they moved to nearby wooded areas.

Other birds seen feeding or landing in the prairie areas were bluebirds, least flycatchers, and common grackles. These birds were probably after seeds produced by the prairie vegetation. Also seen hunting over the prairie were sparrow hawks and red-tailed hawks.

3.3. .2 Forest Habitats

The average density of birds observed in three daily surveys of each forest habitat during the spring study is shown in Table 3.3.3-1. The estimated density of breeding birds is relatively similar along the transects through Forest Stations F-2, F-3, and F-4. In contrast, the estimated density of birds associated with Forest Transect F-1 is nearly double that estimated for other forest transects.

The Students "t" test was used to evaluate differences in the density of birds occurring in the various sampled forest habitats. Of the six possible comparisons, the test indicated two comparisons whereby avian densities were significantly different at a 95 percent confidence limit (Table 3.3.3-2). In both instances, the avian density at Forest Transect F-1 was significantly different from that of other forest habitats.

The reason for the greater density of birds occurring in Transect F-1 is not clear. However, a forest area adjacent to the transect had been recently and selectively harvested. In consequence, saplings, shrubs, vines, and herbaceous vegetation were responding vigorously to the increased insolation penetrating openings in the overhead canopy. It is likely that this change in the environment following logging activities resulted in a greater variety and availability of suitable food items; this in turn may have attracted birds to the harvested and adjacent areas, such as the F-1 transect.

Common yellowthroats, cardinals, and bluejays were among the species most commonly observed to be associated with the harvested forest area. These species were also among the most frequently observed in surveys of Transect F-1. This situation provides some support for the assumption that post-logging habitat is attractive to some bird species, thus effecting an increase in bird density within the local area. Additionally, Transect F-1 is located adjacent to a creek where belted kingfisher and Louisiana water thrush were observed. These species demonstrate a strong preference for aquatic habitats, and other surveyed forest transects, for the most part, lacked suitable aquatic conditions.

Although a tally of all species recorded along transects through the four forest habitats demonstrates a relatively similar total diversity (Table 3.3.3-3), there is noticeable variability in the species of birds observed in the various transects. However, if only the most commonly occurring breeding birds are considered (Table 3.3.3-4), the species consistently associated with forest habitats become apparent. The bluejay was present in all four transects and was usually seen near field-forest boundaries. This species commonly nests along forest borders where the vegetation is relatively dense. The cardinal was also a common inhabitant of the forest habitat; this species will nest wherever shrubby vegetation exists.

The uncommonly occurring birds, listed in Table 3.3.3-3 but omitted from Table 3.3.3-4, include the red-tailed hawk, belted kingfisher, Louisiana water thrush, common yellowthroat, Baltimore oriole, indigo bunting, and rufous-sided towhee. The red-tailed hawk was observed flying above the plant site. The hawk is a forest inhabitant but often feeds on mammals inhabiting open fields. Their daily range of movement is too extensive to be comparable with that of song birds observed during a walking strip census. The belted kingfisher and Louisiana water thrush were observed only along a woodland creek, as previously noted. The common yellowthroat, indigo bunting, and rufous-sided towhee prefer shrubby surroundings and were observed primarily in forest openings. The Baltimore oriole commonly nests in tall trees near open glades or fields and is not a usual inhabitant of the forest interior.

The uniform and relatively high frequency with which the commonly occurring nesting species were observed within the four forest transects (Table 3.3.3-4) is considered to indicate a basic similarity in bird populations in the sampled areas. The general similarity of habitat conditions in the four transects is also indicated.

The fall avian densities of the eight transects are presented in Table 3.3.3-1. The increased variance among plots, compared to the spring survey, was probably due to the flocking behavior of premigratory birds. This causes a wide degree of variance between successive observations; this variance reflected in the generally wider confidence limits is expressed in the standard deviation values presented in Table 3.3.3-1.

The forests were the most productive of the two habitat types, in that birds were actually observed using the plots. Many large flocks of birds would alight in the trees and sometimes drop to the forest floor to feed. Some of the birds observed doing this were common grackles and red-winged blackbirds. Many of the forest nesters had already migrated from the area by the time the fall survey was taken. Some of the birds that had already emigrated were the eastern wood pewee, wood thrush, ovenbird, and summer tanager.

Of the summer resident birds still in the area at the time of the surveys, one of the most abundant seen in the forest plots was the red-headed woodpecker. It was found in every forest plot and can be seen in just about every forest in the area surrounding the proposed plant site. Other summer residents still present were the bluejay, cardinal, tufted titmouse, and common flicker. Many of these birds also winter in this area and are known to be winter residents.

On September 28, 1974, two bald eagles were seen circling over Forest Transect F-4. They were visible for about 4 minutes, then they separated, one (a juvenile) heading west and one (an adult) moving back towards the river. They were at a fairly low altitude when first spotted but moved quickly up and out of sight. Eagles are known to follow the course of the Missouri River and to winter along large tributaries, feeding on dead fish. Because the site is near the river, bald eagles are expected to be seen occasionally over the site.

Generally, all the forests plots had basically the same species during the fall survey and relative numbers seemed to be very close to each other. Many birds were in flocks and did not readily leave the areas. Although large numbers of species were still present, with the coming of winter the numbers should drop off considerably as more birds migrate south.

A compilation of the avian diversity observed during the fall survey within the eight sampling areas is presented in Table 3.3.3-5.

An inventory of the bird species observed during the spring 1974 surveys (spring and fall) is shown in Table 3.3.3-6. A checklist of species observed in an environmental baseline survey (Union Electric Company, 1974) conducted in the preceding year (June 1973) is also included in the table. The list provides some indication of the annual variability in the species occurring in a given area. However, some of the variability is undoubtedly due to differences in time and effort expended to inventory the local avifauna. This is especially true of the fall survey, where several new species were added to the list of birds observed (Table 3.3.3-6). These are species that summer to the north of the plant site and winter to the south and were merely observed in passage. Little significance should be attached to such observations inasmuch as these birds spend only a miniscule amount of time utilizing the resources of the plant site.

Overall, a high proportion of the species observed during one survey were also reported in the other surveys. Only 2 of the 56 species recorded in the 1973 survey were not identified in one of the 1974 surveys. The greatest number of species (68) was identified in the 1974 spring survey; 17 of these species were not recorded in the 1973 inventory.

On the basis of inventory data, most of the bird species occurring at the Callaway Plant site in June were classified as summer residents (Union Electric Company, 1974); in contrast, the species present in the fall survey were a potpourri of winter, summer, and permanent residents, with a scattered contingent of passage species in migration. Summer residents migrate to the south during the fall season, with a few exceptions. In the case of such exceptions, most individuals migrate south, while a few remain in the area during the winter season; these are then considered winter residents. Approximately one-third of the species inhabiting the plant site in June were permanent residents. The ratio for permanent versus other categories is virtually identical for both the 1973 and spring 1974 inventories.

TABLE 3.3.3-1

ESTIMATED MEAN AVIAN DENSITIES (NUMBER/ACRE) FOR PERMANENT SAMPLING STATIONS ON THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, SPRING AND FALL 1974

Sampling Station Transect	Spring		Fall	
	Mean Density	Standard Deviation	Mean Density	Standard Deviation
Pr-1	0.58	1.23	1.81	0.46
Pr-2	1.08	0.36	1.09	0.34
Pr-3	1.75	1.45	5.22	6.37
Pr-4	0.46	0.42	5.22	2.42
F-1	0.66	0.16	5.47	6.32
F-2	0.25	0.15	2.95	1.77
F-3	0.38	0.29	1.40	0.75
F-4	0.34	0.20	1.09	0.72

TABLE 3.3.3-2

COMPARISONS OF MEAN BIRD DENSITY (PER ACRE) BASED ON OBSERVATIONS MADE AT OR IMMEDIATE TO PERMANENT SAMPLING STATIONS LOCATED IN SIMILAR HABITAT TYPES OF THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, EARLY JUNE 1974

Habitat Types	Station Comparisons	Respective Mean Densities	t-Values[a]
Prairie	Pr-2 versus Pr-3	1.080 - 1.754	1.100
	Pr-1 versus Pr-4	0.580 - 1.742	0.230
	Pr-1 versus Pr-2	0.580 - 1.080	0.953
	Pr-3 versus Pr-4	1.754 - 0.457	2.094
	Pr-2 versus Pr-4	1.080 - 0.457	2.753
	Pr-1 versus Pr-3	0.580 - 1.754	1.506
Forest	F-1 versus F-2	0.660 - 0.250	4.083*
	F-3 versus F-4	0.389 - 0.336	0.352
	F-1 versus F-4	0.660 - 0.336	2.980*
	F-2 versus F-3	0.250 - 0.389	1.024
	F-1 versus F-3	0.660 - 0.389	1.971
	F-2 versus F-4	0.250 - 0.336	0.818

[a]Students "t" test at the 95% confidence limit ($P=.05_{(4)}=2.776$)

*Significant at the 95% confidence limit. Values not marked or not statistically significant at $\alpha=.05$

TABLE 3.3.3-3

AVIAN DIVERSITY BASED ON THE MAXIMUM SPECIES OBSERVED IN ANY ONE-DAY SURVEY OF TRANSECTS THAT TRAVERSE EIGHT PERMANENT SAMPLING STATIONS LOCATED WITHIN THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, SPRING 1974

	Number of Individuals Observed/Transect							
	Prairie				Forest			
Species Observed	Pr-1	Pr-2	Pr-3	Pr-4	F-1	F-2	F-3	F-4
Baltimore oriole	+	+	+	+	1[a]	+	+	+
Barn swallow	+	+	+	2[a,b]	+	+	+	+
Belted kingfisher	+	+	+	+	1[a]	+	+	+
Bluejay	2[a]	+	+	1	3	3	3	1
Brown-headed cowbird	+	+	+	+	+	2	+	+
Cardinal	1[a]	+	+	+	4	2	+	1
Common crow	+	1[a,b]	+	+	+	+	+	+
Common flicker	+	+	+	+	1	1	+	1
Common grackle	+	1[a,b]	+	1[a,c]	+	+	2[a]	+
Common yellowthroat	+	+	+	1	3[a]	+	1[a]	+
Dickcissel	1	+	+	2	+	+	+	+
Eastern kingbird	+	1	+	+	+	+	+	+
Eastern meadowlark	9	4	5	1	+	+	+	+
Eastern wood pewee	+	+	+	+	+	+	2	1
Field sparrow	1[b,c]	2	+	1	+	+	+	+
Grasshopper sparrow	+	+	2	1	+	+	+	+
Indigo bunting	+	1[a]	+	+	+	+	1[a]	+

Sheet 1

TABLE 3.3.3-3 (continued)

Species Observed	Number of Individuals Observed/Transect							
	Prairie				Forest			
	Pr-1	Pr-2	Pr-3	Pr-4	F-1	F-2	F-3	F-4
Louisiana waterthrush	+	+	+	+	1[a]	1[a]	+	+
Mockingbird	1[a]	+	+	+	+	+	+	+
Mourning dove	+	1[a,b]	1[a,c]	+	+	+	+	+
Ovenbird	+	+	+	+	2	+	+	1
Purple martin	+	+	+	1	+	+	+	+
Red-tailed hawk	+	+	+	+	+	1[b]	+	+
Red-winged blackbird	5	1[a,b]	3	1	+	+	+	+
Ruby-throated hummingbird	+	+	+	1[a]	+	+	+	+
Rufous-sided towhee	+	+	+	+	+	+	+	1[a]
Summer tanager	+	+	+	+	2	+	1	3
Tufted titmouse	+	+	+	+	+	1	2	1
Whip-poor-will	+	+	+	+	+	+	1	1
White-breasted nuthatch	+	+	+	+	1	2	2	+
Wood thrush	+	+	+	+	+	1	1	+
Yellow-billed cuckoo	+	+	1	+	+	+	+	+
TOTAL SPECIES (Diversity)	7	8	11	5	10	9	10	9

[b]Flying over.

[c]Recorded in adjacent habitat.

[a]Uncommon nesting inhabitant.

TABLE 3.3.3-4

AVIAN DIVERSITY OF COMMONLY NESTING BIRDS BASED ON THE MAXIMUM SPECIES OBSERVED IN ANY ONE DAY SURVEY OF TRANSECTS THAT TRAVERSE EIGHT PERMANENT SAMPLING STATIONS LOCATED WITHIN THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, EARLY JUNE 1974

Species Observed	Prairie Transects Pr-1	Pr-2	Pr-3	Pr-4
Dickcissel	1[a]	2	+	+
Eastern kingbird	+	+	+	1
Eastern meadowlark	9	1	5	4
Field sparrow	1	1	+	2
Grasshopper sparrow	+	1	2	+
Red-winged blackbird	5	1	3	+
Total Species (Diversity)	4	5	3	3

Species Observed	Forest Transects F-1	F-2	F-3	F-4
Bluejay	3	3	3	1
Cardinal	4	2	+	1
Common flicker	1	1	+	1
Eastern wood pewee	+	+	2	1
Ovenbird	2	+	+	1
Summer tanager	2	+	1	3
Tufted titmouse	+	1	2	1
White-breasted nuthatch	1	2	2	+
Whip-poor-will	+	+	1	1
Wood thrush	+	1	1	+
Total Species (Diversity	6	6	7	8

[a]Indicates the number of individuals sighted for each species observed.

+Not observed.

TABLE 3.3.3-5

AVIAN DIVERSITY FOR THE EIGHT PERMANENT SAMPLING STATIONS, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Species	Forest Transects				Prairie Transects			
	F-1	F-2	F-3	F-4	Pr-1	Pr-2	Pr-3	Pr-4
Bald eagle	+	+	+	2F	+	+	+	+
Barred owl	1	+	+	+	+	+	+	+
Bluebird	+	1	+	+	+	6	+	+
Bluejay	6 2H	7	5 4H	5	+	10F	+	7F
Bobwhite quail	+	+	+	+	+	+	12	+
Common crow	5H	+	1	2H	+	3F	2H	+
Common grackle	9F	+	30F	67F	84F	+	+	+
Common nighthawk	+	+	+	+	3F	+	+	+
Cowbird	+	+	+	+	+	3F	+	+
Eastern meadowlark	+	+	+	+	3	6 17H	6	2
Eastern phoebe	+	+	+	1	+	+	+	+
Field sparrow	+	+	+	+	2	1	+	+
Great horned owl	+	1	+	+	1H	3H	1H	+
Hairy woodpecker	+	1	+	1	+	+	1F	+
Hooded warbler	+	+	1	+	+	+	+	+
Least flycatcher	+	+	+	+	+	+	1	1
Mourning dove	+	2	+	+	1F	2F	+	+
Pileated woodpecker	1	+	1 1H	+	1F	+	+	+
Red-bellied woodpecker	1	+	1	1H	+	+	+	+
Red-headed woodpecker	6	6 2H	5	2	1H	1F	2H	1F
Red-tailed hawk	+	1	+	+	1F	+	+	1F
Red-winged blackbird	+	+	+	+	10F	+	+	+
Robin	2	+	1	1 1H	4F	3F	+	2F
Starling	+	+	50F	17	8F	6F	2F	6F
Sparrow hawk	+	+	+	1	+	1F	+	1F
Yellow-billed cuckoo	+	+	2	+	+	+	+	+
Yellow-shafted flicker	2	+	1	+	+	1F	+	+
TOTAL	35	21	103	101	119	63	27	21

F = birds seen flying over the plot.
H = birds heard on or adjacent to the plot.

TABLE 3.3.3-6

CHECKLIST OF BIRD SPECIES OBSERVED DURING THE ENVIRONMENTAL BASELINE INVENTORY (JUNE 1973), THE SPRING MONITORING SURVEY (JUNE 1974), AND THE FALL MONITORING SURVEY (SEPTEMBER 1974), CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI

Common Name	Scientific Name	Baseline Inventory	Spring Monitoring Survey	Fall Monitoring Survey
Acadian flycatcher	Empidonax virescens	x	-	-
American goldfinch	Spinus tristus	x	x	x
Bald eagle	Haliaetus leucocephalus	-	-	x
Baltimore oriole	Icterus galbula	x	x	-
Barn swallow	Hirundo rustica	x	x	-
Barred owl	Strix varia	-	-	x
Belted kingfisher	Megaceryle alcyon	x	x	-
Bewick's wren	Thryomanes bewickii	-	x	-
Black-billed cuckoo	Coccyzus erythropthalmus	x	-	-
Black-capped chickadee	Parus atricapillus	x	x	-
Blue-gray gnatcatcher	Polioptila caerulea	-	x	-
Blue grosbeak	Guiraca caerula	-	x	-
Bluejay	Cyanocitta cristata	x	x	x
Bobwhite	Colinus virginianus	x	x	x
Brown creeper	Certhia familiaris	-	-	x
Brown-headed cowbird	Molothrus ater	x	x	x
Brown thrasher	Toxostoma rufum	x	x	x
Cardinal	Richmondena cardinalis	x	x	x
Carolina wren	Thryothorus ludovicianus	-	x	-
Catbird	Dumetella carolinesis	x	x	-
Chimney swift	Chaetura pelagica	x	x	-
Chipping sparrow	Spizella passerina	x	x	x
Common crow	Corvus brachyrynchos	x	x	x
Common flicker	Colaptes auratus	x	x	x
Common grackle	Quiscalus quiscula	x	x	x
Common nighthawk	Chordeiles minor	x	x	x
Dickcissel	Spiza americana	x	x	-
Downy woodpecker	Dendrocopos pubescens	-	x	x
Eastern bluebird	Sialia sialis	x	x	x

TABLE 3.3.3-6 (continued)

Common Name	Scientific Name	Baseline Inventory	Spring Monitoring Survey	Fall Monitoring Survey
Eastern kingbird	Tyrannus tyrannus	x	x	x
Eastern meadowlark	Sturnella magna	x	x	x
Eastern phoebe	Sayornis phoebe	-	x	x
Eastern wood pewee	Contopus virens	x	x	-
Field sparrow	Spizella pusilla	x	x	x
Grasshopper sparrow	Ammodramus savannarum	x	x	-
Great blue heron	Ardea herodias	-	-	x
Great crested flycatcher	Myiarchus crinitus	x	x	-
Great horned owl	Bubo virginianus	x	-	x
Green heron	Butorides virescens	x	x	-
Hooded warbler	Wilsonia citrina	-	-	x
Horned lark	Eremophila alpestris	x	x	-
House sparrow	Passer domesticus	x	x	-
House wren	Troglodytes aedon	x	x	-
Indigo bunting	Passerina cyanea	x	x	-
Killdeer	Charadrius vociferus	-	x	x
Lark sparrow	Chandestes grammacus	-	x	-
Least flycatcher	Empidonax minimus	-	-	x
Loggerhead shrike	Lanius ludovicianus	x	x	-
Louisiana waterthrush	Seiurus motacilla	-	x	-
Mallard	Anas platyrhynchos	-	-	x
Marsh hawk	Circus cyaneus	-	x	x
Mockingbird	Mimus polyglottos	x	x	x
Mourning dove	Zenaidura macroura	x	x	x
Orchard oriole	Icterus spurius	-	x	-
Pied-billed grebe	Podilymbus podiceps	-	-	x
Pileated woodpecker	Drycocopus pileatus	x	-	x
Purple martin	Progne subis	-	x	-
Red-bellied woodpecker	Centurus carolinus	x	x	x
Red-eyed vireo	Vireo olivaceus	x	x	-
Red-headed woodpecker	Melanerpes erythrocephalus	x	x	x
Red-tailed hawk	Buteo jamaicensis	x	x	x
Red-winged blackbird	Agelaius phoeniceus	-	x	x

TABLE 3.3.3-6 (continued)

Common Name	Scientific Name	Baseline Inventory	Spring Monitoring Survey	Fall Monitoring Survey
Robin	Turdus migratorius	x	x	x
Rock dove	Columba livia	x	x	-
Ruby-crowned kinglet	Regulus calendula	-	-	x
Ruby-throated hummingbird	Archilochus colubris	x	x	-
Rufous-sided towhee	Pipilo erythrophthalmus	x	x	-
Song sparrow	Melospiza melodia	x	x	x
Sparrow hawk	Falco sparverius	x	x	x
Starling	Sturnus vulgaris	x	x	x
Summer tanager	Piranga rubra	x	x	-
Tree sparrow	Spizella arborea	-	-	x
Tufted titmouse	Parus bicolor	x	x	x
Turkey vulture	Cathartes aura	x	x	x
Vesper sparrow	Poecetes gramineus	-	-	x
Whip-poor-will	Caprimulgus vociferus	x	x	-
White-breasted nuthatch	Sitta carolinensis	-	x	x
White-eyed vireo	Vireo griseus	-	x	-
White-throated sparrow	Zonotrichia albicollis	-	-	x
Wood duck	Aix sponsa	-	x	-
Wood thrush	Hylocichla mustelina	x	x	-
Yellow-billed cuckoo	Coccyzus americanus	x	x	x
Yellow-breasted chat	Icteria virens	x	x	-
Yellowthroat	Geothlypis trichas	x	x	-

3.3.4 AMPHIBIANS AND REPTILES

Six species of amphibians and 13 species of reptiles were observed in the environs of the Callaway Plant site during the spring 1974 survey. The fall survey resulted in the collection of 21 species of herpetofauna (154 specimens) and the marking and release at their point of capture of 142 animals.

3.3.4.1 Amphibians

The several habitat types on the Callaway Plant site are attractive to a wide variety of amphibians, judged by their presence on the site during the spring and fall surveys.

Most amphibians pass through several stages of development from the egg to the adult. Water is a requirement for breeding and egg development for most amphibians, although some frogs and toads seek terrestrial environs in an immature or adult form and return to aquatic habitats only to breed. Numerous farm ponds, creeks, and ditches on the plant site serve as amphibian breeding areas. Frog tadpoles and young toads were observed during the survey, indicating completion of the reproductive process before the survey had commenced. Numerical estimates of immature amphibians were not attempted.

The species composition (Table 3.3.4-1) of amphibians reported in the fall is quite different from that reported for the spring survey. Three species collected during the fall survey were not reported during the spring survey. A good portion of this variability between sampling periods is due to the secretive nature of amphibians. Undoubtedly, numerous other species could be found with greater expenditures of time and energy. Every pond checked during the fall survey contained bullfrogs, northern cricket frogs, larval bullfrogs, and most also contained larval leopard frogs.

Seining of fishless ponds in the fall revealed several good populations of newts (both adults and efts) not discovered during the spring sample. Fifty-three adults were marked in one pond. It is likely that certain species of salamanders also use these ponds for breeding sites during early spring, although this has not been documented by field surveys.

Adult bullfrogs, green frogs, and leopard frogs are common inhabitants of permanent water bodies. The American toad, Fowler's toad, gray treefrog, spring peeper, and northern cricket frog require water for breeding and post-hatching development but seek terrestrial environments while relatively immature. The treefrog remains near water, but species of both frogs and toads may travel far from aquatic habitats. Adult bullfrogs were the most commonly occurring amphibian observed during the spring survey (Table 3.3.4-1), while newts were the most common during the fall survey. Every pond inspected on the plant site had good populations of bullfrogs (both adult and larval forms), indicating the species is doing well and represents a possibility for limited sport hunting in the future.

Northern cricket frogs and leopard frogs are also present in most plant site ponds but are not as restricted to water as bullfrogs; they are also encountered in moist woodland situations away from the ponds. Leopard frogs were frequently seen crossing roads at night when the relative humidity was high.

In addition to being difficult to census, amphibian populations are highly sensitive to short-term fluctuations in environmental conditions. Therefore, amphibians probably should not be used as "indicator species" detecting change by annual monitoring programs. However, their role or function in the total ecology of the site cannot be overlooked.

No rare or endangered amphibians were observed during the conduct of the field survey(s).

3.3.4.2 Reptiles

The numbers of each reptile species and the habitat types in which they were observed on the site are presented in Table 3.3.4-1. The prairies, forests, wetlands, ponds, streams, hedgerows, and variety of ecotones between communities provide reptiles with a variety of habitats within a predominantly agricultural area.

The three-toed box turtle was the most common reptile observed throughout the site during the spring survey (Table 3.3.4-1). It is adapted to an omnivorous diet of plant and some animal material and is not restricted to special habitat locations as are many of the other reptiles recorded during the study. Only 2 three-toed turtles were collected in the fall survey. Their major period of activity is late spring, which explains the large number collected in the spring survey. This species is not a good indicator, as it is likely to be found in woods, prairie, and cropland.

Many, if not most, lizards and snakes are most abundant in an ecotone habitat (Table 3.3.4-1). As a result, field-forest edges, old roads, and abandoned barns and houses (where litter is plentiful) are the best places to look for these species. At least two-thirds of the lizards and snakes captured in the fall survey were found in these habitats. Populations of lizards and snakes can be expected to increase at the plant site as the farm houses are abandoned; however, the increase will probably be temporary. As the area reverts to forest, the populations of many of the species should decline. Exceptions would be eastern ring-necked snake, ground skink, and five-lined skink, which do well in forest habitats.

The similarities or disparities in habitats of the permanent sampling stations cannot be meaningfully compared on the basis of herpetofaunal abundance and diversity because too few individuals were observed (Table 3.3.4-2). The ground skink and the three-toed box turtle were rather uniformly observed at forest sampling stations. However, both of these species may occur in prairie habitats. The ground skink is difficult to capture for marking; thus, in some instances, the same individual may have been observed on more than one occasion but recorded as a new sighting.

Table 3.3.4-3 shows the results of an extensive marking program initiated during the fall 1974 field survey. As recaptures of marked individuals are made during subsequent field surveys, a more quantitative review of the ecological role played by each species can then be made.

No rare or endangered reptiles were observed at the plant site during the spring survey.

Previous remarks made about the utility of amphibians for characterizing the local wildlife populations and their significance to annual monitoring program objectives are also applicable to reptiles.

TABLE 3.3.4-1

VARIETY AND NUMBERS OF HERPETOFAUNA OBSERVED IN THE VICINITY OF THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, SPRING AND FALL 1974

	Habitat Type															
	Shrubland		Cropland		Oldfield		Pasture		Creek		Pond		Forest		Total	
Species	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F
Newt (efts)	+[a]	3	+	1	+	+	+	+	+	+	+	+	+	+	0	4
Newt (adults)	+	+	+	+	+	+	+	+	+	+	+	53	+	+	0	53
Plains spadefoot toad	+	+	+	+	+	+	+	1	+	+	+	+	+	+	0	1
Fowler's toad	+	5	+	+	+	+	+	+	+	+	1	+	+	+	1	5
American toad	+	+	+	+	1	+	+	+	+	+	+	+	12	+	13	0
Gray treefrog	+	+	+	+	+	+	+	+	1	+	+	5	+	+	1	5
Spring peeper	+	+	+	+	+	+	+	+	+	+	+	+	+	1	0	1
Northern cricket frog	+	+	+	+	+	+	+	+	+	+	+	16	+	4	0	20
Leopard frog	+	+	+	5	1	+	+	+	2	+	+	1	1	+	4	6
Bullfrog	+	+	+	+	+	+	+	+	3	+	41	11	+	+	44	11
Green frog	+	+	+	+	+	+	+	+	2	1	1	+	+	+	3	1
Snapping turtle	+	+	+	+	+	+	+	+	+	+	2	+	+	+	2	0
Three-toed box turtle	1	+	9	+	7	+	3	1	+	+	+	+	11	1	31	2
Eastern fence lizard	+	3	+	+	+	+	1	+	+	+	+	+	+	+	1	3
Slender glass lizard	+	+	+	+	+	+	1	+	+	+	+	+	+	+	1	0
Ground skink	+	3	+	2	+	+	+	+	+	+	+	+	9	+	9	5
Five-lined skink	+	14	+	+	+	+	+	+	+	+	+	+	1	3	1	17
Common water snake	+	+	+	+	+	+	+	+	2	+	+	+	+	+	2	0
Brown snake	+	+	+	1	+	+	1	+	+	+	+	+	+	+	1	1
Red-bellied snake	+	2	+	+	+	+	+	+	+	+	+	+	+	+	0	2
Western ribbon snake	+	1	+	+	+	+	+	+	+	+	+	+	+	+	0	1
Common garter snake	+	+	1	+	+	+	+	+	+	+	+	+	+	+	1	0
Smooth earth snake	+	1	+	+	+	+	+	+	+	+	+	+	+	+	0	1
Eastern hognose snake	+	+	1	+	+	+	+	+	+	+	+	+	+	+	1	0
Worm snake	+	+	+	+	+	+	+	+	+	+	+	+	+	1	0	1
Eastern ringneck snake	+	+	+	+	+	10	+	+	+	+	+	+	+	2	0	12
Racer	+	+	+	1	+	+	+	+	+	+	+	+	+	+	0	1
Rat snake	1	+	+	+	2	1	+	+	+	+	+	+	+	+	3	1
Common kingsnake	+	+	+	+	+	+	1	+	+	+	+	+	+	+	1	0
Copperhead	+	+	+	+	2	+	+	+	+	+	+	+	+	+	2	0
TOTAL	2	32	11	10	13	11	7	2	10	1	4[illegible]	86	34	12	122	154

[a] not observed.

TABLE 3.3.4-2

VARIETY AND NUMBERS OF HERPETOFAUNA OBSERVED WITHIN PERMANENT SAMPLING STATIONS LOCATED ON THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, SPRING AND FALL 1974

	Prairie Stations								Forest Stations							
	1		2		3		4		1		2		3		4	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Spring peeper	+	+	+	+	+	+	+	+	+	1	+	+	+	+	+	+
American toad	+	+	+	+	1	+	+	+	+	+	2	+	2	+	1	+
Three-toed box turtle	+	+	+	+	+	+	+	+	1	+	1	1	+	+	1	+
Ground skink	+	+	+	+	+	+	+	+	+	+	2	+	2	+	4	+
Copperhead	+	+	+	+	1	+	+	+	+	+	+	+	+	+	+	+

+ = not observed.

TABLE 3.3.4-3

AMPHIBIANS AND REPTILES MARKED AND RELEASED IN THE VICINITY OF PERMANENT PLOTS, FALL 1974

	Prairie Stations				Forest Stations				
	1	2	3	4	1	2	3	4	Total
Newt - efts	+	+	+	+	+	1	3	+	4
Newt - adults	+	53	+	+	+	+	+	+	53
Fowler's toad	+	+	+	+	+	+	1	+	1
Gray treefrog	+	+	+	+	+	+	5	+	5
Spring peeper	+	+	+	+	1	+	+	+	1
Northern cricket frog	+	4	+	+	+	+	12	4	20
Leopard frog	+	+	+	+	+	+	1	+	1
Bullfrog	+	5	+	+	+	+	6	+	11
Green frog	+	+	+	+	+	+	+	1	1
Three-toed box turtle	+	1	+	+	+	1	+	+	2
Eastern fence lizard	+	+	+	+	+	+	+	3	3
Ground skink	+	+	+	+	1	1	+	3	5
Five-lined skink	+	1	1	+	2	+	6	7	17
Brown snake	1	+	+	+	+	+	+	+	1
Red-bellied snake	+	+	+	+	+	+	2	+	2
Western ribbon snake	+	+	+	+	+	+	1	+	1
Worm snake	+	+	+	+	+	+	+	1	1
TOTAL	12	64	1	0	5	3	37	20	142

+ not observed.

3.3.5 INVERTEBRATES

The invertebrates obtained in the field surveys are those normally inhabiting the various vegetative strata of the Callaway Plant site in late May and June (spring survey) and late August and September (fall survey).

The taxonomic identifications of invertebrates collected in both 1974 surveys are shown in Tables 3.3.5-1 and 3.3.5-2. The presence and number of specimens collected are indicated according to major habitat types (forest or prairie), permanent sampling station (F-1, F-4, etc.), and transect number within each station at which a given species was collected.

The preliminary nature of the spring survey precluded making other than very general observations. There was no obvious difference in the species diversity nor numbers of individual invertebrates collected in prairie as opposed to forest habitats. However, a relatively high proportion of the species are apparently associated with only one of the major habitat types; i.e., some species occur only in prairie while others occur only in forest habitats (Table 3.3.5-1). The data indicate that only the thrips occur in both forest and prairie habitats at extremely high densities. The identified families, genera, and species are considered rather numerous, whereas the number of individuals per taxonomic group is relatively few. However, such judgment is highly subjective because a basis for comparison is lacking. There is no known source of base information documenting the diversity and relative abundance of invertebrates in the vicinity of the Callaway Plant site.

The kinds of data reported in Table 3.3.5-2 are typical of those expected from this method of survey. The Insecta represents the largest number of species of any group of organisms. Certain problems are encountered in the identification of certain insects to the species level, resulting in the placement of many specimens only at a higher category such as Family.

The fall survey of invertebrates was dominated by arthropods, especially insects, in the sweeping samples, as was the case in the spring survey. The sweeping method is in fact biased toward collecting these organisms as opposed to other terrestrial invertebrates occupying select habitats or niches other than the exposed surfaces of the vegetative stratum. This bias is inescapable, however, when time and monetary constraints are imposed.

Arthropoda are largely habitat-specific, and this is reflected in the data presented in Tables 3.3.5-1 and 3.3.5-2. A number of trophic levels are represented among the invertebrates sampled. Many species of plant-feeding insects are relatively host-specific, and therefore their relative numbers (by sample) may be a reflection of the density of the host. Others are polyphagous, and some are predaceous on small invertebrates; still others feed on dead or decaying organic matter. Insects in particular are subject to dispersal, both vertical and horizontal, having no difficulty in flying from one site to another over the whole of the area of southern Callaway County, or moving from the ground litter up onto the higher stratum of a plant within a given habitat. Adverse weather conditions prior to or during the collection periods can affect the organisms, reducing the number collected by sweeping. These factors further complicate an analysis of the interrelationships within a given habitat, prairie or forest, and need to be kept in mind both now and in the future when one examines and interprets the data presented in Tables 3.3.5-1 and 3.3.5-2.

The majority of species collected tended to reflect their affinities to either the forest or prairie habitats. For example, species of the planthopper genus Myndus (Homoptera: Cixiidae), and leafhoppers in Erythroneura (Homoptera: Cicadellidae) were well represented in both forest habitats (F-1 and F-4) but were not collected from the prairie sites; the spider Oxyopes salticus (Araneidae: Oxyopidae) was exclusive to the prairie communities. Likewise, some species were collected from one of the paired habitats, but not both. Such was the case of Arthrolips decolor (Coleoptera: Orthoperidae), which was collected from Pr-4 but not the Pr-1 prairie site. This might reflect the different stages of succession of the two prairie habitats.

Many species were collected in relatively low numbers. This could result from a number of factors, including low population levels of the species, aggregations of individuals of a species within the habitat (more easily missed in a given sweep), selectivity in the collection methods used for certain species versus others, adverse microhabitat conditions, weather conditions such as wind, and so forth.

Many more species, organisms, and taxa were collected in the fall survey (ca. 9,500 specimens) than in the spring survey (ca.2,500 specimens) (Table 3.3.5-3), This is probably due in part to the seasonal buildup of populations. It may also be partially due to different personnel taking the June samples and the fall samples.

TABLE 3.3.5-1

TAXONOMIC IDENTIFICATION OF INVERTEBRATES COLLECTED IN SELECTED PERMANENT FOREST (F) AND PRAIRIE (PR) SAMPLING STATIONS LOCATED WITHIN THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, JUNE 1974

Class / Order / Family / Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Arachnida												
Araneida												
Araneidae												
Araneus maruoratus	+	+	+	+	+	+	+	+	+	+	1	+
Genus sp.	+	+	1	+	+	+	1	+	+	2	+	+
Chomisidae												
Misumenops sp.	1	+	+	+	+	+	+	+	+	+	+	+
Linyphiidae												
Genus sp.	+	1	1	+	+	+	+	+	+	+	+	+
Micryphantidae												
Ceraticelus sp.	+	+	+	1	1	+	+	+	+	+	+	+
Genus sp.	+	1	1	+	1	+	1	+	1	+	+	+
Phalangidae												
Genus sp.	1	1	+	3	1	+	+	+	+	+	+	+
Salticidae												
Hentzia sp.	+	+	1	+	+	+	+	+	+	+	+	+
Icius sp.	+	+	+	+	+	+	+	+	1	+	+	+
Metaphieppus sp.	+	+	+	+	+	1	+	+	+	3	+	+
Paraphidippus sp.	1	+	+	+	1	+	1	+	+	1	+	+
Thomisidae												
Coriarachne sp.	+	+	1	+	+	+	+	+	+	+	+	+
Misamena sp.	+	+	1	+	+	+	+	+	+	+	+	+
Misumenops sp.	+	1	+	+	+	+	+	+	+	+	+	+
Philodronus sp.	+	1	+	+	+	+	+	+	+	+	+	+
Synema parvula	+	+	+	+	+	+	+	+	1	+	+	+
Genus sp.	+	+	+	+	+	+	+	+	+	1	+	+
Acarina												
Ascidae												
Asca sp.	+	+	+	+	+	+	+	1	+	+	+	+
Bdellidae												
Genus sp.	+	+	+	+	+	+	+	+	+	1	+	1
Clubionidae												
Genus sp.	+	+	+	+	+	1	+	+	+	1	+	+
Erythraeidae												
Leptus sp.	+	+	+	1	+	+	+	+	+	+	+	+
Ixodides												
Amblyomnea americanum	+	+	1	+	+	+	+	+	+	+	+	+

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TABLE 3.3.5-1 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Arachnida (continued)												
Acarina (continued)												
Lycosidae												
Pardosa sp.	+	+	+	+	+	+	+	+	+	+	+	1
Oecobiidae												
Oecobius sp.	+	+	+	+	+	+	+	+	+	1	+	
Oxyopidae												
Oxyopes salticus	+	+	+	+	+	+	+	+	1	+	1	+
Trombidiidae												
Genus sp.	+	+	+	+	+	+	+	+	+	1	+	+
Tydeidae												
Genus sp.	+	+	+	+	+	+	+	+	+	2	+	+
Insecta												
Collembola												
Entomobryidae												
Genus sp.	1	+	+	+	+	+	+	+	+	+	+	1
Sminthuridae												
Genus sp.	+	+	+	1	+	+	+	+	+	+	+	+
Orthoptera												
Acrididae												
Genus sp. (Nymph)	+	+	+	+	+	+	+	+	1	+	+	1
Gryllidae												
Genus sp. (Nymph)	+	+	+	+	1	+	+	+	+	1	+	+
Oecanthinae												
Genus sp. (Nymph)	+	+	+	1	+	+	+	+	+	+	+	+
Phasmatidae												
Genus sp. (Nymph)	+	+	+	1	+	+	+	+	+	+	+	+
Tettigoniidae												
Genus sp. (Nymph)	1	+	+	2	4	+	4	7	7	10	+	5
Hemiptera												
Anthocoridae												
Orius insidious	+	+	+	+	+	+	+	+	+	3	+	+
Lygaeidae												
Phlegyas abbreviatus	+	+	+	+	+	+	+	+	+	1	+	3
Miridae												
Leptopterna dolobrata	+	+	+	+	+	+	2	3	+	1	+	1
Lygus lineolaris	+	+	+	+	+	+	+	+	7	13	+	7
Phlagiognathus politus	+	+	+	+	+	+	+	+	1	+	+	+
Platytylellus fraternus	+	+	+	+	+	1	+	+	+	+	+	+

TABLE 3.3.5-1 (continued)

Class / Order / Family / Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Hemiptera												
Miridae												
Reuteroscopus sulphureus (adult)	+	+	+	+	1	+	+	+	+	+	+	+
Reuteroscopus sulphureus (nymph)	+	+	+	+	2	+	+	+	+	+	+	+
Stenotus binotatus	+	+	+	+	+	+	2	4	+	6	+	+
Trigonotylus ruficornis	+	+	+	+	+	+	+	+	+	6	+	1
Genus sp.	+	1	+	+	+	+	+	+	+	+	+	+
Neuroptera												
Chrysopidae												
Chrysopa oculata	+	+	+	+	+	+	+	+	+	2	+	+
Chrysopa sp. (larva)	+	+	+	+	+	+	+	+	+	3	+	1
Coniopterygidae												
Coniopteryx vicina	+	+	+	+	2	+	+	+	+	+	+	+
Homoptera												
Aphididae												
Genus sp.	+	+	+	+	1	+	+	+	+	+	+	+
Genus sp. (nymph)	+	+	2	+	+	+	+	+	+	13	3	+
Cercopidae												
Philaenus spumarius	+	+	+	+	+	+	+	+	+	1	+	2
Cicadellidae												
Albera sp.	+	+	+	+	+	+	+	+	1	1	+	1
Cloanthanus frontalis	+	+	+	3	+	+	+	+	+	3	4	4
Doleranus longulus	+	+	+	+	+	+	4	10	4	1	+	1
Draeculacephala sp.	+	+	+	+	+	+	+	+	+	+	+	1
Remadosus magnus	+	+	+	+	+	1	+	+	+	+	+	+
Genus sp.	+	2	+	+	+	+	+	+	+	2	+	+
Genus sp. (nymph)	1	+	+	3	1	4	+	+	2	+	+	1
Cixiidae												
Cixus coloepeum	+	+	1	+	+	+	+	+	+	+	+	+
Delphacidae												
Stobaera sp.	+	+	+	+	+	+	3	+	2	1	+	+
Derbidae												
Cedusa vulgaris	5	1	4	5	3	4	+	+	1	+	+	+
Otiocerus abbotii	1	+	1	+	+	+	+	+	+	+	+	+
Membracidae												
Micrutalis calva	+	+	+	+	+	+	+	+	+	+	1	2
Psyllidae												
Trioza diospyri	+	+	+	+	+	+	+	+	+	2	5	1

TABLE 3.3.5-1 (continued)

Class / Order / Family / Genus and species	F-1 1[a]	F-1 2	F-1 3	F-4 1	F-4 2	F-4 3	Pr-1 1	Pr-1 2	Pr-1 3	Pr-4 1	Pr-4 2	Pr-4 3
Insecta (continued)												
Thysanoptera												
Aeolothripidae												
Aeolothrips albicinctus	+	+	+	+	+	+	+	+	1	+	+	+
Aeolothrips bicolor	+	+	+	+	+	+	2	2	+	3	+	+
Thripidae												
Anaphothrips obscurus	91	277	68	54	25	4	271	424	54	363	+	64
Aptinothrips rufus	+	+	1	+	+	+	+	+	+	+	+	+
Caliothrips sp.	+	+	+	+	+	+	+	+	+	1	+	+
Frankliniella fusca	+	+	+	1	+	+	+	3	+	+	+	1
Frankliniella tritica	+	+	+	+	+	+	+	+	+	15	1	7
Genus sp.	+	+	+	+	+	+	+	+	+	4	2	+
Lepidoptera												
Geometridae												
Genus sp.	+	+	+	2	+	+	+	+	+	+	+	+
Genus sp. (larva)	+	+	+	+	+	+	+	+	+	+	1	+
Hesperidae												
Genus sp.	+	+	+	+	+	+	+	+	1	+	1	+
Noctuidae												
Acronicta oblinita	+	+	+	+	+	+	+	+	+	1	+	+
Genus sp. (larva)	+	+	+	+	+	+	+	+	+	2	+	+
Pyralididae												
Genus sp. (larva)	+	1	1	+	+	+	+	+	+	+	+	+
Sphingidae												
Hemaris diffinis (larva)	+	+	+	+	+	+	+	+	+	+	+	1
Unknown												
Genus sp. (adult)	2	+	2	+	+	3	+	+	+	+	+	+
Genus sp. (larva)	1	+	+	+	+	+	+	+	+	+	+	+
Diptera												
Asilidae												
Dioctria sp.	+	+	+	1	+	+	+	+	+	+	+	+
Leptogaster sp.	+	+	1	+	+	+	+	+	+	+	+	+
Cecidomyiidae												
Genus sp.	+	+	+	1	+	+	+	+	+	1	1	+
Chironomidae												
Genus sp.	1	+	1	+	+	+	+	+	+	+	+	+
Chloropidae												
Genus sp.	8	+	+	+	+	2	1	+	2	+	+	+
Culicidae												
Aedes vexans	1	+	1	1	1	+	+	+	+	+	+	+

TABLE 3.3.5-1 (continued)

Class / Order / Family / Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Diptera												
Dolichopodidae												
Chrysotus sp.	+	+	2	+	+	+	12	8	7	+	+	1
Genus sp.	3	1	2	3	4	1	2	1	1	+	+	1
Empididae												
Genus sp.	+	+	1	+	+	+	+	+	+	+	+	+
Lauxaniidae												
Homoneura philadelphica	+	+	+	1	+	+	+	+	+	+	+	+
Genus sp.	1	+	+	+	+	+	+	+	+	+	+	+
Muscidae												
Genus sp.	+	+	1	1	2	1	1	+	3	7	+	+
Mycetophilidae												
Mycomya sp.	1	1	3	1	2	2	+	+	+	+	+	+
Trichonta sp.	+	+	+	1	+	+	+	+	+	+	+	+
Phoridae												
Genus sp.	+	1	2	+	2	+	+	+	1	+	+	+
Pipurculidae												
Chalarus sp.	1	+	+	+	+	+	+	+	+	+	+	+
Sarcophagidae												
Ravinia sp.	+	+	+	+	+	+	+	4	+	3	+	3
Sciaridae												
Bradsia sp.	+	2	1	+	+	+	+	+	+	+	+	+
Genus sp.	+	+	+	+	+	+	+	+	1	+	+	+
Sphaeroceridae												
Sphaerocera sp.	+	+	+	1	+	+	+	+	+	+	+	+
Syrphidae												
Paragus tibialis	1	+	+	1	+	+	+	+	+	+	+	+
Sphaerophoria cylindrica	+	+	+	+	+	+	+	+	+	+	+	1
Toxomerus geminatus	+	+	+	+	+	+	+	1	1	5	1	4
Tipulidae												
Elliptera sp.	+	1	+	+	+	+	+	+	+	+	+	+
Helius sp.	+	+	1	+	+	+	+	+	+	+	+	+
Genus sp.	+	+	+	+	1	+	+	+	+	+	+	+
Unknown												
Genus sp.	+	+	1	+	+	1	1	+	1	1	+	+
Hymenoptera												
Apidae												
Apid mellifera	+	+	+	+	+	+	+	+	+	1	+	+
Argidae												
Sofus pilicornis	+	+	+	+	+	1	+	+	+	+	+	+

TABLE 3.3.5-1 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Hymenoptera												
Brachonidae												
Genus sp. a.	+	+	+	+	+	+	2	1	+	2	1	2
Genus sp. b.	+	2	1	1	+	1	+	+	+	+	+	1
Chalcidoidea												
Genus sp.	+	+	2	4	+	+	+	+	+	+	+	+
Diapriidae												
Genus sp.	1	1	1	3	2	+	+	+	+	+	+	+
Encyrtidae												
Genus sp.	+	+	+	+	1	+	+	+	+	1	+	+
Eulophidae												
Genus sp.	+	1	+	+	1	+	+	+	+	1	+	+
Eupelmidae												
Genus sp.	+	+	+	+	+	+	1	+	+	7	+	+
Formicidae												
Acanthomyops sp.	+	+	+	+	1	+	+	+	+	+	+	+
Camponotus sp.	1	+	1	+	+	1	+	+	+	+	+	+
Crematogaster sp.	+	+	+	+	+	2	+	+	1	+	+	+
Dolichoderus sp.	+	+	2	+	+	+	+	+	+	+	+	+
Formica sp.	+	+	+	+	+	1	+	+	1	+	2	1
Harpagoxenus americanus	+	+	+	+	+	+	+	+	+	2	+	+
Leptothorax sp.	2	5	2	1	+	1	+	+	+	+	+	+
Monomorium geninatus	+	+	+	+	+	+	+	+	+	+	1	+
Myrica sp.	1	+	.	+	+	+	+	+	+	+	+	+
Paratrechina sp.	+	+	1	+	+	+	+	+	+	+	+	+
Pheidole sp.	+	+	+	3	2	1	+	+	+	+	+	+
Tetramorium caespitum	+	+	+	+	+	1	+	+	+	+	+	+
Halictidae												
Lasioglossum rohweri	+	+	+	1	+	+	+	+	+	+	+	+
Ichneumonidae												
Genus sp.	1	+	+	+	1	+	+	+	+	+	+	+
Mymeridae												
Genus sp.	+	1	1	1	+	+	+	+	+	+	+	+
Pteromalidae												
Genus sp.	+	+	+	+	+	+	+	+	3	1	+	+
Psocoptera												
Pseudocaeciliidae												
Genus sp.	+	2	1	2	+	+	+	+	+	+	+	+
Psocidae												
Genus sp.												

TABLE 3.3.5-1 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Coleoptera												
Alleculidae												
Isomira sp.	+	1	+	+	1	3	+	+	+	+	+	+
Anobiidae												
Brachytarsus stricticus	+	+	+	+	+	+	+	+	+	+	+	1
Caenocara oculata	+	+	+	+	1	1	+	+	+	+	+	+
Petalium bistriatum	1	+	+	1	+	+	+	+	+	+	+	+
Cantheridae												
Cantharis marginalis	1	+	+	1	1	+	+	+	+	+	+	+
Cantharis tantillus	+	1	2	+	+	+	+	1	+	+	+	+
Chauliognathus marginatus	+	+	+	+	+	+	+	+	+	4	1	+
Malthinus occipitalis	+	+	+	1	1	1	+	+	+	+	+	+
Malthinus sp.	+	+	+	1	+	+	+	+	+	+	+	+
Podabus rugulosus	+	+	+	+	+	+	+	+	+	1	+	+
Cerambycidae												
Hetoemis cinerea	+	+	1	+	+	+	+	+	+	+	+	+
Chrysomelidae												
Babia quadriguttata	+	+	+	1	+	+	+	+	+	+	+	+
Chaetocnema sp.	+	+	+	+	+	+	+	+	+	+	+	1
Chlamys sp. (larva)	+	+	+	+	+	+	+	+	+	+	1	+
Epitrix sp.	+	+	+	+	+	+	+	+	+	1	+	+
Exema sp.	+	+	+	+	+	+	+	1	1	+	+	+
Longitarsus sp.	+	+	+	+	+	+	+	+	1	1	+	+
Microrhopala vittata	+	+	+	+	+	+	+	+	+	+	1	+
Oedionychus quercata	1	+	+	+	+	+	+	+	+	+	+	+
Ophraella cribrata	+	+	+	+	+	+	+	+	+	+	+	2
Paria sp.	1	+	1	+	+	+	+	+	+	1	+	+
Phyllecthris dorsalis	2	1	+	1	+	+	+	+	+	+	+	+
Xanthonia sp.	3	2	2	8	1	4	+	+	+	+	+	+
Cleridae												
Korynetinae opetiopalpus	+	+	+	+	+	+	1	+	+	+	+	+
Phyllobaenus humeralis	+	+	+	+	1	+	+	+	+	+	+	+
Coccinellidae												
Ceratomegilla maculata	+	+	+	+	+	+	+	3	1	1	+	+
Hippodamia convergens	+	+	+	+	+	+	+	+	+	5	+	2
Hippodamia tibialis	+	+	+	+	+	+	+	+	1	+	+	+
Psyllobora vigintimaculata	+	+	+	+	+	1	+	+	+	+	+	+
Scymes terminatus	+	+	+	+	+	+	+	2	1	2	+	+
Genus sp. (larva)	+	+	+	+	+	+	1	5	1	+	+	+

TABLE 3.3.5-1 (continued)

Class / Order / Family / Genus and species	F-1 1[a]	F-1 2	F-1 3	F-4 1	F-4 2	F-4 3	Pr-1 1	Pr-1 2	Pr-1 3	Pr-4 1	Pr-4 2	Pr-4 3
Insecta (continued)												
Coleoptera (continued)												
Curculionidae												
Anametis grandulata	+	+	+	+	+	+	+	+	+	+	1	+
Apion sp.	9	5	12	10	+	2	+	+	+	+	+	+
Baris sp.	+	+	+	+	+	+	+	+	+	1	+	+
Odontocorynus sp.	+	+	+	+	+	+	+	+	+	2	1	+
Pandeleteius hilaris	+	2	2	+	+	1	+	+	+	+	+	+
Elateridae												
Ctenicera signaticollis	+	+	+	1	+	+	+	+	+	+	+	+
Limonius basillaris	+	1	2	+	1	+	+	+	+	+	+	+
Limonius quercinus	1	2	2	3	3	5	1	+	+	+	+	+
Erotylidae												
Tritoma sanguinipennis	1	+	+	+	+	+	+	+	+	+	+	+
Euglenidae												
Zonantes fasciatus	3	2	3	+	+	+	+	+	+	+	+	+
Histeridae												
Saprinus sp.	+	+	+	[illegible]	+	+	+	+	+	1	+	+
Melandryidae												
Micronotus sericans	+	1	+	+	1	+	+	+	+	+	+	+
Scraptia sp.	+	+	+	1	+	+	+	+	1	[illegible]	+	+
Mordellidae												
Mordellistena sp.	+	+	1	+	+	+	+	+	+	+	+	+
Orthoperidae												
Orthoperus sp.	+	+	+	+	+	+	2	+	+	+	+	+
Phalacridae												
Phalacrus sp.	+	+	+	+	+	+	+	+	+	1	+	+
Staphylinidae												
Apocellus sphaericollis	+	+	+	1	+	+	+	+	+	+	+	+
Stenus sp.	+	+	+	+	+	+	+	+	+	1	+	+
Tachinus fimbriatus	+	+	+	+	+	+	+	+	+	+	+	1

[a] indicates numbers of specimens collected.

TABLE ?.3.5-2

TAXONOMIC IDENTIFICATION OF INVERTEBRATES COLLECTED IN SELECTED PERMANENT FOREST (F) AND PRAIRIE (PR) SAMPLING STATIONS LOCATED WITHIN THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, SEPTEMBER 13, 1974

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Nematoda												
Unknown												
Unknown												
Genus sp.	+	+	1[b]	+	+	+	+	+	+	+	+	+
Gastropoda												
Pulmonata												
Pupillidae												
Vertigo milium	+	+	+	+	+	+	12	3	32	+	19	2
Succineidae												
Genus sp.	+	+	+	+	+	+	7	3	13	+	+	+
Diplopoda												
Unknown												
Unknown												
Genus sp.	+	+	+	+	2	+	+	+	+	+	+	+
Arachnida												
Chelonethida												
Unknown												
Genus sp.	1	+	+	1	+	+	+	+	+	+	+	+
Phalangida												
Unknown												
Genus sp.	2	2	1	+	1	+	+	+	+	+	+	+
Araneida												
Anyphaenidae												
Anyphaena sp.	+	3	+	+	+	+	+	+	+	+	+	+
Aysha sp.	+	+	+	+	+	1	+	+	+	+	+	+
Araneidae												
Acanthepeira stellata	+	+	+	+	+	+	+	2	+	+	+	+
Aranea sp.	+	+	+	1	+	+	+	+	+	+	+	+
Argiope trifasciata	+	+	+	3	+	+	+	+	+	+	+	+
Micrathena sp.	1	+	+	+	3	+	+	+	+	+	+	+
Neoscona sp.	+	+	+	+	1	+	+	+	+	+	+	+
Genus spp.	+	2	1	+	+	+	7	15	13	1	1	6
Dictynidae												
Dictyna sp.	+	+	+	1	1	+	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class / Order / Family / Genus and species	F-1 1[a]	F-1 2	F-1 3	F-4 1	F-4 2	F-4 3	Pr-1 1	Pr-1 2	Pr-1 3	Pr-4 1	Pr-4 2	Pr-4 3
Arachnida (continued)												
Araneida (continued)												
Gnaphosidae												
Drassodes sp.	1	+	+	+	+	+	+	+	+	+	+	+
Genus sp.	+	+	+	+	+	+	+	1	+	1	+	+
Linyphiidae												
Genus sp.	+	4	+	+	+	4	+	+	+	+	+	+
Lycosidae												
Lycosa cardinensis	+	+	+	+	+	+	1	+	1	+	+	+
Pirata sp.	4	+	+	+	+	+	+	+	+	+	+	+
Micraphantidae												
Lophocareninae	+	+	+	+	+	+	+	+	+	+	8	+
Genus sp.	+	2	+	+	+	+	+	+	+	3	+	4
Oonopidae												
Genus sp.	+	+	+	+	+	1	+	+	+	+	+	+
Oxyopidae												
Oxyopes salticus	+	+	+	+	+	+	102	31	77	25	37	8
Pisauridae												
Pisaurina sp.	+	1	+	+	3	+	+	+	+	+	+	+
Salticidae												
Ballus sp.	+	+	+	+	+	+	+	+	+	+	1	+
Icius sp.	+	+	1	+	+	+	+	+	+	+	+	+
Maevia sp.	+	12	+	+	+	+	+	+	+	+	+	+
Metacyrba sp.	+	+	+	+	+	6	+	+	+	+	+	+
Phidippus sp.	+	+	+	+	+	+	7	5	1	+	1	+
Thiodina sp.	6	+	+	+	+	+	+	+	+	+	+	+
Tetragnathidae												
Tetragnatha sp.	+	+	+	+	+	+	+	+	+	+	+	1
Genus sp.	+	+	+	+	+	+	+	+	+	1	+	+
Therediidae												
Pholcomma spp.	36	37	14	9	35	+	1	+	+	+	+	+
Thomisidae												
Coriarchne sp.	+	1	+	+	+	+	+	+	+	+	+	+
Misumenops sp.	3	6	3	1	10	2	1	1	+	+	+	13
Synema parvula	25	25	14	+	19	58	+	+	+	+	+	+
Xyticus sp.	+	+	+	+	+	+	+	1	+	+	4	1
Genus sp.	+	+	+	+	+	+	+	+	+	4	+	+

TABLE 3.3.5-2 (continued)

Class / Order / Family / Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Arachnida (continued)												
Acarina												
Anystidae												
Genera spp.	+	+	+	+	1	+	+	+	2	9	3	4
Bdellidae												
Genus spp.	+	+	+	+	+	+	+	1	2	+	+	1
Cunaxidae												
Genus spp.	+	1	1	+	+	+	1	+	+	+	+	+
Erythraeidae												
Genus spp.	+	+	+	1	1	+	+	+	+	+	+	+
Oribatelloidae												
Genera spp.	+	4	4	19	14	+	250	318	472	319	262	310
Pachygnathidae												
Genus sp.	+	+	+	+	+	1	+	+	+	+	+	+
Phytoseiidae												
Genera spp.	+	+	1	+	+	14	101	65	70	22	5	23
Tarsonemidae												
Genus sp.	+	+	+	+	+	+	+	1	+	+	+	+
Tetranychidae												
Bryobia sp.	+	+	+	+	+	+	+	1	+	+	+	+
Tetranychus urticae	+	+	+	+	+	+	74	13	54	4	+	2
Tydeidae												
Genera spp.	+	+	+	+	+	+	3	5	8	1	+	2
Insecta												
Collembola												
Entomobryidae												
Genus spp.	+	4	2	+	2	+	545	121	627	99	105	93
Sminthuridae												
Genus spp.	+	+	+	+	+	+	+	+	6	163	154	74
Odonata												
Coenagrionidae												
Enallagma sp.	+	+	+	+	+	+	+	+	+	1	+	+
Isoptera												
Rhinotermitidae												
Reticulotermes flavipes (workers)	+	+	2	+	+	+	+	+	+	+	+	+
Orthopera												
Acrididae												
Dichromorpha viridis	+	+	+	+	+	+	2	1	2	+	+	+
Syrbula admirabilis	+	+	+	+	+	+	+	1	1	+	+	+
Genus spp.	+	1	+	+	+	+	1	+	+	+	+	+
Blattoidae												
Genus sp (nymph)	+	+	+	+	1	+	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Orthopera (continued)												
Gryllidae												
Hapithus agitator	+	1	1	2	+	1	+	+	+	+	+	+
Nemobius fasciatus	+	+	+	+	+	+	1	+	4	+	1	4
Oecanthus angustipennis	+	+	2	+	+	+	+	+	+	+	+	+
Oecanthus latipennis	+	2	1	+	+	+	+	+	+	+	+	+
Genus sp.	+	+	+	+	+	+	+	1	+	+	+	+
Phasmatidae												
Diapheromera femorata	1	1	5	2	2	1	+	+	+	+	+	+
Tetrigidae												
Tettigidea lateralis (nymph)	+	+	+	+	+	1	+	+	+	+	+	+
Tettigoniidae												
Conocephalus strictus	+	+	+	+	+	+	17	15	25	6	9	3
Orchelimum nigripes	+	+	+	+	+	+	1	+	1	+	+	1
Psocoptera												
Psocidae												
Genus sp.	+	1	+	1	+	+	+	+	+	+	+	+
Genus sp. (nymph)	+	+	+	+	1	+	+	+	+	+	+	+
Hemiptera												
Alydidae												
Alydus eurinus (nymph)	+	+	+	+	+	+	+	+	+	1	+	+
Megalotomus quinquespinosus	+	+	1	+	+	+	+	+	+	+	+	+
Anthocoridae												
Orius insidiosus	+	+	+	+	+	+	1	+	1	+	+	1
Berytidae												
Jalysus spinosus	8	4	7	+	5	3	+	+	+	+	+	+
Coreidae												
Archimerus alternatus	+	+	2	+	+	+	+	+	+	+	+	+
Largidae												
Euryphthalmus succinctus	+	+	+	+	1	+	+	+	+	+	+	+
Lygaeidae												
Geocoris uliginosus	+	+	+	+	+	+	+	+	1	+	+	+
Orthaea sp.	+	+	+	+	+	+	1	+	+	+	+	+
Genus sp. (nymphs)	+	+	+	+	+	+	+	+	2	+	+	+
Miridae												
Hyaliodes harti	+	1	6	3	2	2	+	+	+	+	+	+
Lygus lineolaris	+	+	+	+	+	+	+	+	+	1	+	3
Phytocoris sp. a.	+	1	+	1	+	+	+	+	+	+	+	+
Phytocoris sp. b.	+	2	+	+	1	+	+	+	+	+	+	+
Plagiognathus cuneatus	+	1	+	1	+	+	+	+	+	+	+	+
Genus spp. (nymphs)	4	7	5	2	5	4	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Hemiptera (continued)												
Pentatomidae												
Mormidea lugens	1	+	+	+	+	+	+	+	+	+	+	+
Reduviidae												
Sinea sp. (nymphs)	1	+	+	+	+	+	+	+	+	+	+	+
Zelus sp. (nymphs)	+	3	1	+	3	+	+	+	+	+	+	+
Tingidae												
Corythucha arcuata	2	1	4	1	8	7	+	+	+	+	+	+
Corythucha associata	+	+	+	17	+	+	+	+	+	+	+	+
Corythucha cydoniae	+	+	+	5	12	2	+	+	+	+	+	+
Leptopharsa clitoriae	+	7	1	+	+	+	+	+	+	+	+	+
Leptopharsa oblonga	3	+	+	+	10	+	+	+	+	+	+	+
Leptoypha mutica	4	2	+	+	+	+	+	+	+	+	+	+
Physatocheila variegata	+	+	1	+	+	+	+	+	+	+	+	+
Genera spp. (nymphs)	2	1	+	10	9	3	+	+	+	+	+	+
Homoptera												
Acanaloniidae												
Acanalonia bivittata	+	+	2	+	+	1	+	+	+	+	+	+
Achiliidae												
Catonia cinctifrons	+	+	+	3	2	1	+	+	+	+	+	+
A erodidae												
Genus sp.	+	1	6	1	+	1	+	+	+	+	+	+
Aph didae												
Genera spp. (adults and nymphs)	9	38	17	23	25	28	14	12	10	9	+	1
Cerc idae												
Ph laenus spumarius	+	+	+	2	+	+	+	+	+	+	+	+
Cicade lidae												
Clo nthanus cupresecens	2	1	3	1	6	5	+	+	+	2	+	+
Clo nthanus frontalis	+	1	+	1	1	+	+	1	+	+	+	1
Cloanthanus sp.	+	+	+	+	+	+	+	+	+	1	+	+
Coelidia olitoria	1	+	1	+	+	1	+	+	+	+	+	+
Draeculacephala spp.	+	+	1	+	+	+	+	+	+	1	2	+
Empoasca fabae complex	10	3	7	5	3	4	+	+	2	4	3	5
Empoasca spp.	2	1	3	1	+	1	42	14	28	2	1	+
Erythroneura elegans?	+	2	1	+	1	1	+	+	+	+	+	+
Erythroneura comes c mplex	+	1	1	1	1	+	+	+	+	+	+	+
Erythroneura macula complex	+	2	3	+	4	+	+	+	+	+	+	+
Erythroneura nigra	1	+	+	+	+	+	+	+	+	+	+	+
Erythroneura obliqua complex	+	+	+	+	+	1	+	+	+	+	+	+
Erythroneura vulnerata complex sp.a	3	+	+	+	+	+	+	+	+	+	+	+
Erythroneura vulnerata complex sp.b	2	2	2	1	2	2	+	+	+	+	+	+
Erythroneura spp.	36	29	92	54	67	30	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Homoptera (continued)												
Cicadellidae (continued)												
Exitianus exitiosus	+	+	+	+	+	+	3	1	3	3	1	+
Flexamia sp.	+	+	+	+	+	+	10	5	4	+	+	+
Graminella nigrifrons	+	+	+	+	+	+	+	1	+	+	+	+
Gyponana sp.	+	+	+	+	+	+	+	+	+	1	+	+
Hymetta trifasciata	1	3	+	+	1	1	+	+	+	+	+	+
Hymetta spp.	+	1	1	4	4	2	+	+	+	+	+	+
Latulus sayi	+	+	+	+	+	+	34	12	24	1	+	+
Neokolla hieroglyphica	1	4	2	+	+	+	+	+	+	+	+	+
Paraphlepsius irroratus	6	1	4	3	+	3	+	+	+	+	+	+
Paraulacizes irrorata	+	+	2	+	+	1	+	+	+	+	+	+
Polyamia apicata	+	+	+	+	+	+	+	+	7	+	+	+
Scaphoideus spp.	+	2	2	+	+	+	+	+	+	+	+	+
Xestocephalus publicarius	+	+	+	+	+	+	+	2	+	+	+	+
Genera spp. (mostly numphs)	14	25	17	13	23	21	78	13	81	16	2	5
Cixiidae												
Myndus enotatus	20	28	23	4	8	1	+	+	+	+	+	+
Myndus fulvus	17	24	8	21	21	14	+	+	+	+	+	+
Myndus sp.	+	+	1	+	+	+	+	+	+	+	+	+
Coccoidea												
Genera spp.	+	+	+	1	+	1	+	+	2	+	+	+
Delphacidae												
Kelisia axialis	+	2	+	+	+	+	+	+	+	+	+	+
Libernilla ornata	+	+	+	+	+	+	2	4	2	+	+	+
Genus spp.	+	1	2	+	1	+	3	4	4	+	+	+
Derbidae												
Otiocerus degeerii	+	2	+	+	+	+	+	+	+	+	+	+
Dictyopharidae												
Phylloscelis atra	+	+	+	+	+	+	+	+	+	2	3	2
Flatidae												
Ormenis pruinosa	2	+	+	+	+	+	+	+	+	+	+	+
Ormenis septentrionalis	+	+	+	+	+	2	+	+	+	+	+	+
Ormenis venusta	+	1	+	+	+	+	+	+	+	+	+	+
Issidae												
Bruchomorpha vittata	+	+	+	+	+	+	50	36	55	14	10	2
Membracidae												
Campylenchia latipes	1	+	1	+	+	+	+	+	1	+	1	3
Publilia reticulata	+	1	22	+	+	1	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class / Order / Family / Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Homoptera (continued)												
Membracidae (continued)												
Tylopelta americana	+	+	+	1	+	+	+	+	+	+	+	+
Genus spp. (nymphs)	+	+	2	+	+	+	+	+	+	+	+	+
Pseudococcidae												
Genus spp.	+	2	+	+	+	+	+	+	+	+	+	+
Psyllidae												
Livia vernalis	+	+	+	+	+	+	1	+	+	+	+	+
Thysanoptera												
Aeolothripidae												
Aeolothrips bicolor	+	+	+	+	+	+	6	4	5	+	+	+
Phlaeothripidae												
Genera spp.	2	2	+	2	+	+	8	3	18	19	7	10
Thripidae												
Anaphothrips obscurus	+	+	+	+	+	+	9	+	+	+	+	+
Aptinothrips rufus	+	+	+	+	+	+	7	4	8	2	4	2
Chirothrips crassus	+	+	+	+	+	+	+	+	3	+	+	+
Echinothrips americanus	1	1	1	+	1	+	+	+	+	+	+	+
Frankliniella tritici	+	+	+	+	+	+	+	1	3	3	2	3
Scirtothrips niveus	1	2	+	+	+	+	+	+	+	+	+	+
Sericothrips baptisiae	+	+	+	+	+	+	4	+	2	10	1	1
Thrips helianthi	+	+	+	1	+	+	+	+	+	+	+	+
Thrips spp.	+	+	4	+	1	2	+	27	21	15	2	2
Neuroptera												
Chrysopidae												
Chrysopa rufilabris	+	2	1	3	1	1	+	+	+	+	+	+
Chrysopa spp. (larvae)	5	2	4	2	3	1	+	+	1	+	+	+
Coniopterygidae												
Coniopteryx vicina	+	+	+	+	1	+	+	+	+	+	+	+
Coniopteryx vicina ? (larvae)	1	1	+	+	5	3	+	+	+	+	+	+
Hemerobiidae												
Hemerobius humulinus	+	+	1	+	+	+	+	+	+	+	+	+
Lepidoptera												
Aegeriidae												
Synanthidon sp.	+	+	+	+	+	+	+	+	+	1	+	+
Amatidae												
Scepsis fulvicollis	+	+	+	+	+	+	1	+	+	+	+	+
Arctidae												
Genus sp. (larvae)	+	1	1	+	2	+	+	+	+	+	+	+
Eriocranidae												
Genus sp. (larva)	+	+	1	+	+	+	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class / Order / Family / Genus and species	F-1 1[a]	F-1 2	F-1 3	F-4 1	F-4 2	F-4 3	Pr-1 1	Pr-1 2	Pr-1 3	Pr-4 1	Pr-4 2	Pr-4 3
Insecta (continued)												
Lepidoptera (continued)												
Geometridae												
Genus spp. (larvae)	7	7	13	3	7	6	+	+	+	1	2	4
Hesperidae												
Genus spp. (larvae)	+	+	1	+	1	+	+	+	+	+	+	+
Limacodidae												
Genus sp. (larvae)	+	+	+	1	2	+	+	+	+	+	+	+
Megalopygidae												
Genus sp. (larva)	+	+	+	+	1	+	+	+	+	+	+	+
Noctuidae												
Genus spp. (larvae)	+	+	3	+	1	2	+	+	+	3	+	3
Noctuoidae												
Genera spp.	3	4	1	2	+	3	2	1	2	2	1	+
Notodontidae												
Cerura sp. (larva)	+	+	+	+	+	+	+	+	+	+	+	+
Heterocampa sp. (larvae)	+	+	+	1	+	+	+	+	+	+	+	+
Schizura sp. (larvae)	+	+	1	+	+	2	+	+	+	+	+	+
Genus spp. (larvae)	5	3	2	5	3	2	+	+	+	+	+	+
Nymphalidae												
Genus spp. (larvae)	2	5	7	1	3	2	+	+	+	+	+	+
Pyralidae												
Genus sp. (larva)	+	1	+	+	+	+	+	+	+	+	+	+
Sphingidae												
Genus sp. (larva)	+	+	+	+	1	+	+	+	+	+	+	+
Tortricidae												
Genus spp. (larvae)	4	+	4	7	3	6	+	2	+	1	+	1
Unknown												
Genus spp. (larvae)	4	1	8	1	3	2	+	+	+	+	1	1
Coleoptera												
Anobiidae												
Caenocara tenuipalpa?	1	+	+	+	+	+	+	+	+	+	+	+
Bruchidae												
Acanthoscelidae longistilus	+	2	1	+	+	+	+	+	+	+	+	+
Meibomeus musculus	+	+	1	+	+	+	+	+	+	+	+	+
Buprestidae												
Pachyscelus purpurens	+	+	+	+	+	1	+	+	+	+	+	+
Cantharidae												
Chauliognathus pennsylvanicus	+	+	+	+	+	+	+	1	+	+	+	+
Carabidae												
Notiophilus novemstriatus	+	+	+	+	+	1	+	+	+	+	+	+
Chrysomelidae												
Altica sp.	+	+	1	+	+	+	+	+	+	+	+	+
Blepharida rhois	+	+	+	1	+	+	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Coleoptera (continued)												
Chrysomelidae (continued)												
Chaetocnema confinis	+	3	2	+	1	+	+	+	+	+	+	+
Chaetocnema pulicaria	+	1	+	1	1	1	4	2	4	9	6	13
Diabrotica undecimpunctata	+	3	3	+	3	+	1	1	+	1	+	8
Epitrix fuscula	+	+	+	+	+	+	+	+	+	+	+	1
Epitrix sp.	+	+	+	1	+	+	+	+	+	+	+	+
Longitarsis sp.	+	+	+	+	+	+	+	+	+	+	1	+
Microrhopala vittata	+	+	+	+	+	3	+	+	+	+	+	+
Paria cancellagilvipes	2	+	+	+	+	+	+	+	+	+	+	+
Paria spp.	1	1	3	+	+	+	+	+	+	+	+	+
Genus spp. (larvae)	+	2	+	+	+	+	1	+	+	+	+	1
Cleridae												
Hydrocera humeralis	+	+	+	+	+	2	+	+	+	+	+	+
Genus spp. (larvae)	+	+	+	1	+	+	+	+	+	+	+	+
Coccinellidae												
Psyllobora vigintimaculata	+	+	+	2	+	2	+	+	+	+	+	+
Scymnus xanthespis?	1	+	+	+	+	+	+	+	+	+	+	+
Scymnus spp.	+	+	1	+	1	+	+	+	+	+	+	+
Genus sp. (larva)	+	+	+	1	+	+	+	+	+	+	+	+
Curculionidae												
Apions spp.	1	12	+	1	2	+	+	+	+	+	+	+
Centrinites strigicollis	+	+	+	+	1	+	+	+	+	+	+	+
Conotrachelus sp.	+	+	+	+	1	+	+	+	+	+	+	+
Curculio sulcatulus	+	+	+	+	+	1	+	+	+	+	+	+
Cyrtepistomus castaneus	1	3	+	11	+	1	+	+	+	+	+	+
Geraeus picumnus	+	+	+	+	+	+	+	2	+	+	+	+
Hypera punctata	+	+	+	+	+	+	+	1	+	+	+	+
Pandeletius hilaris	1	+	+	+	2	1	+	+	+	+	+	+
Smicronyx sp.	+	+	+	+	+	+	+	+	+	+	+	2
Genus sp. (larvae)	+	1	1	+	+	+	+	+	+	+	+	+
Euglenidae												
Zonantes fasciatus	+	+	+	+	+	1	+	+	+	+	+	+
Zonantes subfasciatus	2	1	4	+	+	+	+	+	+	+	+	+
Lamperidae												
Lucidota corrusca	+	+	+	1	+	+	+	+	+	+	+	+
Lathridiidae												
Cartodere sp.	+	+	+	+	+	+	+	+	2	+	+	+

TABLE 3.3.5-? (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Coleoptera (continued)												
Lathridiidae (continued)												
Corticaria sp.	+	+	+	+	+	+	3	+	+	+	+	+
Melanophthalma sp.	3	10	6	5	7	4	2	+	+	+	+	+
Genus spp.	1	+	+	1	+	+	+	+	+	+	+	+
Genus spp. (larvae)	+	+	+	+	+	+	+	+	+	25	36	39
Mordellidae												
Mordella discoidea	+	+	+	1	+	+	+	+	+	+	+	+
Genus sp. (larvae)	+	+	1	+	+	1	+	+	+	+	+	+
Orthoperidae												
Arthrolips decolor	+	+	+	+	+	+	+	+	+	25	47	45
Arthrolips sp.	+	+	+	+	+	+	+	+	+	3	1	5
Corylophodes marginicollis	+	+	+	+	+	1	+	+	+	+	+	+
Phalacridae												
Genus sp. a.	+	+	1	+	+	+	+	+	+	+	+	+
Genus sp. b.	+	+	+	+	1	+	+	+	+	+	+	+
Scaphidiidae												
Scaphisoma distincta	+	+	+	+	+	+	+	+	1	+	+	+
Scolydidae												
Chramerus hicoriae	+	1	+	+	+	+	+	+	+	+	+	+
Hypothenemus dissimilis	+	+	1	+	+	+	+	+	+	+	+	+
Hypothenemus intertitialis	+	+	2	+	+	+	+	+	+	+	+	+
Pseudopityophthorus minutissimus	+	+	+	+	1	+	+	+	+	+	+	+
Scolytus multistriatus	+	+	+	+	+	+	+	1	+	+	+	+
Staphylinidae												
Stenus humilis	+	+	+	+	+	+	+	+	1	+	+	+
Genus sp.	+	+	1	+	+	+	+	+	+	+	+	+
Tenebrionidae												
Paratenetus punctatus	+	+	1	+	+	+	+	+	+	+	+	+
Unknown												
Genus spp. (larvae)	+	3	+	+	+	+	7	2	4	6	10	+
Diptera												
Anthomyiidae												
Hylemya sp.	+	1	+	+	+	1	+	+	+	1	+	+
Pegomyia sp.	1	+	+	1	+	+	+	+	+	+	+	+
Genus sp.	+	+	+	+	+	+	+	+	+	+	1	+
Bibionidae												
Genus sp.	+	+	+	1	+	+	+	+	+	+	+	1
Bombyliidae												
Systoechus sp.	+	+	+	+	+	+	+	+	+	+	1	+
Calliphoridae												
Lucilia illustris	+	+	+	1	+	+	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Diptera (continued)												
Cecidomyiidae												
Genus spp.	3	8	5	+	5	3	4	+	+	+	1	+
Chironomidae												
Genus spp.	+	+	1	1	1	+	14	31	16	3	2	1
Chloropidae												
Meromyza americana	+	+	+	+	+	+	+	+	2	+	+	+
Genus spp.	+	+	1	1	1	1	31	19	18	2	+	7
Clusiidae												
Clusa lateralis	+	+	+	+	1	+	+	+	+	+	+	+
Culicidae												
Genus spp.	+	2	1	1	2	1	+	+	+	+	+	+
Cyclorrhaphae												
Genera spp. (larvae)	+	2	+	+	+	+	7	5	4	+	3	2
Dolicopodidae												
Genus spp.	4	3	6	+	3	1	1	+	2	+	1	+
Drosophilidae												
Chymomyza amoena	5	3	1	+	1	2	+	+	+	+	+	+
Genus sp.	+	1	1	1	+	+	+	1	1	+	+	+
Empididae												
Genus sp.	1	1	+	+	+	+	+	+	+	+	+	+
Heleomyzidae												
Genus sp.	1	+	+	+	+	+	+	+	+	+	+	+
Muscidae?												
Genus sp.	+	1	+	+	+	+	+	+	+	+	+	1
Mycetophilidae												
Genus spp.	4	1	1	4	+	3	1	+	+	1	+	1
Nematocerae												
Genus spp.	4	5	9	6	7	2	35	32	29	7	5	5
Otitidae												
Genus sp.	+	+	+	+	+	+	1	+	1	1	+	+
Phoridae												
Genus sp.	+	1	6	4	+	+	+	+	+	+	+	+
Pipunculidae												
Pipunculus sp.	+	+	1	+	+	+	+	+	+	+	+	+
Genus sp.	+	+	+	+	1	+	+	+	+	+	+	+
Platypezidae												
Platypeza sp.	1	+	+	+	+	+	+	+	+	+	+	+
Psilidae												
Loxocera cylindrica	1	+	+	+	+	1	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Diptera (continued)												
Sarcophagidae												
Ravinia guerula?	+	+	+	+	+	+	+	1	+	+	+	+
Scatopsidae												
Genus sp.	+	+	+	+	+	+	+	+	+	3	3	3
Sciaridae												
Genus sp.	+	4	+	+	4	1	3	+	4	2	2	2
Sciomyzidae												
Limnia sp.	+	+	+	+	1	+	+	+	+	+	+	+
Schizophora												
Genus sp.	+	2	6	+	2	3	+	2	2	5	4	1
Simuliidae?												
Genus sp.	+	+	+	+	+	+	+	1	+	+	+	+
Sphaeroceridae												
Genus sp.	1	+	+	+	+	1	+	+	+	+	+	+
Stratiomyidae												
Sargus cuprarius	+	2	+	+	+	+	+	+	+	+	+	+
Syrphidae												
Ocyptamus fuscipennis	+	+	+	1	+	+	+	+	+	+	+	+
Toxomerus marginatus	+	1	1	+	+	2	+	+	+	+	+	+
Toxomerus politus	+	1	+	1	+	+	+	+	+	+	+	+
Genus sp.	+	+	+	+	+	+	1	+	+	+	+	+
Tachinidae												
Cholomyia inaequipes	+	+	1	+	+	+	+	+	+	+	+	+
Genus sp.	1	+	+	+	+	+	+	+	+	+	+	+
Tipulidae												
Genus sp.	1	4	3	1	2	+	1	+	+	2	+	+
Unknown												
Genus spp.	2	2	+	+	1	+	+	1	+	+	+	+
Hymenoptera												
Apidae												
Bombus americanorum	+	+	+	+	+	+	+	+	+	1	+	+
Bethylidae												
Pristocera sp.	4	2	1	+	2	+	+	+	+	+	+	+
Brachonidae												
Genus spp.	11	6	5	6	6	2	1	+	1	1	1	1
Chalcididae												
Eurytoma sp.	+	+	+	1	+	+	+	+	+	+	+	+
Perilampus sp.	+	+	1	+	+	+	+	+	+	+	+	+
Genus sp.	+	+	+	+	+	1	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Hymenoptera (continued)												
Chalcidoidae												
Genera spp.	51	47	21	22	25	16	31	27	22	7	7	10
Cynipidae												
Genus spp.	8	4	2	1	2	+	+	1	+	+	+	+
Encyrtidae												
Genus sp.	+	+	+	1	+	1	+	+	+	+	+	+
Eulophidae												
Euplectrus sp.	+	+	1	+	+	+	+	+	+	+	+	+
Tetrastichus sp.	2	+	+	+	+	2	+	+	+	+	+	+
Genus spp.	+	+	1	+	+	1	+	3	+	+	+	+
Eupelmidae												
Eupelmus sp.	+	+	+	+	+	+	+	1	+	+	+	+
Genus sp.	+	+	+	+	+	+	+	+	2	+	+	1
Formicidae												
Aphaenogaster fulva	+	+	+	+	+	1	+	+	+	+	+	+
Crematogaster cerasi	4	1	2	1	+	+	+	+	+	+	+	+
Crematogaster clara	+	+	+	+	+	+	+	2	+	+	+	+
Crematogaster lineolata	3	+	1	1	+	1	+	+	+	+	+	+
Crematogaster sp.	+	+	2	+	+	+	+	+	+	+	+	+
Formica fusca	+	+	2	1	+	+	+	+	+	+	+	+
Lasius sp.	+	+	+	+	+	+	+	+	+	+	+	1
Leptothorax ambiguus	20	9	8	2	+	+	+	+	+	+	+	+
Monomorium minimum	+	+	+	+	+	+	+	+	1	+	+	+
Prenolepis imparis	5	4	5	15	9	4	+	+	+	+	+	+
Solenopsis molesta	+	+	+	+	+	+	1	2	+	+	+	+
Tetramorium caespitum	1	3	1	2	+	+	+	+	+	+	1	+
Ichneumonidae												
Gelis sp.	1	+	+	+	+	+	+	+	+	+	+	+
Genus spp.	1	1	2	+	+	1	1	+	+	+	+	+
Mymaridae												
Genus spp.	5	4	+	+	+	+	11	8	17	5	7	1
Ormyridae												
Ormyrus sp.	1	+	+	+	+	1	+	+	+	+	+	+
Pompilidae												
Genus sp.	+	1	+	+	+	+	+	+	+	+	+	+
Pteromalidae												
Genus sp.	+	+	+	+	+	+	+	3	+	+	+	+
Tiphiidae												
Genus sp.	+	+	+	+	1	+	+	+	+	+	+	+

TABLE 3.3.5-2 (continued)

Class Order Family Genus and species	F-1			F-4			Pr-1			Pr-4		
	1[a]	2	3	1	2	3	1	2	3	1	2	3
Insecta (continued)												
Hymenoptera (continued)												
Unknown												
Genera spp.	+	2	1	1	2	+	+	5	+	+	+	+

[a]samples of 50 sweeps each.

[+]not observed.

TABLE 3.3.5-3

COMPARISON OF INVERTEBRATE SPECIMENS COLLECTED BY PERMANENT STUDY PLOT AND TRANSECT DURING THE SPRING AND FALL SAMPLING PERIOD, 1974 ON THE CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI

	Spring			
Transect	F-1	F-4	Pr-1	Pr-4
1	143	130	319	539
2	326	92	485	41
3	149	54	115	126
Total	618	276	919	706
Grand Total		2519		

	Fall			
Transect	F-1	F-4	Pr-1	Pr-4
1	436	355	1677	934
2	535	392	974	796
3	490	336	1899	751
Total	1461	1083	4550	2481
Grand Total		9575		

3.4 ECOLOGICAL SUMMARY

The following paragraphs and illustrations describe, in a general way, functional relationships and structural components of the regional ecosystem within Callaway County, Missouri. Figure 3.4-1 is a diagrammatic representation of the major ecological associations of the Callaway Plant site. Figure 3.4-2 shows diagrammatically the various trophic levels, their relative contribution to the total biomass of the system, and natural and man-made stresses.

Soil inherently produces and concomitantly is subject to diverse influences, biotic as well as abiotic in nature. Natural soils serve as the starting point in the process of developing the carrying capacity of land for plant and animal communities (Figures 3.4-1 and 3.4-2). Natural soils, including the Goss soil of steep timbered hills and Menfro soils on hills bordering the floodplain in the site area, serve as a foundation upon which the "pyramid of biomass" is based. These soils (Goss and Menfro) have not been significantly altered by man. (Soil is ultimately a storehouse for the raw materials required by plants [the primary producers] for development and growth). The distinction is made between natural and agricultural soils subject to the influence of man. This distinction is further based on use, form, and composition, which additionally separate natural and agricultural soils.

Agricultural soils, including the Mexico-Putnam soils of the site area, start out initially as natural soils but subsequently are somewhat altered. The farmer alters the soil, such as at the Callaway Plant site, by first clearing the land, plowing the soil, and then cultivating for production of a standing crop. Additionally, to further assist in optimizing production from the soil, he utilizes fertilizers, pesticides, herbicides and other chemicals to enhance production and limit or eliminate waste. Productive agricultural land in some respects is "short-circuited" successionally, in that the normal organic cycle must be continually supplemented to maintain a high soil fertility, the prerequisite for successful agricultural development. Cultivation physically increases soil aeration and allows for some organic additions at a more rapid rate; however, it also causes greater moisture evaporation by exposing a greater proportion of the soil surface to the air. Surface water runoff from agricultural soils may be made up of considerable quantities of soluble and suspended material including organic material, fertilizers, silt and residues from herbicides and pesticides. These materials can enter adjacent waterways and have a pronounced influence on the aquatic ecosystem.

Litter, another element of the ecosystem, consists fundamentally of organic components, namely leaves and other vegetative plant parts shed throughout a growing season. These organic additions to the litter layer provide food to decomposers and microorganisms in addition to insects that inhabit the litter mat of various vegetative cover types. Litter generally is composed of two main forms: first, organic litter consisting of twigs, leaf debris, mulches, duff, and brush, or the undecomposed component of the biotic community. The second major component of litter is humus--litter that has undergone and is undergoing aerobic and anerobic decomposition into organic and inorganic components.

Litter provides input to the soil by adding humus content to the upper horizons of the soil profile (Figure 3.4-2). This addition aids in building the soil profile while helping to increase the capability of the soil to retain moisture necessary for plant growth. Plant roots, stems, bacteria, fungi, and small animals residing in the soil or litter mat provide both physical and chemical additions to the substrate that enhance the soil characteristics.

At the elemental level, litter is a storage point in the nitrogen, phosphorus, and sulfur cycles. Carbohydrates, as well as ligins, proteins, and amino acids present in the litter layer are food for the microorganisms, which are important in cycling nutrients into the inorganic forms required for plant growth and development.

The green plant (Figure 3.4-2), in all its diverse shapes, sizes, and locations, forms the basic source of energy upon which all elements of the ecosystem are totally dependent. The reason for this total reliance on the plant is due to the unique ability of green plants to convert solar energy and chemicals through the photosynthetic process into an organic form which is usable by other organisms. As a result, the green plant, the primary producer in the ecological community, functions as the foundation of the food web.

Vegetation of the field and forest, serving as the basis of the ecosystem, receives its energy inputs from the sun, water, minerals, and the atmosphere. Sunlight, as previously mentioned, provides the energy necessary for photosynthesis. Water is an important requirement of plants for physical support metabolism and assists in transporting gases and chemicals throughout the plant. Minerals are required by plants to provide the basic units and cellular materials necessary for normal growth, flowering, and reproduction. Atmospheric gases, in particular carbon dioxide and oxygen, are required by the individual plant to permit photosynthesis and respiration to occur. These primary inputs supply vegetation with the materials necessary for survival and development.

Plants, in their unique position, supply energy in several forms to the primary consumers of the biota. Basically, the energy from plants is in the form of forage materials from the site area, such as acorn, hackberry, greenbriar, smooth sumac, juniper berries, maple seed, persimmon, blackberry, strawberry, black walnut, and wild grape, plus a variety of grains and succulent shrubs, which supply vitamins, starches, sugars, and other compounds necessary for the life of birds and animals (herbivores). In oldfields and transition areas in particular, the forage value of the vegetation is very high, owing to the prevalence of grasses and shrub species used by herbivores including several bird species, rabbits, white-tailed deer, fox, and gray squirrels (Figure 3.4-1).

In addition to providing forage, vegetation also provides cover and concealment for wildlife utilizing the various habitats. Cover is an important factor in controlling the rate of predation occurring in wildlife populations. The vegetation of the site area consists of a diverse flora including forest associations such as oak, oak-hickory, oak-maple, and black walnut-red cedar. Field associations of the site include pasture and oldfield (prairie). Hardwood forests within the site area in addition to dense shrub thickets afford excellent cover and concealment to a broad spectrum of wildlife species (Figure 3.4-1).

Invertebrates are the most abundant of the faunal forms found in the Callaway Plant site area. The multifarious insect species are the most important of the invertebrate fauna, and this position is reinforced by their sheer numbers both in species and individuals. Insects represent every conceivable trophic level from primary consumers such as aphids, to facultative parasites such as wood ticks, to tertiary carnivores such as assasin bugs. There are fructivorous insects, granivorous insects, herbivorous insects, parasitic insects, detritivorous insects, carnivorous insects -- every available plant and animal species is either preyed upon or parasitized by insects. The diets of a good many of the higher animals are based, at least in part, upon the availability of insects as food. The invertebrates, especially the insects, are an integral, essential, and omnipresent component of every terrestrial ecosystem on earth.

Most of the smaller herptiles of the Callaway Plant site are predaceous upon insects. Species such as the ground skink, five-lined skink, and the eastern fence lizard live in the forested areas or edges and feed exclusively upon the insects there. Many of the more grassy areas are inhabited by various species of snakes, which prey upon a variety of species. The hog-nosed snake feeds almost exclusively upon toads, while garter snakes and rat snakes eat small mammals, lizards, skinks, baby birds - almost anything available. The three-toed box turtle is more omnivorous in its habits, eating vegetation and occasional insects. The frogs and toads are largely insectivorous, though the larger species such as the bullfrog may prey upon prairie voles and garter snakes.

The herptiles are in turn prey for a number of larger species such as hawks, crows, owls, weasels, and even hogs.

In a natural system, the wild animals are the principal users or consumers of the available botanical component of the habitat (Figure 3.4-2). This utilization may be direct, as in the case of a white-tailed deer browsing on smooth sumac leaves, or perhaps indirect, as in the case of a prairie vole building a runway from lodged fescue stems and accumulated leaf litter. In any case, the key concept is utilization of available resources and this takes on myriad forms throughout zoological components of the ecosystem. Resource utilization is not, however, a one-way operation, for many of the components are recycled within the system and again become available for use by the plants, i.e., the smooth sumac eaten by the deer is converted within the system and again becomes available for use by the plants; the fescue stems and leaf litter decay in time and their elemental components enrich the soil and, in turn, provide essential nutrients for plant growth; the same recycling occurs when an animal dies and the components of its body decay and eventually are recycled and reused.

The birds of the Callaway Plant site are a very diverse lot, changing their food habits and habitats with the season (Figure 3.4-1). During the nesting season in the spring, various vegetative components of the ecosystem are incorporated into the nesting territory and are fiercely defended by the males, while during the fall, a wide range of habitat type may be frequented. Many birds are granivorous and thus their territories include areas where weeds grow and seeds are abundant. Others are largely insectivorous and their territories are chosen by those areas, primarily grasslands, where insects are abundant. Predatory birds are more wide-ranging, since they prey upon a wider variety of animals. Small raptors such as the sparrow hawk feed primarily upon large insects such as grasshoppers. Larger raptors such as the great horned owl are nocturnal and feed upon species such as mice, voles, and rabbits, which are active at night. Other birds, such as bob-white quail, are omnivorous, feeding alternatively upon seeds, leaves, flowers, insects, spiders, and other materials found along the ground.

Birds are also preyed upon by a variety of predators. Some larger hawks prey upon mourning doves and quail, while many nests are raided by arboreal snakes, specifically the gopher snake and the rat snake.

Birds occupy various zones within a habitat--some preferring the ground surface, others, tall weedy vegetation. Still others occupy the various strata within the forest canopy (Figure 3.4-1).

Birds are very important in the dispersal of vegetative seeds, especially weed seeds. This is important in the natural succession of vegetative communities.

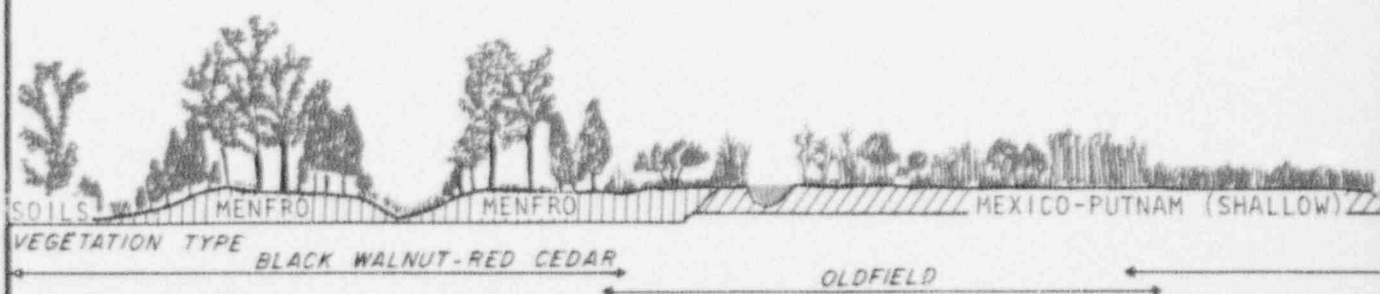
Mammals of the Callaway Plant site are easier to categorize than most other fauna of the area due to their limited numbers and their position in the trophic web (Figures 3.4-1 and 3.4-2).

Shrews are almost exclusively insectivores, although the short-tailed shrew does prey upon the young of mice and of ground-nesting birds. Most rodents are herbivorous, with an occasional insect in their diet. Harvest mice and white-footed mice are granivorous, while the prairie vole and the southern bog lemming cut grass stems to make small "haystacks." Cottontail rabbits also consume a variety of herbaceous plant parts.

The opossum is an omnivore as is the raccoon, but their tastes are such that there is little, if any, competition between them. Carnivorous mammals include the red fox, the coyote, and the long-tailed weasel.

The only really large wild mammal on the site is the white-tailed deer, which is a browser, eating the succulent leaves, stems, and buds of woody plants and forbs.

Small mammals are preyed upon by snakes, bullfrogs, hawks, owls, weasels, foxes, and coyotes; while larger mammals are preyed upon by large hawks, foxes, coyotes, and other top carnivores. Most of the top carnivores are preyed upon only by man.



VEGETATION		
BLACK WALNUT	GLOBOSE CYPERUS	ELM-LEAF GOLD
RED CEDAR	REED FESCUE	CANADA GOLDEN
HONEY LOCUST	MEADOW FESCUE	WHITE CLOVER
AMERICAN ELM	RED CLOVER	RED CLOVER
	SHEEP SORREL	HORSE NETTLE
	YELLOW FOXTAIL	
HERPETOFAUNA		
WORM SNAKE	COPPERHEAD	COPPERHEAD
FIVE-LINED SKINK	LEOPARD FROG	LEOPARD FROG
THREE-TOED BOX TURTLE	THREE-TOED BOX TURTLE	THREE-TOED BO
		GARTER SNAKE
AVIFAUNA		
CARDINAL	DICKCISSEL	DICKCISSEL
DICKCISSEL	SPARROWS	SPARROWS
WARBLERS	FLYCATCHERS	FLYCATCHERS
FLYCATCHERS	BLACKBIRDS	BLACKBIRDS
BLACKBIRDS	STARLINGS	STARLINGS
SPARROW HAWK	GRACKLES	GRACKLES
QUAIL	QUAIL	QUAIL
MOURNING DOVE	MOURNING DOVE	MOURNING DOVE
MAMMALS		
OPOSSUM	OPOSSUM	OPOSSUM
RACCOON	RACCOON	RACCOON
WHITE-TAILED DEER	WHITE-TAILED DEER	WHITE-TAILED
PRAIRIE VOLE	PRAIRIE VOLE	PRAIRIE VOLE
STRIPED SKUNK	STRIPED SKUNK	STRIPED SKUNK
LONG-TAILED WEASEL	RED FOX	RED FOX
RED FOX	COYOTE	COYOTE
COYOTE	COTTONTAIL RABBIT	COTTONTAIL RA
COTTONTAIL RABBIT	SOUTHERN BOG LEMMING	SOUTHERN BOG

ASTURE	OAK-MAPLE	OAK-HICKORY	OAK
ENROD ROD	RED OAK SUGAR MAPLE WHITE OAK PIGNUT HICKORY WHITE ASH	WHITE OAK RED OAK BLACK OAK BUR OAK SHAGBARK HICKORY BITTERNUT HICKORY HOP-HORNBEAM	WHITE OAK POST OAK BLACK OAK RED OAK WHITE ASH SUGAR MAPLE SHAGBARK HICKORY
X TURTLE		AMERICAN TOAD FIVE-LINED SKINK BLACK RAT SNAKE THREE-TOED BOX TURTLE HOG-NOSED SNAKE	
		CARDINAL RED-HEADED WOODPECKER HAIRY WOODPECKER DOWNY WOODPECKER CROWS BARRED OWL GREAT HORNED OWL	
DEER BBIT LEMMING		OPOSSUM RACCOON WHITE-TAILED DEER SHORT-TAILED SHREW STRIPED SKUNK GRAY SQUIRREL FOX SQUIRREL RED FOX COYOTE COTTONTAIL RABBIT	

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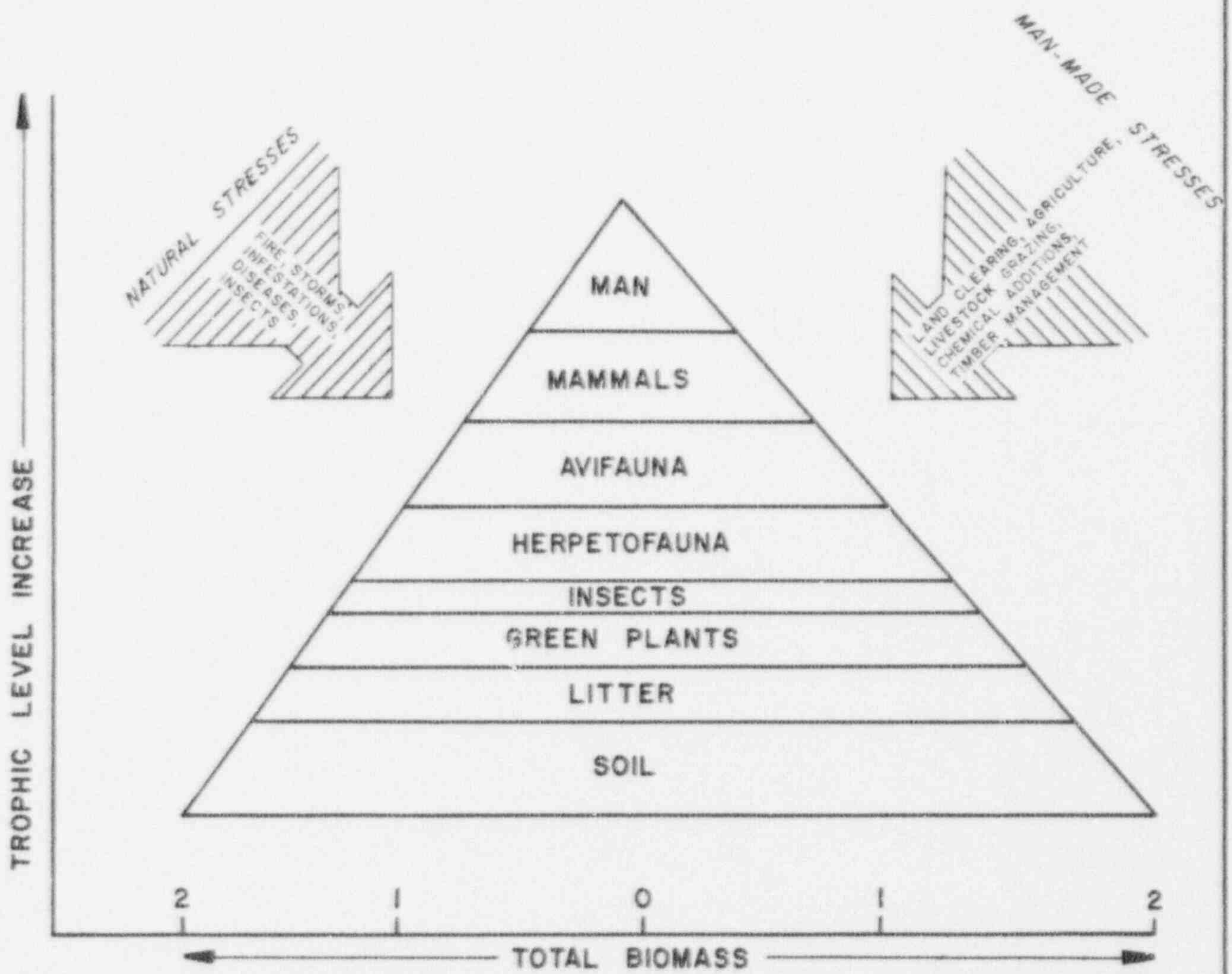
CALLAWAY PLANT
UNITS 1&2

MAJOR ECOLOGICAL ASSOCIATIONS

Figure 3.4-1



UNION ELECTRIC CO.
CALLAWAY PLANT
UNITS 1&2

PYRAMID OF BIOMASS

Figure 3.4-2

3.5 CONCLUSIONS AND RECOMMENDATIONS

The results of the preconstruction monitoring program substantiate the conclusions reached after the baseline inventory regarding anticipated environmental impact from plant construction and operation. To reiterate, the ecology of the Callaway Plant site is not unique, and its particular ecological balance reoccurs many times throughout central and eastern Missouri. Intensive farming has produced favorable habitat for wildlife populations, but these conditions can be found in areas adjacent to the site. Since construction of the facility will remove only a small portion of the total acreage from production and since the ecology of the Callaway County Plant site is not unique, no significant impact from plant construction on the resident wildlife population is anticipated.

Rare and endangered or extremely important economic species occurring near or on the site will be affected little by development of the facility. The turkey, white-tailed deer, and ruffed grouse require forested habitats broken by small fields or openings and a relatively large home range. Only a few acres of forest will be disrupted during construction, and the access road, pipelines, and railroad spur should not affect movement of these species. Other species, such as the bald eagle, are extremely mobile and are not expected to be found near or on the site very often.

As a result of the first year's surveys, some recommendations can be made to improve the program, especially with regard to the invertebrates.

A voluminous amount of material was collected by sweeping, far too much to analyze critically. Also, large numbers of species cannot be dealt with taxonomically and must be identified only to a higher level. This is due to the lack of adequate keys and/or correctly determined collections of certain taxa (and accessibility to them), and to the inadequate knowledge of certain groups possessed by any identifier.

Even with the large amount of material collected, the methods provide at best a survey of only a component of the terrestrial invertebrates. This is not necessarily a shortcoming, but rather a reality. Spring and fall season comparisons are not expected to be completely alike either in species composition or abundance. Thus a certain taxa from the total survey should be selected for comparison. These should be invertebrates that provide the best chance of being identified to the genus and/or species level, or in selected cases, order or family. The chosen higher taxa (genus, family) should, within the taxon, reflect a relatively homogeneous trophic level and not have species representing two or more trophic levels. As a group, the spiders should prove to be a useful monitoring barometer. They occur in large enough numbers to be meaningful, are all predators, are generally habitat specific, and as adults are identifiable to some meaningful level, genus, or species. The Hemiptera and Auchenorrhynchous Homoptera are generally plant feeders whose species suck plant juices via piercing-sucking mouthparts. There is a distinct plant-insect interaction with many of the species being host specific. They are also fairly well known and can be identified. The predaceous Hemipterans are well known and afford observation of an insect predatory group. Also the Orthopterans are largely a mandibulate plant-feeding or scavenger group. The Thysanopterans (Thrips), Neuropterans (lacewings), and Coleopterans (beetles) are fairly well known and reflective of different trophic levels and should continue to be monitored.

Certain orders of arthropods appear to offer little chance of being identified to either family or genus and should be eliminated from serious consideration, as they probably will not satisfy the objectives of a monitoring program. These include the Collembola, Lepidoptera, Diptera, Hymenoptera, and Acarina. Others such as the Odonata, Psocoptera and non-arthropod groups do not occur in sufficient numbers in the sweeps to warrant their inclusion.

Since the invertebrates constitute the largest single component (in terms of number of species) on these permanent study sites, it is necessary to include them in a monitoring program. However, it has been found impractical and scientifically unrealistic to consider all of the invertebrates in the monitoring program.

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4. APPENDIXES A AND B

Both appendixes consist only of tables, the titles of which follow:

NUMBER	TITLE
A-1	Data Summary for Prairie Vegetation Clipped from Subplots of Sampling Station Pr-1, Callaway Plant Site, Callaway County, Missouri, Fall 1974
A-2	Data Summary for Prairie Vegetation Clipped from Subplots of Sampling Station Pr-1 Callaway Plant Site, Callaway County, Missouri, May-June 1974
A-3	Data Summary for Understory Vegetation of Sampling Station Pr-1, Callaway Plant Site, Callaway County, Missouri, Fall 1974
A-4	Data Summary for Prairie Vegetation Clipped from Subplots of Sampling Station Pr-2, Callaway Plant Site, Callaway County, Missouri, Fall 1974
A-5	Data Summary for Prairie Vegetation Clipped from Subplots of Sampling Station Pr-2 Callaway Plant Site, Callaway County, Missouri, May-June 1974
A-6	Data Summary for Understory Vegetation of Sampling Station Pr-2, Callaway Plant Site, Callaway County, Missouri, Fall 1974
A-7	Data Summary for Prairie Vegetation Clipped from Subplots of Sampling Station Pr-3, Callaway Plant Site, Callaway County, Missouri, Fall 1974
A-8	Data Summary for Prairie Vegetation Clipped from Subplots of Sampling Station Pr-3 Callaway Plant Site, Callaway County, Missouri, May-June 1974
A-9	Data Summary for Understory Vegetation of Sampling Station Pr-3, Callaway Plant Site, Callaway County, Missouri, Fall 1974
A-10	Data Summary for Prairie Vegetation Clipped from Subplots of Sampling Station Pr-4, Callaway Plant Site, Callaway County, Missouri, Fall 1974
A-11	Data Summary for Prairie Vegetation Clipped from Subplots of Sampling Station Pr-4 Callaway Plant Site, Callaway County, Missouri, May-June 1974

4. APPENDIXES A AND B (continued)

4. APPENDIXES A AND B (continued)

APPENDIX 8-I

DATA SUMMARY FOR PRAIRIE VEGETATION[a] CLIPPED FROM SUBPLOTS, SAMPLING STATION PR-1, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Scientific Name / Common Name	Subplots-presence indicated by dry weight (grams/0.125 m² plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency	Dry Weight[d] for Species	Relative[e] Weight(%)	Important[f] Value
Festuca elatior L. meadow fescue	228.65	195.90	181.00	180.15	204.55	157.50	141.00	83.90	140.00	215.40	205.00	149.00	259.00	212.00	180.75	285.20	100.00	34.04	3,033.35	99.90	133.94
Carex glaucodea Tuckerm. ---	.10			.80				2.50									18.75	6.38	3.40	0.11	6.49
Cyperus ovularis (Michx.) Torr. hedgehog club rush	1.35																6.25	2.12	1.35	0.04	2.16
Lespedeza striata (Thunb.) H.& A. Japanese lespedeza		.05			.10			1.80								.20	25.00	8.51	2.15	0.05	8.56
Trifolium repens L. white clover		.05															6.25	2.12	0.05	0.00	2.12
Panicum lanuginosum Ell. ---				.05	.10			3.20		.20						.15	31.25	10.63	3.70	0.12	10.75
Potentilla simplex Michx. cinquefoil					.30		.90	4.40		.80					.7		31.25	10.63	6.15	0.20	10.83
Moss sp.					.01											13.20	12.50	4.25	13.21	0.43	4.68
Prunella vulgaris L. calf has					.05												6.25	2.12	0.05	0.00	2.12
Andropogon virginicus L. broom sedge					.80												6.25	2.12	0.80	0.02	2.14
Eragrostis spectabilis (Pursh) Steud. bent grass						1.00											6.25	2.12	1.00	0.03	2.15
Lespedeza stipulacea Maxim. Korean clover						.10									.10		12.50	4.25	0.20	0.00	4.25
Lechea tenuifolia Michx. pineweed								1.20									6.25	2.12	1.20	0.03	2.15
Lespedeza violacea L. Pers. bush clover								.30									6.25	2.12	0.30	0.00	2.12
Solidago nemoralis Ait. old-field goldenrod															.05		6.25	2.12	0.05	0.00	2.12
Juncus tenuis Willde. sedge																.25	6.25	2.12	0.25	0.00	2.12
Cyperus strigosus L. umbrella sedge																.35	6.25	2.12	0.35	0.00	2.12
TOTALS	228.00	196.00	181.00	181.00	205.91	159.00	141.90	96.90	140.00	216.00	205.00	149.00	259.00	212.00	181.00	299.05	293.75	95.48	3,044.76	99.93	199.93

[a] Includes woody and herbaceous plants of less than 20 inches in height.

[b] $\frac{\text{Number of subplots the species occurs}}{\text{Number of subplots sampled (16)}} \times 100$

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative weight (16 subplots) by species

[e] $\frac{\text{Cumulative weight (a species)}}{\text{Cumulative weight (all species)}} \times 100$

[f] Relative frequency + relative weight

APPENDIX A-2

DATA SUMMARY FOR PRAIRIE VEGETATION CLIPPED FROM SUBPLOTS OF SAMPLING STATION PR-1,
CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY-JUNE 1974

Scientific Name / Common Name	Subplots - presence indicated by dry weight (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[a] (%)	Relative[b] Frequency	Dry[c] Weight Per Species	Relative[d] Weight (%)	Importance[e] Value
Festuca arundinacea Schreb. / reed fescue	150.57		152.31		195.22		179.88		119.48		177.05	159.96	102.46		173.78						
Festuca elatior L. / meadow fescue		145.31		146.19		13.76		127.49		175.53				190.67		183.92	] 100.00	17.39	2373.60	94.12	111.51
Dactylis glomerata L. / orchard grass	0.35	3.97	2.29		11.39						1.19		0.91	2.98	3.55	4.70	56.25	9.78	31.33	1.24	11.02
Juncus tenuis Willd. / path rush	0.32	0.45	2.51									0.77	2.41	0.58	3.91	1.01	50.00	8.70	11.94	0.47	9.17
Carex glaucodea Tuckerm. / ---	3.85	1.67	3.10	3.96	0.35	24.48			2.64	0.99		0.26		0.05	7.59	6.61	75.00	13.04	55.43	2.20	15.24
Cerastium viscosum L. / clammy chickweed		0.06		0.10													12.50	2.17	0.16	0.006	2.17
Potentilla simplex Michx. / cinquefoil	0.27			0.98		13.37			1.66	0.31	0.21		0.10				43.75	7.61	16.23	0.64	8.25
Poa pratensis L. / Kentucky bluegrass			0.78				2.53			0.97		0.10	14.79				31.25	5.43	19.17	0.76	6.19
Panicum lanuginosum Ell. / ---				0.10		0.35	0.73	0.35	1.08	0.43			0.29		0.62	0.27	56.25	9.78	4.22	0.17	9.95
Trifolium pratense L. / red clover				1.29									0.07				12.50	2.17	1.36	0.05	2.22
Oxalis europaea Jord. / yellow wood sorrel				0.08		0.08							0.08		0.04		25.00	4.35	0.28	0.01	4.36
Aster sp. L. / aster				0.17				1.85									12.50	2.17	2.02	0.08	2.25
Prunella vulgaris L. / self heal					0.15	2.50										0.18	18.75	3.26	2.83	0.11	3.37
Carex bushii Mack. / ---								0.25	0.30	0.46							18.75	3.26	1.01	0.04	3.30
Ambrosia bidentata Michx. / ragweed						0.28											6.25	1.09	0.28	0.01	1.10
Veronica arvensis L. / corn speedwell						0.18											6.25	1.09	0.18	0.007	1.09
Danthonia spicata (L.) Beauv. / poverty grass						0.42											6.25	1.09	0.42	0.02	1.11
Lespedeza stipulacea Maxim. / Korean clover						1.25											6.25	1.09	1.25	0.05	1.14
Plantago virginica L. / hoary plantain						0.25											6.25	1.09	0.25	0.009	1.09
Ruellia humilis Nutt. / wild petunia						0.23			0.58								12.50	2.17	0.81	0.03	2.20
Agrostis hyemalis (Walt) BSP. / hair grass									0.14								6.25	1.09	0.14	0.006	1.09
Carex festucacea Schk. / ---											0.14						6.25	1.09	0.74	0.03	1.12
Trifolium repens L. / white clover														0.02			6.25	1.09	0.02	.0008	1.09
Totals	155.36	153.44	160.99	151.87	207.11	57.35	183.14	129.94	125.86	178.71	179.18	161.07	121.11	194.30	189.49	176.69	575.00	100.00	2521.78	100.10	200.03

[a] $\frac{\text{Number of subplots the species occurs}}{\text{Number of subplots sampled (16)}} \times 100$

[b] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency for all species}} \times 100$

[c] Cumulative weight (16 subplots) by species

[d] $\frac{\text{Cumulative weight (a species)}}{\text{Cumulative weight (all species)}} \times 100$

[e] Relative frequency and relative weight

APPENDIX A-3

DATA SUMMARY FOR UNDERSTORY VEGETATION[a] OF SAMPLING STATION PR-1, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974 (based on sixteen 6.25-milacre plots)

Scientific Name / Common Name	Frequency[b]	Relative[c] Frequency(%)	Density[d]	Relative[e] Density(%)	Importance[f] Value
Diospyros virginiana L. / persimmon	3.0	23.0	21.0	41.2	64.2
Symphoricarpos sp. Duham. / snowberry	1.0	7.7	15.0	29.4	37.1
Rosa carolina L. / pasture rose	2.0	15.4	7.0	13.8	29.2
Fraxinus americana L. / white ash	1.0	7.7	2.0	3.9	11.6
Crataegus sp. L. / hawthorn	1.0	7.7	1.0	2.0	9.7
Quercus velutina Lam. / black oak	1.0	7.7	1.0	2.0	9.7
Quercus stellata Wang. / post oak	1.0	7.7	1.0	2.0	9.7
Carya sp. Nutt. / hickory	1.0	7.7	1.0	2.0	9.7
Ulmus rubra Muhl. / slippery elm	1.0	7.7	1.0	2.0	9.7
Rubus flagellaris Willd. / dewberry	1.0	7.7	1.0	2.0	9.7
TOTAL	13.0	100.0	51.0	100.3	200.3

Sheet 1

APPENDIX A-3 (continued)

Trees and/or shrubs per quadrat = 3.2
Trees and/or shrubs per acre = 518.4

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[a] Tree or shrub species less than 2.0 inches diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Summation of relative frequency + relative density.

APPENDIX A-4

DATA SUMMARY FOR PRAIRIE VEGETATION[a] CLIPPED FROM SUBPLOTS OF SAMPLING STATION PR-2,
CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Scientific Name / Common Name	Subplots-presence indicated by dry weight (grams/0.125-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency(%)	Dry Weight[d] for Species	Relative[e] Weight(%)	Importance[f] Value
Setaria geniculata (Lam.) Beauv. / prairie foxtail	.05																6.25	0.54	.05	0.00	0.54
Poa compressa L. / Canada blue grass	35.60	36.70	3.20	41.20	33.50	3.20	2.30	8.30	5.20	2.50	1.00	42.30	6.20	20.60	44.60	2.80	100.00	8.74	314.00	15.49	24.23
Carex sp. L. / sedge	.50		4.40			3.10		2.50									25.00	2.18	10.50	0.51	2.69
Panicum lanuginosum Ell. / ---	.85	8.90	5.20	1.90	13.40	2.10	3.40		1.40	6.50		9.90	1.30	16.10	14.60	11.70	87.50	7.65	97.25	4.80	12.45
Tridens flavus (L.) Hitchc. / purpletop	3.60			12.30		0.70	6.30										25.00	2.18	22.90	1.13	3.31
Aristida oligantha Michx. / prairie three awn grass	36.80	6.70			10.30	91.70		21.20						5.80			37.50	3.27	172.50	8.51	11.78
Agrostis alba L. / redtop	27.60	25.30	21.30	54.50	57.00		49.30	21.20	67.20	80.30	61.20	38.30	31.50	17.80	48.20	51.20	93.75	8.19	642.80	31.72	39.91
Aster pilosus Willd. / white heath aster	12.70	2.70		9.90													18.75	1.53	25.30	1.24	2.87
Antennaria neglecta Greene / pussy's toes	1.10																6.25	0.54	1.10	0.05	0.59
Diospyros virginiana L. / persimmon	2.20							1.70									12.50	1.09	3.90	0.19	1.28
Vernonia missurica Raf. / ironweed	6.10											12.20					12.50	1.09	18.30	0.90	1.98
Symphoricarpos orbiculatus Moench / coral berry	2.30																6.25	0.54	2.30	0.11	0.65
Ambrosia bidentata Michx. / ragweed	.70			1.60		1.90	3.20			3.40		4.50		5.10		1.50	50.00	4.37	21.90	1.08	5.45
Prunella vulgaris L. / self heal		4.30						0.60			1.30	8.30					25.00	2.18	14.50	0.71	2.89
Croton capitatus Michx. / hogwort		1.00					2.20		0.40	1.10		0.30	0.80	4.20	1.80		50.00	4.37	11.80	0.58	4.95
Andropogon virginicus L. / broom sedge		2.10					2.50	3.20									18.75	1.63	7.80	0.38	2.01
Achillea millifolium L. / common milfoil		13.20			1.00												12.50	1.09	14.20	0.70	1.79

Sheet 1

APPENDIX A-4 (continued)

Scientific Name / Common Name	Subplots-presence indicated by dry weight (grams/0.125-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency (%)	Dry Weight[d] for Species	Relative[e] Weight (%)	Importance[f] Value
Solanum carolinense L. horse nettle		0.45	1.60		1.30								2.20	1.20		2.10	37.50	3.27	8.25	0.40	3.67
Potentilla simplex Michx. cinquefoil		0.30				2.30		0.60		0.80	0.50	2.00					37.50	3.27	6.30	0.31	3.58
Carex glaucodea Tuckerm. ---		0.70					2.20	0.60				1.90		0.80	0.75		37.50	3.27	6.75	0.33	3.60
Phleum pratense L. timothy		10.30	14.30			10.30		3.90				2.30	42.20	8.40			43.75	3.82	91.80	4.53	8.35
Lespedeza stipulacea Maxim. Korean clover		1.10			2.30	1.70				0.70		1.30	3.90	1.00	1.20		50.00	4.37	13.20	0.65	5.02
Lespedeza striata (Thunb.) H.&A. Japanese lespedeza		5.30	1.30	1.80	4.70	2.10	2.50	0.20	8.20	1.20	0.30	8.60	19.50	10.50	2.10	2.60	93.75	8.19	70.50	3.47	11.66
Strophostyles umbellata (Muhl.) Britt. wild bean			0.70														6.25	0.54	0.70	0.03	0.57
Pycnanthemum tenuifolium Schrad. slender mountain mint			19.60			6.40	1.50	47.00									25.00	2.18	74.50	3.67	5.85
Solidago altissima L. tall goldenrod			50.30		1.30		3.10				2.20				25.50	0.70	37.50	3.27	83.10	4.10	7.37
Paspalum laeve Michx. ---					0.70				41.20			1.60					18.75	1.63	43.50	2.14	3.77
Eragrostis spectabilis (Pursh) Steud. purple love grass					4.70												6.25	0.54	4.70	0.23	0.77
Ruellia humilis Nutt. wild petunia						2.10						2.40		0.20			18.75	1.63	4.70	0.23	1.86
Convolvulus sepium L. hedge bindweed						1.70							1.80				12.50	1.09	3.50	0.17	1.26
Juncus tenuis Willd. path rush							1.30			1.20			2.20				18.75	1.63	4.70	0.23	1.86
Muhlenbergii schreberi Gmel. nimble will							30.20			1.90		11.30					18.75	1.63	43.40	2.14	3.77
Poa pratensis L. Kentucky bluegrass							5.20		22.40	20.30	44.60					49.80	31.25	2.73	142.30	7.02	9.75
Fragaria virginiana Duchesne wild strawberry								1.40									6.25	0.54	1.40	0.07	0.61
Rubus flagellaris Willd. dewberry								6.20									6.25	0.54	6.20	0.30	0.84
--- Moss sp.								2.20									6.25	0.54	2.20	0.10	0.64

APPENDIX A-4 (continued)

Scientific Name Common Name	Subplots presence indicated by dry weight (grams/0.125-milacre plots)																Frequency[b] (%)	Relative[c] Frequency(%)	Dry Weight[d] for Species	Relative[e] Weight(%)	Importance[f] Value
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16					
Paspalum ciliatifolium Michx. ---									2.20								6.25	0.54	2.20	0.10	0.64
Steironema lanceolatum (Walt.) Grey loosestrife										1.10							6.25	0.54	1.10	0.05	0.59
Cyperus ovularis (Michx.) Torr. hedgehog club rush											3.20						6.25	0.54	3.20	0.15	0.69
Cyperus strigosus L. umbrella sedge											0.90						6.25	0.54	0.90	0.04	0.58
Vernonia baldwini Torr. ironweed											5.60			6.40			12.50	1.09	12.00	0.59	1.68
Lactuca canadensis L. wild lettuce												13.70					6.25	0.54	13.70	0.67	1.21
TOTAL	120.10	119.05	122.20	122.80	129.20	130.30	115.20	120.80	141.20	120.80	130.80	160.80	111.60	128.10	138.75	122.20	1,183.73	99.75	2,025.90	100.12	199.87

[a] Includes woody and herbaceous plants of less than 20 inches in height.

[b] $\frac{\text{Number of subplots the species occurs}}{\text{Number of subplots sampled (16)}} \times 100$

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative weight (16 subplots) by species

[e] $\frac{\text{Cumulative weight (a species)}}{\text{Cumulative weight (all species)}} \times 100$

[f] Relative frequency + relative weight.

APPENDIX A-5

DATA SUMMARY FOR PRAIRIE VEGETATION CLIPPED FROM SUBPLOTS OF SAMPLING STATION PR-2,
CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY-JUNE 1974

Scientific Name Common Name	Subplots - presence indicated by dry weight (grams/0.125-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[a] %	Relative[b] Frequency	Dry[c] Weight for Species	Relative[d] Weight (%)	Importance[e] Value
Bromus racemosus L. hairy chess	1.48	9.36	14.05	0.95	15.59	14.09	0.57		3.52		3.18	0.22	17.01	7.29	12.25	9.19	87.50	5.53	109.63	5.86	11.39
Achillea millifolium L. common milfoil	0.51				1.56		0.64					0.15					25.00	1.58	2.84	0.15	1.73
Strophostyles umbellata (Muhl.) Britt. wild bean	0.06								0.07								12.50	0.79	0.13	0.01	0.80
Carex bushii Mack. ---	1.14		2.26	2.16	3.65	11.50	19.29	3.74	20.26	5.40	16.34	1.46	2.34	0.74	1.10		87.50	5.53	90.68	4.84	10.37
Diospyros virginiana L. persimmon	2.18				1.86		2.60			3.40							25.00	1.58	9.82	0.52	2.10
Lactuca canadensis L. wild lettuce	0.26			0.32				0.55									18.75	1.19	1.13	0.06	1.25
Symphoricarpos orbiculatus Moench. coral berry	13.74															1.21	12.50	0.79	14.95	0.80	1.57
Vernonia sp. Schreb. ironweed	7.26				3.25	6.73	1.11					2.43		6.28		6.36	43.75	2.77	33.42	1.79	4.56
Lespedeza stipulacea Maxim Korean clover	0.37		1.69		0.12		0.29	0.06	3.50	1.52	3.44	1.12	2.65	0.26		0.06	75.00	4.74	16.88	0.79	5.53
Solanum carolinense L. horse nettle	0.44	0.24	0.06		0.10	0.20	0.31		0.09	0.13		0.71			0.05	0.35	68.75	4.35	2.68	0.14	4.49
Oxalis europaea Jord. yellow wood sorrel	0.11												0.32				12.50	0.79	0.43	0.02	0.81
Ambrosia bidentata Michx. ragweed	0.83	0.15	0.10									0.12		0.10	0.16	0.04	43.75	2.77	1.50	0.08	2.85
Cerastium viscosum L. clammy chickweed	0.07	0.08		0.13	0.06	0.09	0.11	0.20	0.03		0.43	0.13	0.21		0.34		75.00	4.76	1.88	0.10	4.84
Phleum pratense L. timothy	1.58	6.30	7.73	1.98	20.54	10.57	12.07	5.63	24.81	19.02	20.81	6.12	11.00	66.70	34.17	35.66	100.00	6.32	286.69	15.31	21.63
Carex glaucodea Tuckerm. ---	0.33		12.08	6.13		2.86	0.60	12.49		2.68	1.30	13.13	8.76		0.24		68.75	4.35	60.79	3.35	7.70
Panicum lanuginosum Ell. ---	0.24	14.44	7.63	1.91	23.61	2.52	4.64	6.63	10.06	1.55	1.63	3.76	10.42	10.15	5.98	1.11	100.00	6.32	105.86	5.65	11.97
Poa pratensis L. Kentucky bluegrass	8.10	22.69	41.05	16.00	50.88	26.11	9.36	53.09	32.53	26.37	15.93	31.50	17.40	37.86	26.76	3.44	100.00	6.32	416.56	22.25	28.57
Agrostis alba L. redtop	57.16	4.72		23.99	10.48	37.02	49.42		17.88	63.79	48.20	12.16	9.17	6.00	52.75	14.18	87.50	5.53	402.82	21.52	27.05
Plantago virginica L. hoary plantain		0.10		0.07	0.13	0.06		0.01									31.25	1.98	0.37	0.02	2.00
Juncus tenuis Willd. path rush		2.93									0.74	0.09					18.75	1.19	3.76	0.20	1.39
Prunella vulgaris L. self heal		0.65		0.39	0.24		0.11	0.19				14.16		12.10			43.75	2.77	27.64	1.48	4.25
Erigeron strigosus Muhl. daisy fleabane		2.97		0.20	0.17			0.47					0.24				31.25	1.98	4.05	0.22	2.20
Croton monanthogynus Michx. croton		0.15		0.12	0.04		0.04		0.36	0.01					0.09		43.75	2.77	0.51	0.03	2.80
Trifolium pratense L. red clover		8.58					5.08										12.50	0.79	13.66	0.73	1.52
Pycnanthemum flexuosum (Walt.) BSP slender mountain mint		19.17	36.65	6.07		8.00	31.85	8.71				15.19					43.75	2.77	125.64	6.70	9.47
Trifolium campestre Schreb. large hop clover		0.45		0.23	0.17	0.50		0.12					1.09			0.01	43.75	2.77	2.59	0.14	2.91
Potentilla simplex Michx. cinquefoil		0.40															6.25	0.40	0.40	0.02	0.42
Panicum perlongum Nash ---		0.17		1.85													12.50	0. 9	2.02	0.11	0.90
Rumex acetocella L. sheep sorrel			5.93	0.19									30.65	0.74			25.00	1.58	37.51	2.00	3.58
Trifolium repens L. white clover			0.27	0.80									0.26				18.75	1.19	1.33	0.07	1.26
Erigeron annuus (L.) Pers. whitetop fleabane			0.48														6.25	0.40	0.48	0.03	0.43
Solidago sp. L. goldenrod			4.67			1.73			0.38			0.31	7.91		7.65	5.00	43.75	2.77	27.65	1.48	4.25
Aster sp. L. aster			1.11	10.55													12.50	0.79	11.66	0.62	1.41
Gramineae (sterile culm) ---			2.35														6.25	0.40	2.35	0.13	0.53
Festuca elatior L. meadow fescue				1.37													6.25	0.40	1.37	0.07	0.47

APPENDIX 2-5 (Continued)

Scientific Name / Common Name	Subplots - presence indicated by dry weight (grams/0.125-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[a] (%)	Relative Frequency[b]	Dry Weight per Species[c]	Relative Weight[d] (%)	Importance Value[e]
Erigeron sp. L. fleabane					6.21												6.25	0.40	6.21	0.33	0.73
Convolvulus sepium L. hedge bindweed						1.59											6.25	0.40	1.59	0.08	0.48
Ruellia humilis Nutt. wild petunia						2.14						0.61		0.13			18.75	1.19	2.88	0.15	1.34
Fragaria virginiana Duchesne wild strawberry								13.94	3.54	1.68	1.11	1.90					31.25	1.98	22.17	1.18	3.16
Gleditsia triacanthos L. honey locust								0.08									6.25	0.40	0.08	.004	0.40
Rosa setigera Michx. var. tomentosa Torr. & Gray prairie rose								0.24									6.25	0.40	0.24	0.01	0.41
Penstemon pallidus Small. beard tongue								0.74									6.25	0.40	0.74	0.04	0.44
Carex sp. L. ---										0.07							6.25	0.40	0.07	.004	0.40
Carya ovalis (Wang.) Sarg. false shagbark												6.14					6.25	0.40	6.14	0.33	0.73
Eupatorium serotinum Michx. late boneset												0.61					6.25	0.40	0.61	0.03	0.43
Carex festucacea Schk. ---													9.37				6.25	0.40	9.37	0.50	0.90
Eleocharis tenuis (Willd.) Schultes spike rush															0.68	0.02	12.50	0.79	0.70	0.04	0.83
Dianthus armeria L. deptford pink															0.17		6.25	0.40	0.17	0.01	0.41
Carex albolutescens (Willd.) Schwein																1.80	6.25	0.40	1.80	0.10	0.50
Total	97.83	93.32	137.71	75.23	138.44	125.71	137.89	107.09	116.81	125.62	109.93	112.02	128.60	167.85	139.79	78.63	1581.25	100.00	1872.25	100.09	200.18

a = Number of subplots the species occurs / Number of subplots sampled (16) X 100

b = Frequency of a species occurrences / Cumulative frequency for all species X 100

c Cumulative weight (16 subplots) by species

d = Cumulative weight (a species) / Cumulative weight (all species) X 100

e Relative frequency and relative weight

Sheet 2

APPENDIX A-6

DATA SUMMARY FOR UNDERSTORY VEGETATION[a] OF SAMPLING STATION PR-2, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974 (based on sixteen 6.25-milacre plots)

Scientific Name Common Name	Frequency[b]	Relative Frequency(%)[c]	Density[d]	Relative Density(%)[e]	Importance Value[f]
Diospyros virginiana L. persimmon	12.0	52.2	107.0	77.0	129.2
Rubus flagellaris Willd. dewberry	4.0	17.4	14.0	10.1	27.5
Fraxinus americana L. white ash	3.0	13.0	14.0	10.1	23.1
Symphoricarpos sp. Duham. snowberry	2.0	8.7	2.0	1.4	10.1
Ulmus rubra Muhl. slippery elm	2.0	8.7	2.0	1.4	10.1
TOTAL	23.0	100.0	139.0	100.0	200.0

Trees and/or shrubs per quadrat = 8.7
Trees and/or shrubs per acre = 1,409.4

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[a] Tree or shrub less than 2.0 inches diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Summation of relative frequency + relative density

APPENDIX A-7

DATA SUMMARY FOR PRAIRIE VEGETATION[a] CLIPPED FROM SUBPLOTS OF SAMPLING STATION PP-3,
CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Scientific Name / Common Name	Subplots-presence indicated by dry weight (grams/0.125-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[a] (%)	Relative[b] Frequency(%)	Dry Weight[c] for Species	Relative[d] Weight(%)	Importance[e] Value
Lespedeza stipulacea Maxim. / Korean clover	1.20				2.65	0.60		2.10	17.50	0.40	3.20			3.90	2.30	0.25	62.50	6.99	34.10	1.81	8.80
Panicum lanuginosum Ell. / ---	0.20	3.80			1.30	13.30	11.30	2.00	0.15	3.90	0.15	1.00	1.30			1.40	75.00	8.39	40.00	2.12	10.51
Lespedeza striata (Thunb.) H.& A. / Japanese lespedeza	4.70				1.75	2.50	2.30	14.90	1.10	0.80	5.30	0.75		2.20	0.40	1.20	75.00	8.39	37.80	2.00	10.39
Muhlenbergia schreberi Gmel. / nimble will	36.70	30.00					2.30	7.10									25.00	2.79	66.10	3.51	6.30
Agrostis alba L. / redtop	20.20	20.00	25.00	41.40		12.90	36.60	11.40			47.60	17.30	76.60	25.20	88.30	45.30	81.25	9.09	431.30	22.99	32.08
Phleum pratense L. / timothy	2.00				2.20					12.10		4.30	25.10	25.10			31.25	3.49	45.70	2.42	5.93
Solanum carolinense L. / horse nettle	0.20		0.55		2.20												18.75	2.09	2.95	0.15	2.24
Ambrosia bidentata Michx. / ragweed	0.80					0.90			0.75	6.20					2.60	1.10	37.50	4.19	12.35	0.65	4.84
Poa compressa L. / Canada blue grass	70.00	60.70	80.90	55.50	71.20	25.60	65.20	1.20	36.90	67.40	35.60	65.60	1.70		0.20	4.20	93.80	10.49	657.10	34.93	45.42
Juncus tenuis Willd. / path rush		1.60		3.45		0.20	0.30								0.80	0.30	37.50	4.19	6.65	0.35	4.54
Vernonia missurica Raf. / ironweed		22.20															6.25	0.69	22.50	1.18	1.87
Aster pilosus Willd. / white heath aster		4.10			1.65		1.20			4.20	0.20				1.10		37.50	4.19	13.45	0.66	4.85
Trifolium repens L. / white clover			0.80		0.20					1.20	0.50	2.50	0.30		0.60	5.40	50.00	5.59	6.50	0.34	5.93
Solidago altissima L. / tall goldenrod			2.40		26.50					4.20	1.70						25.00	2.79	34.80	1.85	4.64
Rosa sp.				1.20		0.30			62.60		1.10						25.00	2.79	65.20	3.46	6.25
Solidago nemoralis Ait. / old-field goldenrod				0.20													6.25	0.69	0.20	0.01	0.70
Festuca elatior L. / meadow fescue					7.20								42.50				12.50	1.39	49.70	2.64	4.03

APPENDIX A-7 (continued)

	Subplots-presence indicated by dry weight (grams/0.125-milacre plots)[a]																Frequency[b] (%)	Relative[c] Frequency (%)	Dry Weight[d] for Species	Relative[e] Weight (%)	Importance[f] Value
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16					
Erigeron sp. L. fleabane						9.90											6.25	0.69	9.90	0.52	1.21
Cyperus strigosus L. umbrella sedge						3.45											6.25	0.69	3.45	0.18	0.87
Carex glaucodea Tuckerm. ---						0.20											6.25	0.69	0.20	0.01	0.70
Poa pratensis L. Kentucky bluegrass						36.10		38.30						36.20	60.20	55.50	31.25	3.49	226.30	12.03	15.52
Paspalum laeve Michx. ---						0.80					12.30	41.90					18.75	2.09	57.00	3.03	5.12
Tridens flavus (L.) Hitchc. purpletop						19.10						11.30					12.50	1.39	30.40	1.61	3.00
Eragrostis spectabilis (Pursh) Steud. purple love grass							5.20										6.25	0.69	5.20	0.27	0.96
Bromus sp. L. brome grass							0.60			1.50							12.50	1.39	2.10	0.11	1.50
Crotonopsis elliptica Willd. rushfoil								0.10	0.15								12.50	1.39	0.25	0.01	1.40
Trifolium campestre Schreb. large hop clover									0.10								6.25	0.69	0.10	0.00	0.69
Paspalum ciliatifolium Michx. ---									0.60			1.00	0.20			1.60	25.00	2.79	3.40	0.18	2.97
Aristida oligantha Michx. prairie three awn grass									2.90		0.20						12.50	1.39	3.10	0.16	1.55
Carex sp. L. sedge									0.10								6.25	0.69	0.10	0.00	0.69
Pycnanthemum tenuifolium Schrad. slender mountain mint										3.10							6.25	0.69	3.10	0.16	0.85
Teucrium canadense L. wood sage												7.30					6.25	0.69	7.30	0.38	1.07
Cyperus ovularis (Michx.) Torr. hedgehog club rush														0.10			6.25	0.69	0.10	0.00	0.69
Rubus flagellaris Willd. dewberry														2.20			6.25	0.69	2.20	0.11	0.80
Carex festucacea Schkuhr sedge														1.20			6.25	0.69	1.20	0.06	0.75
TOTALS	136.00	132.40	108.35	10[illegible].95	116.85	125.85	141.00	77.00	122.85	105.00	108.05	151.05	126.90	100.10	116.50	111.25	893.80	99.75	1,881.00	99.95	199.60

[a] Includes woody and herbaceous plants of less than 20 inches in height.

[b] (Number of subplots the species occurs / Number of subplots sampled (16)) x 100

[c] (Frequency of a species occurrence / Cumulative frequency of all species) x 100

[d] Cumulative weight (16 subplots) by species

[e] (Cumulative weight (a species) / Cumulative weight (all species)) x 100

[f] Relative frequency + relative weight

APPENDIX A-8

DATA SUMMARY FOR PRAIRIE VEGETATION CLIPPED FROM SUBPLOTS OF SAMPLING STATION PR-3, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY-JUNE 1974

Scientific Name / Common Name	Subplots - presence indicated by dry weights (grams/0.125-millacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency (%)[a]	Relative Frequency[b]	Dry Weight Per Species[c]	Relative Weights (%)[d]	Importance Value[e]
Phleum pratense L.																					
timothy	29.51	26.46	1.95	1.05	21.31	1.33	2.03		16.75	17.00	9.91	10.92	26.30	1.85	12.25	30.85	93.75	7.81	203.47	8.80	16.61
Bromus racemosus L.																					
hairy chess	6.19	13.30	3.08	7.09	36.84	12.56	6.73	13.98	19.17	14.71	8.01	1.39	7.67	10.10	11.62	10.37	100.00	8.33	182.81	7.91	16.24
Agrostis alba L.																					
redtop	48.53	41.29	60.13	54.48	23.30	2.25	77.46	2.40	3.99	63.17	6.01	75.12	27.79	30.07	83.50	31.07	100.00	8.33	632.56	27.36	35.69
Poa pratensis																					
Kentucky blue grass	49.01	39.26	48.69	0.16	43.68	35.46	50.98	61.60	80.78	44.96	70.56	46.66	35.68	28.69	32.09	13.46	100.00	8.33	703.66	30.43	38.76
Panicum lanuginosum Ell.																					
---	0.75	3.56	0.51	4.00		15.15	10.40	3.92	2.97	0.40	1.69	0.30	0.43	0.30	0.18		87.50	7.29	44.74	1.93	9.22
Trifolium repens L.																					
white clover	1.32				8.65	0.78			6.13	0.05	3.54	2.37	3.57		2.01	10.47	62.50	5.21	39.09	1.69	6.90
Lespedeza stipulacea Maxim.																					
Korean clover	0.75	0.31		0.33	1.25	2.45	2.65	1.55	1.83		0.31			0.25			62.50	5.21	11.68	0.51	5.72
Carex glaucodea Tuckerm.																					
---	0.35	3.54		1.78						0.77			3.38				31.25	2.60	9.82	0.42	3.02
Carex bushii Mack.																					
---	0.78	12.13	4.35	0.65		0.75	0.93	13.98	0.05	4.89	1.35	2.48	4.71	2.45	2.65	15.25	93.75	7.81	67.26	2.91	10.72
Cerastium viscosum L.																					
clammy chickweed	0.36	1.52	0.14		0.25			1.03	0.85		1.82		1.47				50.00	4.17	7.46	0.32	4.49
Prunella vulgaris L.																					
self-heal	0.29																6.25	0.52	0.29	0.01	0.53
Erigeron annuus (L.) Pers.																					
whitetop fleabane		17.36				28.49											12.50	1.04	45.85	1.98	3.02
Vernonia sp.																					
ironweed		6.26	5.25						0.08		1.37	3.01	16.07	25.09	0.76		50.00	4.17	57.87	2.50	6.67
Juncus tenuis Willd.																					
path rush			4.00		0.38							1.45	4.90	18.60	13.08	3.99	43.75	3.65	46.40	2.01	5.66
Solanum carolinense L.																					
horse nettle			0.28			0.34	0.31	0.41			0.09	0.10	0.15			0.20	50.00	4.17	1.88	0.08	4.25
Solidago sp.																					
goldenrod			16.15								28.26	30.17	18.40				25.00	2.08	92.96	4.02	6.10
Oxalis europaea Jord.																					
yellow wood sorrel				0.15													6.25	0.52	0.15	0.01	0.53
Achillea millifolium L.																					
milfoil				0.22				30.44					2.87				18.75	1.56	33.53	1.45	3.01
Erigeron strigosus Muhl.																					
daisy fleabane				71.41			1.60		3.20		4.81						25.00	2.08	80.82	3.50	5.58
Ambrosia bidentata Michx.																					
ragweed				0.08	0.20	0.36			0.15	0.05				0.27			37.50	3.13	1.11	0.05	3.18
Festuca elatior L.																					
meadow fescue					9.00												6.25	0.52	9.00	0.39	0.91
Croton monanthogynus Michx.																					
croton					0.12												6.25	0.52	0.12	0.01	0.53
Veronica arvensis L.																					
corn speedwell					0.50												6.25	0.52	0.50	0.02	0.54
Barbarea vulgaris (R.) R.R.																					
yellow rocket					0.36												6.25	0.52	0.36	0.02	0.54
Aster sp.																					
aster					0.81					0.84				0.27			18.75	1.56	1.72	0.07	1.63
Eleocharis compressa Sull.																					
spike rush						2.73	1.33					2.02					18.75	1.56	6.28	0.27	1.83
Carex albolutescens Schwein.																					
---						1.10	0.10										12.50	1.04	1.20	0.05	1.09
Trifolium campestre Schreb.																					
large hop clover							0.15		5.60								12.50	1.04	5.75	0.25	1.29
Strophostyles umbellata (Muhl.) Britt.																					
wild bean							0.23										6.25	0.52	0.23	0.01	0.53
Carex muhlenbergii Schk. var. australis Olney																					
---								5.32									6.25	0.52	5.32	0.23	0.75
Lactuca canadensis L.																					
wild lettuce									0.15			1.65					12.50	1.04	1.80	0.08	1.12
Plantago virginica L.																					
hoary plantain									0.15								6.25	0.33	0.15	0.01	0.53
Juncus dudleyi Wieg.																					
---											0.84						6.25	0.52	0.84	0.04	0.56
Trifolium pratense L.																					
red clover													6.60			8.67	12.50	1.04	15.27	0.66	1.70
Symphoricarpos orbiculatus Moench.																					
coral berry														0.30							
Totals	138.04	162.71	164.53	161.38	148.65	123.95	154.92	134.63	139.85	166.84	140.57	177.64	157.99	118.64	157.94	126.33	1200.00	99.97	2312.41	100.02	199.99

a = (Number of subplots the species occurs / Number of subplots sampled (16)) X 100

b = (Frequency of a species occurrence / Cumulative frequency for all species) X 100

c = Cumulative weight (16 subplots) by species

d = (Cumulative weight (a species) / Cumulative weight (all species)) X 100

e = Relative frequency + relative weight

APPENDIX A-9

DATA SUMMARY FOR UNDERSTORY VEGETATION[a] OF SAMPLING STATION PR-3, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974
(based on sixteen 6.25-milacre plots)

Scientific Name Common Name	Frequency[b]	Relative[c] Frequency(%)	Density[d]	Relative[e] Density(%)	Importance[f] Value
Symphoricarpos sp. Duham. snowberry	1.0	33.3	4.0	66.7	100.0
Ulmus rubra Muhl. slippery elm	1.0	33.3	1.0	16.7	50.0
Gleditsia triacanthos L. honey locust	1.0	33.3	1.0	16.7	50.0
TOTAL	3.0	99.9	6.0	100.1	200.0

Trees and/or shrubs per quadrat = 0.4
Trees and/or shrubs per acre = 64.8

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[a] Tree or shrub less than 2.0 inches diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Summation of relative frequency + relative density.

APPENDIX A-10

DATA SUMMARY FOR PRAIRIE VEGETATION[a] CLIPPED FROM SUBPLOTS OF SUBPLOTS OF SAMPLING STATION PR-4, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Scientific Name / Common Name	Subplots-presence indicated by dry weight (grams/0.125-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[a] (%)	Relative[b] Frequency(%)	Dry Weight[c] for Species	Relative[d] Weight(%)	Importance Value
Festuca elatior L. / meadow fescue	155.35	171.75	163.80	182.30	156.00	152.80	100.90	154.00	112.90	200.25	164.85	131.35	147.00	182.40	142.25	226.95	100.00	37.20	2,517.55	99.00	136.20
Melilotus alba Desr. / white sweet clover	0.25	0.25	0.20	4.10		1.80	1.20										37.50	13.95	7.75	0.30	14.25
Lespedeza stipulacea Maxim. / Korean clover	0.45				0.40	0.90	3.10			0.35	0.25						37.50	13.95	5.00	0.19	14.14
Convolvulus sp. L. / bindweed				0.10													6.25	2.32	0.10	0.00	2.32
Solanum carolinense L. / horse nettle				0.50		1.80											12.50	4.65	2.30	0.09	4.74
Lactuca canadensis L. / wild lettuce						0.40											6.25	2.32	0.40	0.02	2.33
Solidago nemoralis Ait. / old-field goldenrod							0.80										6.25	2.32	0.80	0.03	2.35
Lespedeza violacea (L.) Pers. / bush clover									0.10						0.45	0.30	18.75	6.97	0.85	0.03	7.00
Lespedeza striata (Thunb.) H.&A. / Japanese lespedeza										0.20		0.35		2.50			18.75	6.97	3.05	0.11	7.08
Bidens aristosa (Michx.) Britt. / tickseed sunflower												0.25					6.25	2.32	0.25	0.00	2.32
Vitis cinerea Engelm. / grayback grape												0.50					6.25	32	0.50	0.01	2.33
Carex glaucodea Tuckerm. / ---																	6.25	2	0.10	0.00	2.32
Sabatia angularis (L.) Pursh / rose pink															4.20		6.25	2.32	4.17	0.16	2.48
TOTAL	156.00	172.00	164.00	187.00	157.00	157.10	106.00	154.00	113.00	201.00	165.00	132.45	147.00	195.00	147.00	229.00	268.75	99.92	2,542.55	99.93	199.86

[a]Includes woody and herbaceous plants of less than 20 inches in height.

[b] (Number of subplots the species occurs / Number of subplots sampled (16)) x 100

[c] (Frequency of a species occurrence / Cumulative frequency of all species) x 100

[d]Cumulative weight (16 subplots) by species

[e] (Cumulative weight (a species) / Cumulative weight (all species)) x 100

[f]Relative frequency + relative weight

APPENDIX A-11

DATA SUMMARY FOR PRAIRIE VEGETATION CLIPPED FROM SUBPLOTS OF SAMPLING STATION PR-4
CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY-JUNE 1974

Scientific Name / Common Name	Subplots - presence indicated by dry weights (grams/0.125-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency (%)[a]	Relative Frequency[b]	Dry Weight Per Species[c]	Relative Weights (%)[d]	Importance Value[e]
Festuca arundinacea Schreb. / reed fescue	94.12	71.11		147.85			121.66			97.63	108.00			95.95	120.73	115.67					
Festuca elatior L. / meadow fescue			103.38		119.06	160.45		106.68	117.65			66.93	65.96				100.00	25.81	1712.83	97.99	123.80
Melilotus officinalis (L.) Lam. / yellow sweet clover	6.91																6.25	1.61	6.91	0.40	2.01
Lespedeza stipulacea Maxim. / Korean clover		0.05	0.23	1.75			0.12			0.08	0.08			0.09		0.03	50.00	12.90	2.43	0.14	13.04
Aster sp. L. / aster		0.11	0.05	0.15								0.15			0.10		31.25	8.06	0.56	0.03	8.09
Solanum carolinense L. / horse nettle		0.02	0.84	0.06	0.08	0.40	0.01	0.37				0.15		0.03	0.27		62.50	16.13	2.23	0.13	16.26
Cirsium altissimum (L.) Spreng. / tall thistle			0.15														6.25	1.61	0.15	0.01	1.62
Erigeron strigosus Muhl. / daisy fleabane			0.42														6.25	1.61	0.42	0.02	1.63
Trifolium campestre Schreb. / large hop clover			0.16		0.01	1.96		0.82									25.00	6.45	2.95	0.17	6.62
Strophostyles umbellata (Muhl.) Britt. / wild bean			0.04	0.07													12.50	3.23	0.11	0.01	3.24
Lactuca canadensis L. / wild lettuce						0.06											6.25	1.61	0.06	.003	1.61
Oxalis europaea Jord. / yellow wood sorrel							0.15										6.25	1.61	0.15	0.01	1.62
Sabatia angularis (L.) Pursh / rose pink									1.00								6.25	1.61	1.00	0.06	1.67
Panicum lanuginosum Ell. / ---											0.32						6.25	1.61	0.32	0.02	1.63
Carex glaucodes Tuckerm. / ---											0.09	0.10					12.50	3.23	0.19	0.01	3.24
Rubus pensilvanicus Poir. / high-bush blackberry												13.67					6.25	1.61	13.67	0.78	2.39
Ambrosia artemisiifolia L. / common ragweed												0.10		0.03			12.50	3.23	0.13	0.01	3.24
Eupatorium perfoliatum L. / boneset												0.36					6.25	1.61	0.36	0.02	1.63
Ulmus rubra Muhl. / slippery elm												0.06					6.25	1.61	0.06	0.003	1.61
Hypericum punctatum L. / dotted St. Johns-wort														1.64			6.25	1.61	1.64	0.09	1.70
Solidago sp. / goldenrod															1.59		6.25	1.61	1.59	0.09	1.70
Potentilla simplex Michx. / cinquefoil																0.15	6.25	1.62	0.15	0.01	1.62
Totals	101.03	71.29	105.27	149.88	119.15	162.87	121.92	107.87	118.65	97.73	108.49	81.52	65.96	97.74	122.69	115.85	387.50	99.97	1747.91	100.00	199.97

[a] = $\frac{\text{Number of subplots the species occurs}}{\text{Number of subplots sampled (16)}} \times 100$

[b] = $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency for all species}} \times 100$

[c] = Cumulative weight (16 subplots) by species

[d] = $\frac{\text{Cumulative weight (a species)}}{\text{Cumulative weight (all species)}} \times 100$

[e] = Relative frequency + relative weight

APPENDIX A-12

DATA SUMMARY FOR UNDERSTORY VEGETATION[a] OF SAMPLING STATION PR-4, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974
(based on sixteen 6.25-milacre plots)

Scientific Name Common Name	Frequency[b]	Relative[c] Frequency(%)	Density[d]	Relative[e] Density(%)	Importance[f] Value
Rubus flagellaris Willd. dewberry	2.0	100.0	3.0	100.0	200.0
TOTAL	2.0	100.0	3.0	100.0	200.0

Trees and/or shrubs per quadrat = 0.2
Trees and/or shrubs per acre = 32.4

---

[a]Tree or shrub less than 2.0 inches diameter at breast height.

[b]Number of subplots a species occurs.

[c]$\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d]Cumulative number of a species within subplots sampled.

[e]$\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f]Summation of relative frequency + relative density.

APPENDIX A-13

TRANSITIONAL SPECIES PREFERRING DISTURBED SITES
(including overstory, understory, and ground layer)

Family Genus & Species	Forest Sampling Stations				Prairie Sampling Stations			
	F-1	F-2	F-3	F-4	Pr-1	Pr-2	Pr-3	Pr-4
Aceraceae								
Acer saccharum Marsh	x	x	x	x				
Acanthaceae								
Ruellia humilis Nutt.					x	x		
Anacardiaceae								
Rhus radicans L.	x	x						
Apocynaceae								
Apocynum cannabinum L.				x	x	x		x
Caprifoliaceae								
Symphoricarpos orbiculatus Moench	x	x	x	x	x	x	x	
Caryophyllaceae								
Cerastium viscosum L.					x	x	x	
Dianthus armeria L.						x		
Celastraceae								
Celastrus scandens L.		x	x					
Cistaceae								
Lechea tenuifolia Michx.	x	x			x			
Compositae								
Achillea millifolium L.						x	x	
Ambrosia artemisifolia L.			x					
Ambrosia bidentata Michx.					x	x	x	x
Aster pilosus Willd.		x			x	x	x	x
Aster anomalus Engelm.	x			x				
Bidens aristosa (Michx.) Britt.		x						
Cirsium altissimum (L.) Spreng.				x			x	x

Family Genus & Species	Forest Sampling Stations F-1	F-2	F-3	F-4	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4
Erigeron strigosus Muhl.						x	x	x
Erigeron annuus (L.) Pers.						x	x	
Eupatorium serotinum Michx.		x			x	x		x
Helianthus strumosus L.			x	x				x
Lactuca canadensis L.			x	x			x	x
Solidago altissima L.		x	x			x	x	
Solidago nemoralis Ait.		x		x				
Vernonia baldwinii Torr.				x	x		x	
Vernonia missurica Raf.					x	x	x	x
Convolvulaceae								
Convolvulus sepium L.		x				x		x
Cruciferae								
Barbarea vulgaris R. Br.							x	
Cupressaceae								
Juniperus virginiana L.	x	x	x	x		x		
Cyperaceae								
Carex bushii Mack.	x		x	x	x	x	x	
Carex festucacea Schk.						x		
Carex gravida Bailey	x					x	x	
Cyperus ovularis (Michx.) Torr.					x			
Cyperus strigosus L.						x	x	
Ebenaceae								
Diospyros virginiana L.	x	x	x		x	x		x
Euphorbiaceae								
Croton capitatus Michx.				x	x	x		x
Croton monogynanthus Michx.						x	x	
Crotonopsis elliptica Willd.		x	x					

APPENDIX A-13 (continued)

Family Genus & Species	Forest Sampling Stations F-1	F-2	F-3	F-4	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4
Gramineae								
Agrostis alba L.					x	x	x	
Agrostis hyemalis (Walt.) BSP					x			
Aristida oligantha Michx.						x		
Dactylis glomerata L.					x			
Danthonia spicata (L.) Beauv.		x						
Festuca elatior L.					x		x	x
Eragrostis spectabilis (Pursh) Steud.					x		x	
Panicum lanuginosum Ell. & Vars.	x				x	x	x	x
Paspalum laeve Michx. & Vars.						x	x	
Phleum pratense L.				x	x	x	x	
Poa compressa L.						x	x	
Poa pratensis L.					x	x	x	
Guttiferae								
Hypericum punctatum Lam.		x	x	x	x	x		x
Juncaeae								
Juncus tenuis Willd.					x	x	x	
Labiatae								
Prunella vulgaris L.				x	x	x	x	
Pycnanthemum tenuifolium Schrad.		x				x	x	x
Teucrium canadense L.				x	x			
Lauraceae								
Sassafras albidum (Nutt.) Nees			x	x				
Leguminosae								
Amorpha canescens Pursh				x				
Gleditsia triacanthos L.						x	x	
Lespedeza stipulacea Maxim.				x	x	x	x	x
Lespedeza striata (Thunb.)H.&A.		x	x	x			x	
Lespedeza violacea (L.) Pers.	x	x	x	x	x			

APPENDIX A-13 (continued)

Family Genus & Species	Forest Sampling Stations				Prairie Sampling Stations			
	F-1	F-2	F-3	F-4	Pr-1	Pr-2	Pr-3	Pr-4
Melilotus alba Desr.								x
Trifolium campestre Schreb.						x	x	x
Trifolium pratense L.						x	x	
Trifolium repens L.						x	x	
Moraceae								
Morus rubra L.	x		x	x		x	x	
Oleaceae								
Fraxinus americana L.	x	x	x	x		x		
Plantaginaceae								
Plantago virginiana L.					x	x		
Podophyllaceae								
Podophyllum peltatum L.				x				
Polygonaceae								
Rumex acetocella L.						x		
Primulaceae								
Lysmachia lanceolata Walt.		x						
Rosaceae								
Potentilla simplex Michx.	x	x			x	x		
Prunus americana L.	x	x		x				
Prunus serotina L.	x	x	x	x				
Prunus virginiana L.	x	x	x					
Rosa arkansana Porter	x							
Rosa carolina L.	x	x	x	x	x			
Rosa setigera Michx.	x					x		
Rubus flagellaris L.		x	x		x	x	x	x
Rubus occidentalis L.	x	x		x				
Rubus pensylvanicus Poir.			x			x		x

APPENDIX A-13 (continued)

Family Genus & Species	Forest Sampling Stations				Prairie Sampling Stations			
	F-1	F-2	F-3	F-4	Pr-1	Pr-2	Pr-3	Pr-4
Saxifragaceae								
Heuchera sp.		x						
Solanaceae								
Solanum carolinense L.						x	x	x
Ulmaceae								
Ulmus rubra Muhl.	x	x	x		x	x	x	
Vitaceae								
Parthanocissus quinquefolia (L.) Planch	x	x	x	x				
Vitis aestivalis Michx.	x		x					
Vitis cinerea Engelm.	x	x	x	x				
Vitis vulpina L.	x	x	x	x				

Adapted from D. B. Dunn, 1974-personal communication.

APPENDIX A-14

DATA SUMMARY FOR IDENTIFIED SPECIES OF SAMPLING STATIONS,
CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI,
SPRING, SUMMER, FALL 1974

(Letter designations: A=ground cover, B=understory, C=overstory-stratifications)

Scientific Name Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Acalypha gracilens Gray three-seeded mercury					A		A	
Acer saccharum Marsh sugar maple					B	AB	BC	BC
Achillea milliifolium L. common milfoil		A	A					
Aesculus glabra Willd. Ohio buckeye					B			
Agrimonia rostellata Wallr. agrimony							A	
Agrostis alba L. redtop		A	A			A		
Agrostis hyemalis (Walt.) BSP. hair grass	A						A	
Agrostis perennans (Walt.) Tuckerm. upland bent					A	A		A
Agrostis sp. L. bent grass	A							
Ambrosia artemisifolia L. common ragweed			A	A				
Ambrosia bidentata Michx. ragweed	A	A	A					
Amelanchier arborea (Michx.) Fern. shadbush					ABC	ABC	AB	ABC
Amorpha canescens Pursh. lead plant								A
Andropogon virginicus L. broom sedge	A	A		A				
Anemonella thalictroides (L.) Spach. rue anemone					A	A	A	
Antennaria neglecta Greene pussy's toes		A						
Antennaria plantaginifolia (L.) Hook. pussy's toes						A	A	A

Sheet 1

APPENDIX A-14 (Continued)

Scientific Name Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Apocynum cannabinum L. Indian hemp					A			
Aristida oligantha Michx. prairie three-awn grass		A	A					
Asclepias hirtella (Pennell) Woods milkweed		A						
Asclepias purpurascens L. purple milkweed			A					
Asclepias quadrifolia Jacq. milkweed						A		
Asclepias sp. L. milkweed					A			
Asimina triloba (L.) Dunal. pawpaw							A	
Asplenium platyneuron (L.) Oakes ebony spleenwort					A		A	
Aster anomalus Engelm. aster						A		A
Aster patens Ait. spreading aster					A		A	
Aster pilosus Willd. white heath aster		A	A					
Aster sp. L. aster	A	A	A	A	A	A	A	A
Aster turbinellus Lindl. aster								A
Baptisim leucantha T. & G. white wild indigo		A	A					
Barbarea vulgaris (R.) B.R. yellow rocket			A					
Bidens aristosa (Michx.) Britt. tickseed sunflower				A				
Botrychium virginianum (L.) Sw. rattlesnake fern					A	A		A
Brachyelytrum erectum (Schreb.) Beauv. ---					A			
Bromus purgans L. Canada brome					A	A		

APPENDIX A-14 (Continued)

Scientific Name / Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Bromus racemosa L. hairy chess		A	A					
Bromus sp. L. Brome grass			A					
Campsis radicans (L.) Seem. trumpet creeper							B	
Carex alata Torr. and Gray ---								A
Carex albolutescens (Schwein) ---		A	A			A		
Carex artitecta Mack. ---					A	A		
Carex bushii Mack. ---	A	A	A		A	A	A	A
Carex cephalophora Muhl. ---							A	
Carex festucacea Schkuhr. ---	A	A	A					
Carex glaucodea Tuckerm. ---	A	A	A	A	A	A	A	A
Carex gravida Bailey ---					A		A	
Carex muhlenbergii Schk. ---								A
Carex muhlenbergii Schk. var. australis Olney ---			A					
Carex rosea Schk. ---					A	A	A	A
Carex sp. L. sedge	A	A	A					
Carya ovalis (Wang.) Sarg. false shagbark		A						
Carya ovata (Mill.) K. Koch shagbark hickory					AC	C	AC	C
Carya sp. Nutt. hickory	B				B	B	B	B
Carya texana Buckl. black hickory					C	C	C	C
Carya texana Buckl. var. villosa (Sarg.) Little black hickory					A			

APPENDIX A-14 (Continued)

Scientific Name / Common Name	Prairie Sampling Stations				Forest Sampling Stations			
	Pr-1	Pr-2	Pr-3	Pr-4	F-1	F-2	F-3	F-4
Carya tomentosa Nutt. mockernut hickory					AC	C	C	
Cassia fasciculata Michx. partridge pea		A						
Ceanothus americana L. New Jersey tea								A
Celastrus scandens L. bittersweet						AB	A	A
Celastrus sp. L. bittersweet						B		
Celtis occidentalis L. hackberry					B		B	
Celtis tenuifolia Nutt. var. smallii (Beadle) Sarg. dwarf hackberry					B			
Cerastium viscosum L. clammy chickweed	A	A	A					
Cercis canadensis L. redbud					A		B	B
Cirsium altissimum (L.) Spreng. tall thistle				A				
Compositae (genus unident.) ---								A
Convolvulus sepium L. hedge bindweed		A						
Convolvulus sp. L. bindweed				A				
Conyza canadensis (L.) Cron. horse weed					A			
Cornus florida L. flowering dogwood					ABC	ABC	ABC	ABC
Crataegus danielsii Palmer hawthorn								A
Crataegus sp. L. hawthorn	B				B	B	B	B
Crataegus uniflora Muench. hawthorn	A							
Croton capitatus Michx. hogwort		A						
Croton monanthogynus Michx. croton		A	A					
Crotonopsis elliptica Willd. rushfoil			A				A	

APPENDIX A-14 (Continued)

Scientific Name / Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Cunila origanoides (L.) Britt. dittary					A	A	A	
Cyanchum laeve (Michx.) Pers. angle-pod						A		A
Cyperus esculentus L. yellow nut grass			A					
Cyperus ovularis (Michx.) Torr. hedgehog club rush	A	A	A					A
Cyperus strigosus L. umbrella sedge	A	A	A					
Dactylis glomerata L. orchard grass	A							
Danthonia spicata (L.) Beauv. poverty grass	A				A	A	A	
Daucus carota L. wild carrot		A						
Desmodium dillenii Darl. tick trefoil					A	A	A	A
Desmodium glutinosum (Muhl.) Wood tick trefoil						A	A	A
Desmodium nudiflorum (L.) D.C. tick trefoil					A	A	A	A
Dianthus armeria L. deptford pink		A						
Digitaria ischaemum (Schreb.) Muhl. crab grass		A						
Diodia teres Walt. rough buttonweed				A				
Dioscorea villosa L. yam						A		A
Diospyros virginiana L. persimmon	B	AB				ABC	B	AB
Echinochloa muricata (Beauv.) Fern. barnyard grass			A					
Eleocharis compressa Sull. spike rush			A					
Eleocharis tenuis (Willd.) Schultes spike rush		A						
Elymus villosus Muhl. wild rye					A	A		A
Eragrostis spectablis (Pursh) Steud. purple love grass	A	A	A					

APPENDIX A-14 (Continued

Scientific Name Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Erechtites brieracifolia (L.) Raf. fireweed					A			
Erigeron annuus (L.) Pers. whitetop fleabane		A	A					
Erigeron sp. L. fleabane		A	A					
Erigeron strigosus Muhl. daisy fleabane		A	A	A				
Euonymus atropurpeus Jacq. wahoo						B	A	B
Eupatorium fistulosum Barrett joe-pye weed							A	
Eupatorium perfoliatum L. boneset				A				
Eupatorium serotinum Michx. late boneset		A						
Euphorbia corollata L. flowering spurge		A						A
Euphorbia maculata L. nodding spurge				A				
Euphorbia sp. L. spurge								A
Festuca arundinacea Schreb. reed fescue	A			A				
Festuca elatior L. meadow fescue	A	A	A	A				
Festuca obtusa Biehler nodding fescue					A			
Fragaria virginiana Duchesne wild strawberry		A						
Fraxinus americana L. white ash	B	B			ABC	AB	AB	BC
Fraxinus pennsylvanica Marsh red ash								A
Galium circaezans Michx. wild licorice					A	A	A	A
Galium concinnum Torr. & Gray elegant bedstraw					A	A	A	
Galium pilosum Ait. hairy bedstraw					A	A		
Gaura filiformis Small. ---		A						

APPENDIX A-14 (Continued)

Scientific Name Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Geum canadense Jacq. white avens					A			
Gillenia stipulata (Muhl.) Trel. Indian physic						A		A
Gleditsia triacanthos L. honey locust		A	B					
Gramineae (sterile culm) ---		A						
Helianthus sp. L. sunflower						A		A
Helianthus strumosus L. sunflower								A
Helianthus tuberosa L. Jerusalem artichoke							A	
Helienium flexuosum Raf. sneezeweed		A						
Heuchera hirsuticaulis (Wheelock) Rydb. alum root							A	
Heuchera sp. L. alum root					A	A	A	
Hieraceum gronovii L. hawkweed					A	A	A	A
Hypericum punctatum L. dotted St. Johns-wort				A				A
Ipomoea pandulata (L.) G.F.W. Mey. wild potato vine	A							
Juglans nigra L. walnut						A		
Juncus dudleyi Wieg. ---			A					
Juncus tenuis Willd. path rush	A	A	A					
Juniperus virginiana L. red cedar					ABC	B	B	B
Krigia biflora (Walt.) Blake dwarf dandelion						A		
Lactuca canadensis L. wild lettuce		A	A	A				A
Lactuca canadensis L. var. obovata Wieg. wild lettuce		A		A			A	
Lactuca sp. L. lettuce						A		A

APPENDIX A-14 (Continued)

Scientific Name / Common Name	Prairie Sampling Stations				Forest Sampling Stations			
	Pr-1	Pr-2	Pr-3	Pr-4	F-1	F-2	F-3	F-4
Lechia tenuifolia Mi.nx pineweed	A					A		
Lespedeza procumbens Michx. bush clover	A							
Lespedeza stipulacea Maxim. Korean clover	A	A	A	A				
Lespedeza striata (Thunb.) H.&A. Japanese lespedeza	A	A	A	A				
Lespedeza violacea (L.) Pers. bush clover	A			A	A	A	A	A
Lespedeza virginica (L.) Britt. bush clover					A			
Linum sp. L. flax					A			A
Lobelia inflata L. Indian tobacco	A				A		A	
Lobelia spicata Lam. ---						A		
Lysmachia lanceolata Walt. loosestrife		A				A		
Melilotus alba Desr. white sweet clover				A				
Melilotus officinalis (L.) Lam. yellow sweet clover				A				
Monarda russelliana Nutt. horsemint							A	A
Monotropa uniflora L. Indian pipe								A
Morus rubra L. red mulberry					B	BC	BC	B
Moss sp. ---	A	A	A					
Muhlenbergii schreberi Gmel. nimble will		A	A					
Muhlenbergia sobolifera (Muhl.) Trin. muhly					A	A		
Oenothera strigosa (Rydb.) Mac. & Bush evening primrose				A				
Ostrya virginiana (Mill.) K. Koch hop-hornbeam					ABC	AB	B	B
Oxalis europaea Jord. yellow wood sorrel	A	A	A	A	A	A		

APPENDIX A-14 (Continued)

Scientific Name Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Panicum boscii Poir. ---							A	A
Panicum clandestinum L. ---			A					
Panicum dichotomum L. ---							A	
Panicum dichotomiflorum Michx. ---			A					
Panicum lanuginosum Ell. ---	A	A	A	A	A	A		A
Panicum lanuginosum var. implicatum (Scribn.) Fern. ---			A		A		A	
Panicum lanuginosum var. lanuginosum (Scribn.) Fern. ---						A		
Panicum linearifolium Scribn. ---								A
Panicum perlongum Nash ---		A						
Panicum sp. L. panic grass						A		
Panicum sphaerocarpon Ell. ---								A
Panicum subvillosum Ashe ---							A	A
Parthenium integrifolium Ait. American feverfew								A
Parthenocissus quinquefolia (L.) Pursh Virginia creeper					A	A	A	A
Paspalum ciliatifolium Michx. ---		A	A					
Paspalum floridanum Michx. ---		A						
Paspalum laeve Michx. ---		A	A					
Penstemon pallidus Small. beard tongue		A						
Phleum pratense L. timothy		A	A					
Phryma leptostachya L. lopseed					A			
Physalis virginiana Mill. ground cherry							A	

APPENDIX A-14 (Continued)

Scientific Name Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Plantago rugelii Decne. plantain	A							
Plantago virginica L. hoary plantain	A		A					
Poa compressa L. Canada bluegrass		A	A					
Poa pratensis L. Kentucky bluegrass	A	A	A					
Poa sylvestris Gray sylvan bluegrass					A			
Podophyllum peltatum L. may apple					A	A	A	
Polygonum scandens L. var. cristatum (Engelm & Gray) Gl. false buckwheat					A			
Polystichum acrostichoides (Michx.) Scott Christmas fern					A		A	
Potentilla simplex Michx. cinquefoil	A	A		A		A	A	A
Prunella vulgaris L. self heal	A	A	A					A
Prunus americana Marsh. wild plum					A	B	B	B
Prunus mexicana Wats. big tree plum								B
Prunus serotina Ehrh. black cherry					,	ABC	AB	B
Prunus sp. L. cherry						A		A
Prunus virginiana L. choke cherry					A	A	A	
Psoralea psoralioides (Walt.) Cory var. eglandulosa (Ell.) Freeman Sampson's snakeroot								A
Pycnanthenum tenuifolium Schrad. slender mountain mint		A	A					
Quercus alba L. and/or var. white oak					ABC	ABC	ABC	ABC
Quercus x fernowi Trel. (Quercus alba x Quercus stellata) oak								B
Quercus imbricaria Michx. shingle oak						A		

APPENDIX A-14 (Continued)

Scientific Name Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Quercus macrocarpa Michx. bur oak					A	A		
Quercus macrocarpa Michx. x Q. marilandica bur oak hybrid								A
Quercus marilandica Muenchh. x Q. unknown black jack and/or oak hybrid					A	A		AC
Quercus rubra L. and var. red oak					BC	BC	BC	AB
Quercus shumardii Buckl. shumard oak					A			A
Quercus stellata Wang. post oak	B				C	AC	C	BC
Quercus stellata Wang. x Q. alba or Q. mari. post oak hybrid					A			
Quercus velutina Lam. black oak	B				ABC	ABC	ABC	ABC
Quercus velutina Lam. x Q. bushii Sarg. black oak hybrid								A
Rhamnus lanceolata Pursh buckthorn					A			
Rhus aromatica Ait. fragrant sumac					AB	AB	AB	AB
Rhus radicans L. poison ivy					B	AB	A	
Ribes missouriensis Nutt. Missouri gooseberry					A			
Rosa arkansana Porter cockerell					A			B
Rosa carolina L. pasture rose	B				A	AB	AB	AB
Rosa setigera Michx. var. tomentosa Torr. & Gray prairie rose		A			A			
Rubus argutus Link high-bush blackberry			A					
Rubus flagellaris Willd. dewberry	B	B	A	B	AB	A	AB	B
Rubus occidentalis L. black raspberry					A	AB		

APPENDIX A-14 (Continued)

Scientific Name / Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Rubus ostryfolius Rydb. high-bush blackberry	A			B		B		
Rubus pensilvanicus Poir. high-bush blackberry				A			A	
Rudbeckia hirta L. black-eyed susan		A						
Ruellia humilis Nutt. wild petunia	A	A						
Rumex acetocella L. sheep sorrel		A						
Rumex crispus L. sour dock			A					
Sabatia angularis (L.) Pursh rose pink			A	A				
Sanicula canadensis L. black snakeroot					A	A		A
Sassafras albidum (nutt.) Nees sassafras					AB	ABC	B	AB
Schrankia nuttallii (A.D.C. ex Britt. & Rose) Standl. sensitive brier	A	A	A			A		A
Scutellaria parvula Michx. skullcap						A		
Setaria geniculata (Lam.) Beauv. prairie foxtail		A						
Setaria glanca (L.) Beauv. yellow foxtail	A							
Smilacina racemosa L. Desf. false Solomon's seal					A	A	A	
Smilacina stellata (L.) Desf. starry false Solomon's seal					A			
Smilax sp. L. catbrier						B		
Smilax tamnoides L. bristly greenbrier					A	A		A
Solanum carolinense L. horse nettle		A	A	A				
Solidago altissima L. tall goldenrod		A	A					
Solidago nemoralis Ait. old-field goldenrod	A		A	A				
Solidago petiolaris Ait. goldenrod								A
Solidago sp. L. goldenrod		A	A	A	A			A

APPENDIX A-14 (Continued)

Scientific Name Common Name	Prairie Sampling Stations Pr-1	Pr-2	Pr-3	Pr-4	Forest Sampling Stations F-1	F-2	F-3	F-4
Solidago ulmifolia Muhl. elm-leaf goldenrod					A	A	A	A
Spiranthes tuberosa Raf. little ladies' tresses					A			
Strophostyles helvola (L.) D.C. wild bean					A	A	A	A
Strophostyles leiosperma (T&G) Piper wild bean	A							
Strophostyles umbellata (Muhl.) Britt. wild bean		A	A	A				
Symphoricarpos orbiculatus Moench coral berry		A	A			A	A	A
Symphoricarpos sp. Duham. snowberry	B	B	B			B	B	
Teucrium canadense L. wood sage			A					A
Tradescantia earnestiana Anders. & Woods spiderwort					A			
Tradescantia ohiensis Raf. spiderwort						A		
Tridens flavus (L.) Hitchc. purple-top		A	A					
Trifolium campestre Schreb. large hop clover		A	A	A				
Trifolium pratense L. red clover	A	A	A					
Trifolium repens L. white clover	A	A	A					
Triphora trianthophora (S.W.) Rydb. nodding pogonia					A			
Ulmus rubra Muhl. slippery elm	B	B	B	A	ABC	AB	B	BC
Verbena hastata L. blue vervain			A					
Vernonia baldwini Torr. ironweed		A	A					
Vernonia missurica Raf. ironweed		A	A					

APPENDIX A-14 (Continued)

Scientific Name Common Name	Prairie Sampling Stations Pr-1	 Pr-2	 Pr-3	 Pr-4	Forest Sampling Stations F-1	 F-2	 F-3	 F-4
Vernonia sp. Schreb. ironweed		A	A					
Veronica arvensis L. corn speedwell	A		A					
Veronicastrum virginicum (L.) Farw. culvers root							A	
Viburnum prunifolium L. black haw						B	B	
Viburnum rafinesquianum Schultes downy arrow-wood						A		
Viburnum rufidulum Raf. southern black haw					A	AB	A	
Viburnum sp. L. viburnum					B			
Viola papilionacea Pursh common violet						A		
Viola triloba Schwein. f. dilatata Ell. three-lobed violet					A		A	A
Vitis aestivalis Michx. summer grape					B		AB	B
Vitis cinerea Engelm. grayback grape				A	AB	AB	ABC	AB
Vitis vulpina L. winter grape					B	AB	AB	B
Zanthoxylum americanum Mill. prickly ash						B		

APPENDIX A-15

DATA SUMMARY OF FOREST GROUND VEGETATION[a] CLIPPED FROM SUBPLOTS OF SAMPLING STATION F-1, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Scientific Name / Common Name	Subplots-presence indicated by dry weights (grams/0.25-millacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency (%)	Dry Weight[d] for Species	Relative[e] Weight (%)	Importance[illegible] Value
Carex rosea Schk. / ---	2.50		0.60	0.35		2.20			0.80	7.60						0.25	43.75	7.77	14.30	8.79	16.56
Amelanchier arborea (Michx.) Fern. / shadbush	0.50																6.25	1.11	0.50	0.30	1.41
Solidago ulmifolia Muhl. / elm-leaf goldenrod	1.30							1.50									12.50	2.22	2.80	1.72	3.94
Cornus florida L. / flowering dogwood	3.20								0.25								12.50	2.22	3.45	2.12	4.34
Quercus alba[f] L. and var. / white oak	4.30				2.10	13.30		3.95						1.70	0.35		37.50	6.66	25.70	15.80	22.46
Strophostyles helvola (L.) Ell. / wild bean	0.15	0.60	0.40				0.30							0.30		1.05	37.50	6.66	2.80	1.72	8.38
Desmodium nudiflorum (L.) D.C. / tick trefoil	1.20	2.00							1.25			1.60					25.00	4.4[illegible]	6.05	3.72	8.16
Galium concinnum Torr. & Gray / elegant bedstraw		0.30	0.50				0.30										18.75	3.33	1.10	0.67	4.00
Fraxinus americana L. / white ash		5.20		8.60		0.30	2.20				1.25						31.25	5.55	17.55	10.79	16.34
Botrychium virginianum (L.) Sw. / rattlesnake fern		0.10															6.25	1.11	0.10	0.06	1.17
Galium circaezans Michx. / wild licorice			0.25						0.05				0.05				18.75	3.33	0.35	0.21	3.54
Geum canadense Jacq. / white avens			2.10														6.25	1.11	2.10	1.29	2.40
Sanicula canadensis L. / black snakeroot			1.40														6.25	1.11	1.40	0.86	1.97
Muhlenbergia sobolifera (Muhl.) Trin. / muhly			1.70														6.25	1.11	1.70	1.04	2.15
Carya texana Buckl. var. villosa (Sarg.) Little / black hickory				3.00													6.25	1.11	3.00	1.84	2.95
Triphora trianthophora (S.W.) R'Db. / nodding pogonia				0.01													6.25	1.11	0.01	0.00	1.11
Vitis cinerea Engelm. / grayback grape				1.15													6 [illegible]	1.11	1.15	0.70	1.81

Sheet 1

APPENDIX A-15 (continued)

Scientific Name Common Name	Subplots-presence indicated by dry weights (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency(%)	Dry Weight[d] for Species	Relative[e] Weight(%)	Importance[f] Value
Rhus aromatica Ait. fragrant sumac					18.90		4.90							11.70			18.75	3.33	35.50	21.82	25.15
Carya tomentosa Nutt. mockernut hickory					5.60												6.25	1.11	5.60	3.44	4.55
Lespedeza violacea (L.) Pers. bush clover					0.50												6.25	1.11	0.50	0.30	1.41
Rosa carolina L. pasture rose					1.20		1.25		0.10		2.40						25.00	4.44	4.95	3.04	7.48
Rubus flagellaris Willd. dewberry					0.90						1.10						12.50	2.22	2.00	1.22	3.44
Festuca obtusa Biehler nodding fescue						1.30											6.25	1.11	1.30	0.79	1.90
Carex bushii Mack. ---						0.70		1.80									12.50	2.22	2.50	1.53	3.75
Carya ovata (Mill.) K. Koch shagbark hickory						1.10							5.10				12.50	2.22	6.20	3.81	6.03
Sassafras albidum (Nutt.) Nees sassafras						0.60											6.25	1.11	0.60	0.36	1.47
Cercis canadensis L. redbud							0.15										6.25	1.11	0.15	0.09	1.20
Prunus americana Marsh. wild plum							0.60										6.25	1.11	0.60	0.36	1.47
Carex glaucodea Tuckerm. ---							0.10	0.40	0.15				0.55				25.00	4.44	1.20	0.73	5.17
Parthenocissus quinquefolia (L.) Planch. Virginia creeper							0.50	0.60		2.60	1.45			1.05	0.15	1.20	43.75	7.77	7.55	4.64	12.41
Panicum lanuginosum Ell. ---								0.40	0.02				0.05				18.75	3.33	0.47	0.28	3.61
Desmodium dillenii Darl. ---								1.10									6.25	1.11	1.10	0.67	1.78
Smilacina stellata (L.) Desf. starry false Solomon's seal								0.80									6.25	1.11	0.80	0.49	1.60
Apocynum cannabinum L. Indian hemp									1.05								6.25	1.11	1.05	0.64	1.75

APPENDIX A-15 (continued)

Scientific Name Common Name	Subplots-presence indicated by dry weights (grams/0.25-milacre plots)[a] 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency(%)	Dry Weight[d] for Species	Relative[e] Weight(%)	Importance[f] Value
Juniperus virginiana L. red cedar									0.20								6.25	1.11	0.20	0.12	1.23
Quercus velutina Lam. black oak										4.20							6.25	1.11	4.20	2.58	3.69
Prunus virginiana L. choke cherry												0.15		0.65			12.50	2.22	0.80	0.49	2.71
Rosa setigera Michx. prairie rose												0.80					6.25	1.11	0.80	2.49	1.60
Heuchera sp. L. alum root												0.10					6.25	1.11	0.10	0.06	1.17
Viburnum rufidulum Raf. southern black haw														0.20			6.25	1.11	0.20	0.12	1.23
Ostrya virginiana (Mill.) K. Koch hop-hornbeam																0.20	6.25	1.11	0.20	0.12	1.23
TOTAL	13.15	8.20	6.95	13.11	29.20	19.50	10.30	10.55	3.87	14.40	6.20	2.55	5.75	15.60	0.50	2.70	562.50	99.90	162.63	99.82	199.72

[a]Includes woody and herbaceous plants of less than 20 inches in height.

[b]$\frac{\text{Number of subplots the species occurs}}{\text{Number of subplots sampled (16)}} \times 100$

[c]$\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d]Cumulative weight (16 subplots) by species

[e]$\frac{\text{Cumulative weight (a species)}}{\text{Cumulative weight (all species)}} \times 100$

[f]Relative frequency + relative weight.

APPENDIX A-16

DATA SUMMARY OF FOREST GROUND VEGETATION* CLIPPED FROM SUBPLOTS OF SAMPLING STATION F-1, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY-JUNE 1974

Scientific Name Common Name	Subplots - presence indicated by dry weights (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency (%)[a]	Relative Frequency[b]	Dry Weight Per Species[c]	Relative Weight (%)[d]	Importance Value[e]
Fraxinus americana L. white ash	6.10	19.33		17.37				0.03			0.10						31.25	4.85	40.93	14.75	15.60
Amelanchier arborea (Michx.) Fern. shadbush	0.10																6.25	0.97	0.10	0.04	1.01
Rubus flagellaris Willd. dewberry	0.40		0.26														12.50	1.94	0.66	0.24	2.18
Desmodium nudiflorum (L.) D.C. tick trefoil	0.48		0.13				1.46					0.70	0.30			0.20	37.50	5.83	3.27	1.18	7.01
Parthenocissus quinquefolia (L.) Porsh Virginia creeper	7.36	9.82	11.15	1.97	0.05	8.13	2.29	2.31	3.46	0.52	1.82	0.15	0.01	1.30	0.17	0.26	100.00	15.53	51.06	18.40	33.93
Aster sp. aster	1.03										0.09				0.02		18.75	2.91	1.14	0.41	3.32
Quercus alba L. white oak	1.50							6.97		26.82			1.29				25.00	3.88	34.53	12.45	16.33
Carex rosea Schk. ---	0.34	0.02	0.81														18.75	2.91	1.37	0.49	3.40
Prunus serotina Ehrh. black cherry	1.06																6.25	0.97	1.06	0.38	1.35
Quercus macrocarpa Michx. bur oak		1.58	10.96		22.59												18.75	2.91	35.13	12.66	15.57
Anemonella thalictroides (L.) Spach. rue anemone		0.01									0.22					0.03	18.75	2.91	0.26	0.09	3.00
Galium circaezans Michx. wild licorice		0.02	0.02									0.05					18.75	2.91	0.09	0.03	2.94
Poa sylvestris Gray sylvan bluegrass			2.03														6.25	0.97	2.03	0.73	1.70
Ostrya virginiana (Mill.) K. Koch hop hornbeam			0.97										0.40	0.04	0.01	0.15	31.25	4.85	1.57	0.57	5.42
Strophostyles helvola (L.) D.C. wild bean			1.32			0.19			0.17	0.01			0.07				31.25	4.85	1.76	0.63	5.48
Solidago sp. goldenrod			3.17														6.25	0.97	3.17	1.14	2.11
Galium concinnum Torr. & Gray elegant bedstraw			0.78	0.11		1.00	0.30										25.00	3.88	2.19	0.79	4.67
Danthonia spicata (L.) Beauv. poverty grass			2.00														6.25	0.97	2.00	0.72	1.69
Rhamnus lanceolata Pursh buckthorn			0.17														6.25	0.97	0.17	0.06	1.03
Rhus aromatica Ait. fragrant sumac			0.31		15.85	0.07			3.08					3.59			31.25	4.85	22.90	8.25	13.10
Carex bushii Mack. ---				0.68								2.55	3.29		0.50		25.00	3.88	7.02	2.53	6.41
Elymus villosus Muhl. wild rye					0.51												6.25	0.97	0.51	0.18	1.15
Smilax tamnoides L. bristly greenbriar						0.45											6.25	0.97	0.45	0.16	1.13
Sanicula canadensis L. black snakeroot						6.66											6.25	0.97	6.64	2.39	3.36
Festuca obtusa Biehler nodding fescue						7.15											6.25	0.97	7.15	2.58	3.55
Rubus occidentalis L. black raspberry						4.32											6.25	0.97	4.32	1.56	2.53
Carya ovata (Mill.) K. Koch shagbark hickory							3.01	0.22					0.95		1.46		25.00	3.88	4.74	1.71	5.59
Quercus marilandica** Moench. X Q. unknown black jack and/or oak hybrid							0.26							(4.71)			12.50	1.94	4.97	1.79	3.73
Carex gravida Bailey ---								4.48			2.09						12.50	1.94	6.57	2.37	4.31
Rosa carolina L. pasture rose									3.27					2.33			12.50	1.94	5.60	2.02	3.96
Quercus stellata Wang. X Q. alba or Q. mari. post oak hybrid									**16.92								6.25	0.97	16.92	6.10	7.07
Podophyllum peltatum L. may apple										0.06							6.25	0.97	0.06	0.02	0.99
Tradescantia ernestiana Anders. & Woods spiderwort											0.10						6.25	0.97	0.10	0.03	1.00

APPENDIX A-16 (continued)

Scientific Name Common Name	Subplots - presence indicated by dry weights (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency (%)[a]	Relative Frequency[b]	Dry Weight Per Species[c]	Relative Weights (%)[d]	Importance Value[e]
Cornus florida L. flowering dogwood											0.06						6.25	0.97	0.06	0.02	0.99
Asclepias sp. L. milkweed											0.08						6.25	0.97	0.08	0.03	1.00
Smilacina racemosa L. Desf. false Solomon's seal												3.49					6.25	0.97	3.49	1.26	2.23
Rosa arkansana Porter cockerell												1.27					6.25	0.97	1.27	0.46	1.43
Ulmus rubra Muhl. slippery elm												0.27					6.25	0.97	0.27	0.10	1.07
Quercus shumardii Buckl. shumard oak															1.25		6.25	0.97	1.25	0.45	1.42
Vitis cinerea Engelm. grayback grape															0.52		6.25	0.97	0.52	0.19	1.16
Carex [illegible] Mack. ---																0.10	6.25	0.97	0.10	0.04	1.01
Totals	16.77	30.78	34.08	20.13	39.00	27.95	7.32	12.00	26.90	27.41	4.61	8.48	5.41	11.97	3.93	0.72	643.75	99.93	277.46	100.00	199.93

*Includes woody and herbaceous plants of less than 20 inches in height.
**Includes the species and/or its hybrids.

a = (Number of subplots the species occurs / Number of subplots samples (16)) X 100

b = (Frequency of a species occurrence / Cumulative frequency of all species) X 100

c = Cumulative weight (16 subplots) by species

d = (Cumulative weight (a species) / Cumulative weight (all species)) X 100

e = Relative frequency + relative weight

APPENDIX A-17

DATA SUMMARY FOR UNDERSTORY VEGETATION[a] OF SAMPLING STATION F-1, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974
(based on sixteen 6.25-milacre plots)

Scientific Name / Common Name	Frequency[b]	Relative[c] Frequency (%)	Density[d]	Relative[e] Density (%)	Importance[f] Value
Cornus florida L. flowering dogwood	14.0	14.1	78.0	21.2	35.3
Quercus alba[g] L. and var. white oak	10.0	10.1	45.0	12.2	22.3
Carya sp. Nutt. hickory	12.0	12.1	37.0	10.1	22.2
Fraxinus americana L. white ash	7.0	7.1	46.0	12.5	19.6
Rhus aromatica Ait. fragrant sumac	5.0	5.1	53.0	14.4	19.5
Ostrya virginiana (Mill.) K. Koch hop-hornbeam	8.0	8.1	25.0	6.8	14.9
Quercus velutina Lam. black oak	6.0	6.1	22.0	6.0	12.1
Amelanchier arborea (Michx. f.) Fern. shadbush	6.0	6.1	10.0	2.6	8.7
Ulmus rubra Muhl. slippery elm	6.0	6.1	6.0	1.6	7.7
Juniperus virginiana L. red cedar	5.0	5.1	8.0	2.2	7.3
Quercus rubra[g] L. and var. red oak	4.0	4.0	8.0	2.2	6.2

APPENDIX A-17 (continued)

Scientific Name Common Name	Frequency[b]	Relative Frequency (%)[c]	Density[d]	Relative Density (%)[e]	Importance Value[f]
Vitis vulpina L. winter grape	3.0	3.0	5.0	1.4	4.4
Rubus flagellaris Willd. dewberry	2.0	2.0	5.0	1.4	3.4
Rhus radicans L. poison ivy	1.0	1.0	7.0	1.9	2.9
Morus rubra L. red mulberry	1.0	1.0	2.0	0.5	1.5
Vitis aestivalis Michx. summer grape	1.0	1.0	2.0	0.5	1.5
Celtis occidentalis L. hackberry	1.0	1.0	2.0	0.5	1.5
Aesculus glabra Willd. Ohio buckeye	1.0	1.0	1.0	0.3	1.3
Viburnum sp. L. viburnum	1.0	1.0	1.0	0.3	1.3
Prunus serotina Ehrh. black cherry	1.0	1.0	1.0	0.3	1.3
Crataegus sp. L. hawthorn	1.0	1.0	1.0	0.3	1.3
Sassafras albidum (Nutt.) Nees sassafras	1.0	1.0	1.0	0.3	1.3
Acer saccharum Marsh sugar maple	1.0	1.0	1.0	0.3	1.3
Vitis cinerea Engelm. grayback grape	1.0	1.0	1.0	0.3	1.3
TOTAL	99.9	100.0	368.0	100.1	200.1

APPENDIX A-17 (continued)

Trees and/or shrubs per quadrat = 23.0

Trees and/or shrubs per acre = 3,726

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[a] Tree or shrub less than 2.0 inches diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Summation of relative frequency + relative density.

[g] Includes the species and varieties.

APPENDIX A-18

DATA SUMMARY FOR OVERSTORY VEGETATION[a] OF SAMPLING STATION F-1, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974
(based on sixteen 25-milacre plots)

Scientific Name / Common Name	Frequency[b]	Relative Frequency (%)[c]	Density[d]	Relative Density (%)[e]	Dominance[f]	Relative Dominance (%)[g]	Importance Value[h]
Quercus alba[i] L. and var. white oak	14.0	25.5	32.0	28.8	4,377.4	78.5	132.8
Cornus florida L. flowering dogwood	9.0	16.4	28.0	25.2	124.0	2.2	43.8
Quercus velutina Lam. black oak	8.0	14.5	19.0	17.1	143.4	2.6	34.2
Carya ovata (Mill.) K. Koch shagbark hickory	6.0	10.9	8.0	7.2	34.9	0.6	18.7
Quercus stellata Wang. post oak	2.0	3.6	4.0	3.6	495.2	8.9	16.1
Amelanchier arborea (Michx.f.) Fern. shadbush	4.0	7.3	5.0	4.5	22.7	0.4	12.2
Carya texana Buckl. black hickory	2.0	3.6	2.0	1.8	313.6	5.6	11.0
Ostrya virginiana (Mill.) K. Koch hop-hornbeam	3.0	5.5	5.0	4.5	20.9	0.4	10.4
Quercus rubra L. red oak	2.0	3.6	2.0	1.8	9.8	0.2	5.6
Ulmus rubra Muhl. slippery elm	1.0	1.8	2.0	1.8	8.0	0.1	3.7

Scientific Name Common Name	Frequency[b]	Relative Frequency (%)[c]	Density[d]	Relative Density (%)[e]	Dominance[f]	Relative Dominance (%)[g]	Importance Value[h]
Juniperus virginiana L. red cedar	1.0	1.8	1.0	0.9	12.6	0.2	2.9
Carya tomentosa Nutt. mockernut hickory	1.0	1.8	1.0	0.9	4.9	0.1	2.8
Fraxinus americana L. white ash	1.0	1.8	1.0	0.9	3.1	0.1	2.8
TOTAL	55.0	98.1	110.0	99.0	5,570.5	99.9	297.0

Trees per quadrat = 6.9
Trees per acre = 279.5
Basal area per quadrat = 348.5 sq. in.
Basal area per acre = 14,114.3 sq. in.

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[a] Tree species 20 inches or greater diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Cumulative basal area (sq. in.) of a species within subplots sampled.

[g] $\frac{\text{Cumulative basal area of a species}}{\text{Cumulative basal area of all species}} \times 100$

[h] Summation of relative frequency + relative density + relative dominance.

[i] Includes species and varieties.

APPENDIX A-19

INCREMENT CORE SUMMARY FOR OVERSTORY VEGETATION[a] OF SAMPLING STATIONS F-1 TO F-4, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974
(Distribution and Mean Age[b], by Diameter Size Classes)

Sampling Station	Species	Specimen Number	Age	Diameter Class	Age	Diameter Class	Age	Diameter Class	Age	Diameter Class
F-1	Slippery elm	21500	15	2.04	20	2.20				
	White ash	21501	20	2.00						
	White oak	21502	90	17.00	127	15.18	129	13.20	129	13.23
	Post oak	21504	77	7.60						
	Hybrid oak	21505	135	12.10	132	12.01				
	Black oak	21506	29	2.06	31	3.16	38	4.24		
	Red oak	21507	31	2.28	22	2.40				
	Red mulberry	21508	30	2.36						
	Flowering dogwood	21509	29	2.50	15	2.00	22	2.36		
	Shadbush	21510	21	2.16	27	2.39	25	2.30		
	Red cedar	21511	54	4.10						
	Hop-hornbeam	21512	25	2.20						
	Black hickory	21513	111	16.52						
	Shagbark hickory	21514	24	2.12	23	2.06				
	Mockernut hickory	21515	20	2.24						
F-2	Red oak	21516	27	3.44	36	8.30	24	5.00	34	8.00
	Black oak	21517	29	3.00	39	8.16	34	9.00	40	6.32
	Post oak	21518	32	6.60						
	Hybrid oak	21519a	41	7.18	43	6.48				
	White oak	21519	39	5.00	62	11.18	27	6.08		
	Shagbark hickory	21520	28	3.50	18	2.22	54	7.18		
	Black hickory	21521	24	5.40	26	4.04	25	3.43		
	Mockernut hickory	21522	23	3.00	19	2.16	27	5.00		
	Shadbush	21523	22	2.50	30	3.08				
	Sassafras	21524	17	3.40	28	3.18				
	Red mulberry	21525	23	3.00						
	Flowering dogwood	21526	24	2.16	21	2.36				
	Black cherry	21527	25	3.00						

APPENDIX A-19 (continued)

Sampling Station	Species	Specimen Number	Age	Diameter Class	Age	Diameter Class	Age	Diameter Class	Age	Diameter Class
F-3	Red oak	21529	32	7.28		11.19	50	10.18		
	Post oak	21530	29	4.40	50	8.16				
	Hybrid oak	21531	38	6.60						
	White oak hybrid	21532	31	6.36	49	90.38	49	11.14		
	White oak	21533	19	3.06	37	6.34				
	Black oak	21534	16	2.50	47	13.40				
	Black oak hybrid	21535	53	13.08	54	11.18	48	13.04		
	Black hickory	21537	31	4.12	16	3.32	35	5.46	61	7.48
	Shagbark hickroy	21538	43	6.32						
	Mockernut hickory	21539	10	2.06	15	2.00				
	Red mulberry	21540	20	2.12						
	Sugar maple	21541	43	11.18	23	2.17				
	Flowering dogwood	21542	19	2.29	11	2.00				
F-4	Black-jack oak	21543	102	7.14						
	Post oak	21544	97	6.37	103	9.75	84	5.62		
	Hybrid oak	21545	32	3.15	57	6.5				
	White oak	21546	110	16.0	30	4.16				
	White oak hybrid	21547	35	3.56	66	15.40	34	4.22	32	3.22
	Black oak	21548	72	13.26	67	11.55	69	11.30		
	Sugar maple	21549	21	2.56						
	Flowering dogwood	21550	22	2.32	22	2.25	26	2.08		
	Black hickory	21551	32	3.12	27	2.30				
	Shagbark hickory	21552	102	10.62						
	Shadbush	21553	31	2.36	27	2.11				
	Slippery elm	21554	31	3.20						
	White ash	21555	26	2.22						

[a] Tree species 2.0 inches or greater diameter at breast height.

[b] Ages in years were determined from cores taken at 4.5 feet from ground.

APPENDIX A-20

DATA SUMMARY OF FOREST GROUND VEGETATION[a] CLIPPED FROM SUBPLOTS OF SAMPLING STATION F-2, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Scientific Name / Common Name	Subplots-presence indicated by dry weights (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency(%)	Dry Weight[d] for Species	Relative[e] Weight(%)	Importance[f] Value
Galium concinnum Torr. & Gray elegant bedstraw	2.90			3.05	1.43	2.10	0.01					0.10					37.50	6.97	9.75	6.97	13.94
Rubus occidentalis L. black raspberry	1.70																6.25	1.16	1.70	1.35	2.51
Oxalis europaea Jord. yellow wood sorrel	0.03																6.25	1.16	0.03	0.02	1.18
Potentilla simplex Michx. cinquefoil	1.90				0.50												12.50	2.32	2.40	1.91	4.23
Rhus aromatica Ait. fragrant sumac	0.50			0.60	7.20			9.50	1.50								31.25	5.81	19.30	15.37	21.18
Strophostyles helvola (L.) Britt. wild bean	0.04		2.55		0.20				0.55	2.05		2.60		0.25			43.75	8.13	6.24	4.97	13.10
Quercus alba[g] L. and var. white oak	0.20						2.30					2.80	1.50	7.30			31.25	5.81	12.10	9.63	15.44
Carex glaucodea Tuckerm. ---	0.10																6.25	1.16	0.10	0.07	1.23
Parthenocissus quinquefolia (L.) Planch. Virginia creeper	0.60				0.70	0.15	1.30			3.30			0.75	1.30		0.80	50.00	9.30	8.90	7.08	16.38
Carex bushii Mack. ---		1.00												1.50	0.50		18.75	3.48	3.00	2.38	5.86
Vitis cinerea Engelm. graybark grape		0.20	1.50												0.30		18.75	3.48	2.00	1.59	5.07
Galium circaezans Michx. wild licorice		0.30				0.10								0.03			18.75	3.48	0.43	0.34	3.82
Quercus stellata Wang. post oak		1.60															6.25	1.16	1.60	1.27	2.69
Ostrya virginiana (Mill.) K. Koch hop hornbeam		2.75		3.60									7.50				18.75	3.48	8.85	7.04	10.52
Panicum lanuginosum[g] var. lanuginosum (Scribn.) Fern. ---			0.02											0.45	0.05		18.75	3.48	0.52	0.41	3.89
Carex rosea Schkuhr ---			2.60			2.20	0.05			4.10					0.75		31.25	5.81	9.60	7.71	13.52
Agrostis perennans (Walt.) Tuckerm. upland bent			0.55														6.25	1.16	0.55	0.43	1.59
Aster anomalus Engelm. aster			0.05														6.25	1.16	0.05	0.03	1.19

(Sheet 1)

APPENDIX A-20 (continued)

Scientific Name / Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency(%)	Dry Weight[d] for Species	Relative[e] Weight(%)	Importance[f] Value
Subplots (numbers indicated by dry weight (grams) of aboveground plants)																					
Solidago ulmifolia Muhl. / elm-leaf goldenrod			4.20				3.25										12.50	2.32	6.75	5.17	7.49
Heuchera sp. L. / alum root			0.02							0.20							12.50	2.32	0.31	0.17	2.48
Desmodium illenii Darl. / —			3.15														6.25	1.16	3.15	2.50	3.66
Fraxinus americana L. / white ash					0.70												6.25	1.16	0.70	0.55	1.71
Quercus imbricaria Michx. / shingle oak					0.15					1.50	0.30						18.75	3.48	1.95	1.53	4.31
Rosa carolina L. / pasture rose						0.20									0.50		12.50	2.32	0.70	0.55	2.87
Prunus virginiana L. / choke cherry							3.40						0.25				12.50	2.32	3.65	2.90	5.22
Vitis vulpina L. / frost grape									1.40								6.25	1.16	1.40	1.11	2.27
Muhlenbergia sobolifera (Muhl.) Trin. / muhly										[illegible]							6.25	[illegible]	[illegible]	[illegible]	[illegible]
Lysimachia lanceolata Walt. / loosestrife										0.03		0.75					12.50	2.32	0.78	0.62	2.94
Acer saccharum Marsh. / sugar maple											1.40						6.25	1.16	1.40	1.10	1.06
Desmodium nudiflorum (L.) D.C. / tick trefoil											0.20						6.25	1.16	0.20	0.15	1.31
Danthonia spicata (L.) Beauv. / poverty grass												0.80					6.25	1.16	0.80	0.57	1.73
Quercus velutina Lam. / black oak													1.00				6.25	1.16	1.00	0.79	1.95
Lespedeza violacea (L.) Pers. / bush clover														1.40			6.25	1.16	1.40	1.11	2.27
Ulmus rubra Muhl. / slippery elm														0.50			6.25	1.16	0.50	0.39	1.55
Sanicula canadensis L. / black snakeroot														0.90			6.25	1.16	0.90	0.71	1.87
Antennaria plantaginifolia (L.) Hook. / pussy's toes															3.20		6.25	1.16	3.20	2.54	3.70

Sheet 2

APPENDIX K-20 (continued)

Scientific Name Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency (%)	Dry Weight[d] for Species	Relative[e] Weight (%)	Importance[f] Value
	Subplots-presence indicated by dry weight (grams/0.25-milacre plots)																				
Desmodium glutinosum (Muhl.) Wood Tick trefoil																0.20	6.25	1.16	0.20	0.15	1.31
Diospyros virginiana L. persimmon																0.20	6.25	1.16	0.20	0.15	1.31
TOTAL	7.97	1.85	16.71	6.35	11.05	4.95	7.34	7.50	7.[illegible]	17.68	7.90	4.55	8.00	11.63	5.10	.30	537.50	99.81	25.55	39.[illegible]	199.59

[a]Includes woody and herbaceous plants of less than 20 inches in height.

[b]Number of subplots the species occurs / Number of subplots sampled (16) x 100

[c]Frequency of a species or stratum / Cumulative frequency of all species x 100

[d]Cumulative weight (16 subplots) for species

[e]Cumulative weight (a species) / Cumulative weight (all species) x 100

[f]Relative frequency + relative weight.

Sheet 1

TABLE A-21

DATA SUMMARY OF FOREST GROUND VEGETATION CLIPPED FROM SUBPLOTS OF SAMPLING STATION F-2, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY-JUNE 1974

Scientific Name / Common Name	Subplots - presence indicated by dry weight (grams/[illegible] plots): 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency (%)[a]	Relative Frequency (%)[b]	Dry Weight Per Species[c]	Relative Weight (%)[d]	Importance Value[e]
Rubus occidentalis L. / black raspberry	17.05																6.25	0.70	15.05	7.25	3.95
Tradescantia ohiensis Raf. / spiderwort	10.77																[illegible]	0.70	10.77	3.91	[illegible]
Potentilla simplex Michx. / cinquefoil	3.63				0.43					0.15							18.75	2.10	4.61	1.75	3.85
Galium concinnum Torr. & Gray / elegant bedstraw	3.61			2.53	0.47	[illegible]										0.3	31.25	[illegible]	8.25	[illegible]	4.65
Oxalis europaea Jord. / yellow wood sorrel	0.08																[illegible]	0.70	0.08	0.03	0.73
Carex bushii Mack. / ---	1.26	3.61			1.66	0.20				0.62				0.31		0.21	43.75	[illegible]	11.63	[illegible]	9.31
Lespedeza violacea (L.) Pers. / bush clover	[illegible]				0.48												12.50	[illegible]	0.58	0.18	1.58
Lactuca sp. L. / lettuce	[illegible]		0.03														12.50	1.40	0.10	0.06	1.46
Parthenocissus quinquefolia (L.) Planch. / Virginia creeper	1.76	0.13		13.82	[illegible]	1.81	0.41	0.28	13.61	6.96	0.98	7.15	3.12	0.26		0.02	87.50	9.79	52.01	[illegible]	29.58
Sassafras albidum (Nutt.) Nees. / sassafras	1.50							[illegible]									12.50	1.40	[illegible]	1.07	2.47
Carex glaucodea Tuckerm. / ---	1.55	0.19	0.20		0.21					4.21		0.11					37.50	4.20	6.63	2.53	6.73
Viola papilionacea Pursh. / common violet	0.02		0.01				0.03		0.31		[illegible]	0.01					37.50	4.20	0.63	0.16	4.36
Vitis cinerea Engelm. / graybark grape		3.60	4.31								0.48			0.01		4.76	31.25	3.50	[illegible]	4.99	[illegible]
Panicum lanuginosum Ell. / ---		[illegible]			[illegible]												12.50	1.40	0.15	0.06	1.46
Cornus florida L. / flowering dogwood		0.10		2.61													12.50	1.40	2.71	1.03	2.53
Helianthus sp. L. / sunflower		0.63															6.25	0.70	[illegible]	0.16	[illegible]
Hieracium sp. L. / hawkweed		[illegible]															6.25	[illegible]	0.36	0.09	0.79
Podophyllum peltatum L. / may apple			2.03				[illegible]									2.35	18.75	[illegible]	[illegible]	[illegible]	5.88
Strophostyles helvola (L.) Britt. / wild bean			1.03		[illegible]					0.59	0.10	0.06				0.06	37.50	[illegible]	2.73	1.36	5.26
Quercus macrocarpa Michx. / bur oak			3.25														6.25	[illegible]	3.25	1.22	1.94
Desmodium glutinosum (Muhl.) Wood / tick trefoil			0.07		0.36							1.26		1.25		0.36	31.25	[illegible]	3.28	1.25	6.76
Amelanchier arborea (Michx.) Fern. / shadbush			0.07		0.88	[illegible]						[illegible]	0.28		0.08		37.50	4.20	2.66	0.86	5.15
Lysimachia lanceolata Walt. / loosestrife			0.03											[illegible]			12.50	1.40	0.19	0.07	1.57
Anemonella thalictroides (L.) Spach. / rue anemone			0.01		0.23					0.10			0.01		0.01		31.25	3.50	0.36	0.14	3.66
Scutellaria parvula Michx. / skullcap			0.11		0.04												12.50	1.40	0.15	0.06	1.46
Bromus purgans L. / Canada brome			1.71														6.25	0.70	1.71	0.65	1.35
Carex albursina Sheldon / ---			4.46														6.25	0.70	4.46	1.86	2.56
Symphoricarpos orbiculatus Moench. / coral berry				13.19												1.07	12.50	1.40	[illegible]	[illegible]	6.44
Rhus aromatica Ait. / fragrant sumac				6.43			0.60	13.86	9.16	0.18							31.25	3.50	[illegible]	[illegible]	15.01
Dioscorea villosa L. / yam				0.02		[illegible]											12.50	1.40	[illegible]	0.09	1.48
Fraxinus americana L. / white ash					[illegible]			[illegible]									12.50	1.40	14.77	5.62	7.02
Quercus alba L. / white oak					0.51					0.07	0.31		5.43				25.00	2.80	6.36	2.41	5.21
Antennaria plantaginifolia (L.) Hook. / pussy's toes					1.83								2.26				12.50	1.40	[illegible]	1.55	2.95
Viburnum rafinesquianum Schultes. / downy arrow-wood					[illegible]						0.16						12.50	1.40	1.17	0.45	1.85
Galium circaezans Michx. / wild licorice					[illegible]								0.21	0.03			18.75	2.10	[illegible]	0.11	2.21
Carex rosea Schk. / ---					0.86		0.38		0.38		1.26		1.22			1.53	37.50	4.20	5.83	2.22	6.42
Agrostis alba L. / redtop					0.48												6.25	0.70	0.48	0.19	0.89
Rosa carolina L. / pasture rose									7.06			0.29					12.50	[illegible]	[illegible]	[illegible]	5.18
Smilacina racemosa L. / false Solomon's seal									0.13						0.48	0.20	18.75	[illegible]	0.81	0.31	2.41
Asclepias quadrifolia Jacq. / milkweed									0.10								[illegible]	[illegible]	0.10	0.04	0.75

APPENDIX B-22 (continued)

Scientific Name / Common Name	Subplots and Plant Biomass* Indicated by dry weight (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency (%)[a]	Relative Frequency[b]	Dry Weight Per Species[c]	Relative Weight (%)[d]	Importance Value[e]
Rhus radicans L. poison ivy										5.71							6.25	0.70	5.71	2.17	2.87
Krigia biflora (Walt.) Blake dwarf dandelion										0.38							6.25	0.70	0.38	0.16	0.86
Prunus sp. L. cherry										0.11							6.25	0.70	0.11	0.06	0.76
Celastrus scandens L. bittersweet										1.32							6.25	0.70	1.32	0.50	1.20
Aster sp. L. aster												0.61					6.25	0.70	0.61	0.23	0.93
Quercus marilandica** Muenchh. EC spp. black jack and/or oak hybrid														7.40	(0.06)		12.50	1.40	7.46	2.83	4.23
Rubus flagellaris Willd. dewberry														0.72			6.25	0.70	0.72	0.27	0.97
Cynanchum laeve (Michx.) Pers. angle pod														0.45			6.25	0.70	0.45	0.17	0.87
Botrychium virginianum (L.) Sw. rattlesnake fern														0.06			6.25	0.70	0.06	0.02	0.72
Viburnum rufidulum Raf. southern black haw														0.63			6.25	0.70	0.65	0.17	0.87
Elymus villosus Muhl. wild rye														1.03			6.25	0.70	1.03	0.39	1.09
Panicum sp. L. ---															0.01		6.25	0.70	0.01	0.004	0.70
Carex artitecta Mack. ---															0.13		6.25	0.70	0.13	0.05	0.75
Prunus serotina Ehrh. black cherry																0.05	6.25	0.70	0.05	0.02	0.72
Totals	[illegible]	8.19	17.82	37.6[illegible]	.11	4.78	5.11	26.59	30.96	29.74	3.30	9.49	12.53	16.28	0.74	10.96	893.75	100.08	261.90	100.31	200.09

*Includes woody and herbaceous plants of less than 20 inches in height.
**Includes the species and/or its hybrids.

[a] = Number of subplots the species occurs / Number of subplots sampled (16) x 100

[b] = Frequency of a species occurrence / Cumulative frequency of all species x 100

[c] = Cumulative weight (16 subplots) by species

[d] = Cumulative weight (a species) / Cumulative weight (all species) x 100

[e] = Relative frequency + relative weight

APPENDIX A-22

DATA SUMMARY FOR UNDERSTORY VEGETATION[a] OF SAMPLING STATION F-2,
CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974
(based on sixteen 6.25-milacre plots)

Scientific Name Common Name	Frequency[b]	Relative[c] Frequency (%)	Density[d]	Relative[e] Density (%)	Importance[f] Value
Rhus aromatica Ait. fragrant sumac	11.0	7.6	117.0	18.3	25.9
Cornus florida L. flowering dogwood	13.0	9.0	88.0	13.8	22.8
Quercus alba[g] L. and var. white oak	12.0	8.3	66.0	10.3	18.6
Fraxinus americana L. white ash	14.0	9.7	35.0	5.5	15.2
Acer saccharum Marsh sugar maple	7.0	4.8	43.0	6.7	11.5
Carya sp. L. hickory	9.0	6.2	17.0	2.7	8.9
Symphoricarpos sp. Duham. snowberry	4.0	2.8	38.0	6.0	8.8
Quercus velutina Lam. black oak	7.0	4.8	17.0	2.7	7.5
Rosa carolina L. pasture rose	7.0	4.8	12.0	1.9	6.7
Rhus radicans L. poison ivy	[illegible]	1.3	34.0	5.3	6.6
Amelanchier arborea (Michx.f.) Fern. shadbush	[illegible]	4.1	13.0	2.0	6.1

APPENDIX A-22 (continued)

Scientific Name Common Name	Frequency[b]	Relative Frequency (%)[c]	Density[d]	Relative Density (%)[e]	Importance Value[f]
Ulmus rubra Muhl. slippery elm	5.0	3.4	15.0	2.4	5.8
Viburnum prunifolium L. black haw	1.0	0.7	32.0	5.0	5.7
Prunus americana Marsh. wild plum	5.0	3.4	12.0	1.9	5.3
Juniperus virginiana L. red cedar	6.0	4.1	7.0	1.1	5.2
Prunus serotina Ehrh. black cherry	5.0	3.4	8.0	1.3	4.7
Zanthoxylum sp. L. prickly ash	2.0	1.3	21.0	3.3	4.6
Sassafras albidum (Nutt.) Nees sassafras	4.0	2.8	11.0	1.7	4.5
Diospyros virginiana L. persimmon	3.0	2.1	10.0	1.6	3.7
Celastrus sp. L. bittersweet	4.0	2.8	4.0	0.6	3.4
Vitis vulpina L. winter grape	3.0	2.1	7.0	1.1	3.2
Vitis cinerea Engelm. grayback grape	3.0	2.1	4.0	0.6	2.7
Rubus occidentalis L. black raspberry	2.0	1.3	7.0	1.1	2.4
Ostrya virginiana (Mill.) K. Koch hop-hornbeam	2.0	1.3	6.0	0.9	2.2

Scientific Name / Common Name	Frequency[b]	Relative Frequency (%)[c]	Density[d]	Relative Density (%)[e]	Importance Value[f]
Crataegus sp. L. hawthorn	2.0	1.3	3.0	0.5	1.8
Quercus rubra L. red oak	2.0	1.3	2.0	0.3	1.6
Celastrus scandens L. american bittersweet	1.0	0.7	3.0	0.5	1.2
Morus rubra L. red mulberry	1.0	0.7	4.0	0.6	1.3
Euonymus atropurpureus Jacq. wahoo	1.0	0.7	1.0	0.2	0.9
Smilax sp. L. catbrier	1.0	0.7	1.0	0.2	0.9
TOTAL	145.0	99.6	638.0	100.1	199.7

Trees and/or shrubs per quadrat = 39.9
Trees and/or shrubs per acre = 6,463.8

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[a] Tree or shrub less than 2.0 inches diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Summation of relative frequency + relative density

[g] Includes the species and varieties.

APPENDIX A-23

DATA SUMMARY FOR OVERSTORY VEGETATION[a] OF SAMPLING STATION F-2, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974 (based on sixteen 25-milacre plots)

Scientific Name / Common Name	Frequency[b]	Relative Frequency (%)[c]	Density[d]	Relative Density (%)[e]	Dominance[f]	Relative Dominance (%)[g]	Importance Value[h]
Quercus alba[i] L. and var. white oak	15.0	25.0	73.0	46.7	2,859.7	63.2	134.9
Carya ovata (Mill.) K. Koch shagbark hickory	11.0	18.3	24.0	15.4	442.5	9.8	43.5
Carya texana Buckl. black hickory	6.0	10.0	17.0	10.9	248.4	5.5	26.4
Quercus rubra L. red oak	5.0	8.3	6.0	3.8	515.9	11.4	23.5
Quercus velutina Lam. black oak	6.0	10.0	10.0	6.4	264.4	5.8	22.2
Cornus florida L. flowering dogwood	6.0	10.0	14.0	9.0	67.2	1.5	20.5
Amelanchier arborea (Michx.f.) Fern. shadbush	3.0	5.0	3.0	1.9	19.1	0.4	7.3
Carya tomentosa Nutt. mockernut hickory	2.0	3.3	3.0	1.9	29.8	0.7	5.9
Sassafras albidum (Nutt.) Nees sassafras	2.0	3.3	2.0	1.3	19.2	0.4	5.0
Quercus stellata Wang. post oak	1.0	1.7	1.0	0.6	38.5	0.9	3.2
Prunus serotina Ehrh. black cherry	1.0	1.7	1.0	0.6	7.1	0.2	2.5

Scientific Name Common Name	Frequency[b]	Relative Frequency (%)[c]	Density[d]	Relative Density (%)[e]	Dominance[f]	Relative Dominance (%)[g]	Importance Value[h]
Morus rubra L. red mulberry	1.0	1.7	1.0	0.6	7.1	0.2	2.5
Diospyros virginiana L. persimmon	1.0	1.7	1.0	0.6	4.9	0.1	2.4
TOTAL	60.0	100.0	156.0	99.7	4,523.8	100.1	299.8

Trees per quadrat = 9.8
Trees per acre = 396.8
Basal area per quadrat = 282.7 sq. in.
Basal area per acre = 11,449.4 sq. in.

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[a] Tree species 2.0 inches or greater diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Cumulative basal area (sq. in.) of a species within subplots sampled.

[g] $\frac{\text{Cumulative basal area of a species}}{\text{Cumulative basal area of all species}} \times 100$

[h] Summation of relative frequency + relative density + relative dominance.

[i] Includes species and varieties

APPENDIX A-24

DATA SUMMARY OF FOREST GROUND VEGETATION[a] CLIPPED FROM SUBPLOTS OF SAMPLING STATION F-3,
CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Scientific Name / Common Name	Subplots-presence indicated by dry weights (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency(%)	Dry Weight[d] for Species	Relative[e] Weight(%)	Importance[f] Value
Carex rosea Schkuhr / ---	2.00	1.65		0.70	0.10	2.00	0.10	1.05		4.40				1.30		0.25	62.50	12.65	13.55	12.66	25.31
Desmodium nudiflorum (L.) D.C. / tick trefoil	1.00					0.20	8.60	0.60	4.40					0.40			37.50	7.59	15.20	12.34	19.93
Strophostyles helvola (L.) Britt. / wild bean	2.50		0.30		2.05							0.50	0.30	2.50			37.50	7.59	8.15	7.50	15.09
Prunus virginiana (L.) / choke cherry		0.75	0.25														12.50	2.63	1.00	0.92	3.55
Monarda russeliana Nutt. / horsemint		0.30			1.60						7.30						18.75	3.79	9.20	8.47	12.26
Panicum boscii Poir. / ---		0.10															6.25	1.26	0.10	0.90	2.16
Parthenocissus quinquefolia (L.) Planch / virginia creeper		0.30	0.40					0.40	.05	2.60	1.30	0.85	3.95	0.05	3.80		62.50	12.65	13.70	12.61	25.26
Quercus velutina Lam. / black oak			2.30									0.05					12.50	2.63	2.35	2.16	4.79
Carex bushii Mack. / ---	0.90	0.20	0.75			0.80						0.60					31.25	6.32	3.15	2.90	9.22
Quercus alba[g] L. and var. / white oak			0.15								0.70						12.50	2.63	0.85	0.41	3.04
Rhus aromatica Ait. / fragrant sumac			3.50	4.10							3.60	5.40				5.57	31.25	6.32	22.17	20.41	26.73
Galium circaezans Michx. / wild licorice			0.02		0.02					0.25							18.75	3.79	0.29	0.26	4.05
Solidago ulmifolia Muhl. / elm-leaf goldenrod					0.90												6.25	1.26	0.90	0.82	2.08
Lespedeza violacea (L.) Pers. / bush clover						0.02				0.60							12.50	2.63	0.62	0.57	3.20
Fraxinus americana L. / white ash						0.05											6.25	1.26	0.05	0.04	1.30
Potentilla simplex Michx. / cinquefoil						0.35					0.80						12.50	2.63	1.15	1.05	3.68
Heuchera sp. L. / alum root						0.15											6.25	1.26	0.15	0.13	1.39

APPENDIX B-24 (continued)

Scientific Name Common Name	Subplots-presence indicated by dry weights (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency (%)	Dry Weight[d] for Species	Relative[e] Weight (%)	Importance[f] Value
Panicum lanuginosum var. *implicatum* (Scribn.) Fern. ---						0.10											6.25	1.26	0.10	0.90	2.16
Antennaria plantaginifolia (L.) Hook. pussy's toes						2.10	0.20							0.50			18.75	3.79	2.80	2.57	6.36
Vitis cinerea Engelm. graybark grape							3.50										6.25	1.26	3.50	3.22	4.48
Rosa carolina L. pasture rose								0.40							0.90	0.80	18.75	3.79	2.10	1.93	5.72
Lactuca canadensis L. wild lettuce										0.30							6.25	1.26	0.30	0.27	1.53
Cornus florida L. flowering dogwood											0.05	0.05					12.50	2.63	0.10	0.90	3.53
Galium concinnum Torr. & Gray elegant bedstraw												1.15		0.80			12.50	2.63	1.95	1.79	4.42
Desmodium glutinosum (Muhl.) Wood tick trefoil												4.85					6.25	1.26	4.85	4.46	5.72
Viburnum rufidulum Raf. southern black haw													0.50				6.25	1.26	0.50	0.46	1.72
Rubus flagellaris Willd. dewberry														0.80			6.25	1.26	0.80	0.73	1.99
Vitis vulpina L. winter grape															1.00		6.25	1.26	1.00	0.92	2.18
TOTAL	6.20	3.30	7.67	4.80	4.67	5.77	10.40	2.85	4.65	8.75	13.35	13.45	4.75	4.35	5.70	6.62	493.75	100.55	108.50	102.30	202.85

[a] Includes woody and herbaceous plants of less than 20 inches in height.

[b] $\frac{\text{Numbers of subplots the species occurs}}{\text{Number of subplots sampled (16)}} \times 100$

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative weight (16 subplots) by species

[e] $\frac{\text{Cumulative weight (a species)}}{\text{Cumulative weight (all species)}} \times 100$

[f] Relative frequency + relative weight

APPENDIX A-25

DATA SUMMARY OF FO EST GROUND VEGETATION[a] CLIPPED FROM SUBPLOTS OF SAMPLING STATION F-3, CALL-AY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY-JUNE 1974

Scientific Name / Common Name	Subplots - presence indicated by dry weights (grams/0.25-milacre plot) 1	2	3	4	[illegible]	6	7	8	9	10	11	12	13		13	16	Frequency (%)[a]	Relative Frequency[b]	Dry Weight Per Species[c]	Relative Weight (%)[d]	Importance Value[e]
Aster sp. L. aster	1.12									0.08							12.50	1.89	1.20	0.68	2.57
Parthenocissus quinquefolia (L.) Pursh Virginia creeper	1.50		7.66	0.86	1.33	1.57		1.96	3.28	0.36	0.54	1.73	0.02	0.94		0.83	81.25	12.26	26.36	14.99	27.25
Carex bushii Mack. ---	0.22			1.68		0.35		0.03				1.29	0.01		1.49		43.75	6.60	5.07	2.86	9.46
Galium circaezans Michx. wild licorice	0.11	0.01			0.18			0.13		0.13	0.07	3.39	0.56	0.07			56.25	8.49	3.67	2.07	10.56
Anemonella thalictroides (L.) Spach. rue anemone	0.10	0.40		0.92		0.07								0.03			31.25	4.72	0.62	0.35	5.07
Desmodium nudiflorum (L.) D.C. tick trefoil		0.42					11.95	0.20	2.22								25.00	3.77	14.79	8.35	12.12
Rhus aromatica Ait. fragrant sumac			11.65	1.21	6.09			5.06	0.06		8.78		1.06	0.43		20.20	56.25	8.49	54.63	30.72	39.21
Strophostyles helvola (L.) Britt. wild bean			1.60			0.57		0.01	0.05	0.02	2.61	1.46	1.06	1.67		0.36	62.50	9.43	9.17	5.17	14.60
Rosa carolina L. pasture rose			2.43		0.37							1.83					18.75	2.83	4.60	2.60	5.43
Vitis cinerea Engelm. grayback grape			9.74			0.10	0.03	0.09			0.05						31.25	4.72	10.01	5.65	10.37
Monarda russelliana Nutt. horsemint			4.83		0.11												12.50	1.89	4.94	2.79	4.68
Quercus alba** L. white oak				0.31		0.16	(0.20)										18.75	2.83	0.65	0.37	3.20
Carya ovata (Mill.) K. Koch shagbark hickory				0.81													6.25	0.94	0.81	0.46	1.40
Carex glaucodea Tuckerm. ---				0.20													6.25	0.94	0.20	0.11	1.05
Rhus radicans L. poison ivy					2.90												6.25	0.94	2.90	1.64	2.58
Celastrus scandens L. bittersweet					0.35												6.25	0.94	0.35	0.20	1.14
Amelanchier arborea (Michx. f.) Fern. shadbush					0.23												6.25	0.94	0.23	0.13	1.07
Smilacina racemosa L. false Solomon's seal					0.08				1.83								12.50	1.89	1.91	1.08	2.97
Cornus florida L. flowering dogwood						1.72		0.20			0.60		0.09				25.00	3.77	2.61	1.47	5.24
Panicum boscii Poir. ---						0.01											6.25	0.94	0.01	.001	0.94
Panicum subvillosum Ashe ---						0.16											6.25	0.94	0.16	0.09	1.03
Antennaria plantaginifolia (L.) Hook. pussy's toes						0.18											6.25	0.94	0.18	0.10	1.04
Carex rosea Schk. ---							1.94										6.25	0.94	1.94	1.09	2.03

APPENDIX 5-25 (continued)

Scientific Name / Common Name	Subplots - presence indicated by dry weights (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency (%)[a]	Relative Frequency[b]	Dry Weight Per Species[c]	Relative Weights (%)[d]	Importance Values[e]
Viola triloba Schwein. f. dilatata Ell. three-lobed violet								0.15									6.25	0.94	0.15	0.08	1.02
Lactuca canadensis L. var. obovata Wieg. wild lettuce								0.55									6.25	0.94	0.55	0.31	1.25
Prunus serotina Ehrh. black cherry								0.19		1.56	1.38						18.75	2.83	3.03	1.65	4.48
Podophyllum peltatum L. may apple									3.33								6.25	0.94	3.33	1.88	2.82
Vitis aestivalis Michx. summer grape									0.01								6.25	0.94	0.01	.001	0.94
Symphoricarpos orbiculatus Moench. coral berry										2.91							6.25	0.94	2.91	1.64	2.58
Carex gravida Bailey ----										0.06	0.67			1.66			18.75	2.83	2.37	1.34	4.17
Danthonia spicata (L.) Beauv. poverty grass										0.12							6.25	0.94	0.12	0.08	1.02
Rubus flagellaris Willd. dewberry														2.03			6.25	0.94	2.03	1.15	2.09
Galium concinnum Torr. & Gray elegant bedstraw														0.15			6.25	0.94	0.15	0.09	1.03
Rubus pensilvanicus Poir. highbush blackberry														4.10			6.25	0.94	4.10	2.31	3.25
Veronicastrum virginicum (L.) Farw. culvers root														0.38			6.25	0.94	0.38	0.21	1.15
Euonymus atropurpurea Jacq. wahoo																9.96	6.25	0.94	9.96	5.62	6.56
Agrimonia rostellata Wallr. agrimony																0.36	6.25	0.94	0.36	0.19	1.13
Asimina triloba (L.) Dunal. pawpaw																0.88	6.25	0.94	0.88	0.49	1.43
Totals	3.05	0.83	37.88	5.07	10.52	4.87	16.12	8.57	10.76	5.24	14.30	13.70	2.80	11.56	1.49	32.53	662.50	99.92	177.30	100.00	199.92

*Includes woody and herbaceous plants of less than 20 inches in height.
**Includes the species and/or its hybrids.

[a] = Number of subplots the species occurs / Number of subplots sampled (16) X 100

[b] = Frequency of a species occurrence / Cumulative frequency of all species X 100

[c] = Cumulative weight (16 subplots) by species

[d] = Cumulative weight (a species) / Cumulative weight (all species) X 100

[e] = Relative frequency + relative weight

Sheet 2

APPENDIX A-26

DATA SUMMARY FOR UNDERSTORY VEGETATION[a] OF SAMPLING STATION F-3, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974
(based on sixteen 6.25-milacre plots)

Scientific Name Common Name	Frequency[b]	Relative[c] Frequency(%)	Density[d]	Relative[e] Density(%)	Importance[f] Value
Rhus aromatica Ait. fragrant sumac	14.0	12.3	306.0	58.4	70.7
Cornus florida L. flowering dogwood	15.0	13.2	49.0	9.4	22.6
Prunus serotina Ehrh. black cherry	12.0	10.5	22.0	4.2	14.7
Quercus velutina Lam. black oak	10.0	8.8	24.0	4.6	13.4
Carya sp. Nutt. hickory	9.0	7.9	27.0	5.2	13.1
Quercus alba[g] L. and var. white oak	9.0	7.9	15.0	2.9	10.8
Acer saccharum Marsh sugar maple	3.0	2.6	22.0	4.2	6.8
Sassafras albidum (Nutt.) Nees sassafras	5.0	4.4	12.0	2.3	6.7
Quercus rubra L. red oak	4.0	3.5	6.0	1.1	4.6
Vitus vulpina L. winter grape	5.0	4.4	1.0	0.2	4.6
Rosa carolina L. pasture rose	4.0	3.5	4.0	0.8	4.3

APPENDIX A-26 (continued)

Scientific Name / Common Name	Frequency[b]	Relative Frequency(%)[c]	Density[d]	Relative Density(%)[e]	Importance Value[f]
Rubus flagellaris Willd. / dewberry	3.0	2.6	6.0	1.1	3.7
Vitis cinerea Engelm. / grayback grape	3.0	2.6	4.0	0.8	3.4
Prunus americana Marsh. / wild plum	2.0	1.8	6.0	1.1	2.9
Morus rubra L. / red mulberry	2.0	1.8	4.0	0.8	2.6
Juniperus virginiana L. / red cedar	2.0	1.8	3.0	0.6	2.4
Symphoricarpos sp. Duham. / snowberry	2.0	1.8	3.0	0.6	2.4
Crataegus sp. L. / hawthorn	2.0	1.8	2.0	0.4	2.2
Fraxinus americana L. / white ash	2.0	1.8	2.0	0.4	2.2
Vitis aestivalis Michx. / summer grape	2.0	1.8	2.0	0.4	2.2
Amelanchier arborea (Michx.f.) Fern. / shadbush	1.0	0.9	1.0	0.2	1.1
Celtis occidentalis L. / hackberry	1.0	0.9	1.0	0.2	1.1
Diospyros virginiana L. / persimmon	1.0	0.9	1.0	0.2	1.1

APPENDIX A-26 (continued)

Scientific Name / Common Name	Frequency[b]	Relative Frequency(%)[c]	Density[d]	Relative Density(%)[e]	Importance Value[f]
Viburnum prunifolium L. / black haw	1.0	0.9	1.0	0.2	1.1
TOTAL	114.0	100.4	524.0	100.3	200.7

Trees and/or shrubs per quadrat = 39.9
Trees and/or shrubs per acre = 6,463.8

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[a] Tree or shrub less than 2.0 inches diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Summation of relative frequency + relative density.

[g] Includes the species and varieties.

APPENDIX A-27

DATA SUMMARY FOR OVERSTORY VEGETATION[a] OF SAMPLING STATION F-3, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974 (based on sixteen 25 milacre plots)

Scientific Name / Common Name	Frequency[b]	Relative Frequency(%)[c]	Density[d]	Relative Density(%)[e]	Dominance[f]	Relative Dominance(%)[g]	Importance Value[h]
Quercus alba[i] L. and var. / white oak	14.0	26.9	102.0	57.0	3,175.1	58.3	142.2
Quercus velutina Lam. / black oak	9.0	17.3	24.0	13.4	1,296.3	23.8	54.5
Cornus florida L. / flowering dogwood	9.0	17.3	12.0	6.7	63.6	1.2	25.2
Carya texana Buckl. / black hickory	6.0	11.5	14.0	7.8	210.6	3.9	23.2
Quercus stellata Wang. / post oak	4.0	7.7	9.0	5.0	204.3	3.8	16.5
Quercus rubra L. / red oak	3.0	5.8	6.0	3.4	287.0	5.3	14.5
Carya ovata (Mill) K. Koch / shagbark hickory	2.0	3.8	6.0	3.4	84.2	1.5	8.7
Acer saccharum Marsh / sugar maple	2.0	3.8	2.0	1.1	108.8	2.0	6.9
Carya tomentosa Nutt. / mockernut hickory	1.0	1.9	2.0	1.1	6.2	0.1	3.1
Morus rubra L. / red mulberry	1.0	1.9	1.0	0.6	3.1	0.1	2.6
Vitis cinerea Engelm. / grayback grape	1.0	1.9	1.0	0.6	3.1	0.1	2.6
TOTAL	52.0	99.8	179.0	100.1	5,442.3	100.1	300.0

Sheet 1

Trees per quadrat	=	11.2
Trees per acre	=	453.6
Basal area per quadrat	=	340.1 sq. in.
Basal area per acre	=	13,774.1 sq. in.

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[a] Tree species 2.0 inches or greater diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Cumulative basal area (sq. in.) of a species within the subplots sampled.

[g] $\frac{\text{Cumulative basal area of a species}}{\text{Cumulative basal area of all species}} \times 100$

[h] Summation of relative frequency + relative density + relative dominance.

[i] Includes species and varieties.

APPENDIX A-28

DATA SUMMARY OF FOREST GROUND VEGETATION[a] CLIPPED FROM SUBPLOTS OF SAMPLING STATION F-4,
CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974

Scientific Name / Common Name	Subplots - presence indicated by dry weights (grams/0.2 m², in plots)																Frequency[b] (%)	Relative[c] Frequency (%)	Dry[d] Weight For Species	Relative[e] Weight (%)	Importance[f] Value
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16					
Rhus aromatica Ait. / fragrant sumac	6.00		4.75	5.95		4.25		3.55	4.55						11.20		43.75	10.6	40.25	24.04	34.64[1]
Panicum boscii Poir. / ---		0.60			0.65									0.25	3.90		25.00	6.54	5.40	3.23	9.76
Potentilla simplex Michx. / cinquefoil		6.80															6.25	1.51	6.80	4.06	5.57
Helianthus strumosus L. / sunflower		4.45		12.80													12.50	3.03	17.25	10.30	13.33[3]
Rosa carolina L. / pasture rose			2.35				3.80			0.55	2.65					1.50	31.25	7.57	9.55	5.70	13.27[4]
Vitis cinerea Engelm / grayback grape			4.10						2.90								12.50	3.03	7.00	4.19	7.22
Quercus velutina Lam. / black oak			3.20	2.10				0.05			0.50	1.45					31.25	7.57	7.30	4.36	11.93[5]
Lespedeza violacea (L.) Pers / bush clover			2.30		0.90										4.60		18.75	4.54	7.80	4.65	9.19
Carex rosea Schk. / ---					6.25									0.05		2.40	18.75	4.54	8.70	5.79	10.33[6]
Carex glaucodea Tuckerm. / ---					0.30												6.25	1.51	0.30	0.17	1.68
Carex muhlenbergii Schk. / ---					0.20												6.25	1.51	0.20	0.12	1.63
Carex bushii Mack. / ---					0.40											1.10	12.50	3.03	1.50	0.89	3.92
Panicum lanuginosum Ell. / ---					0.15											0.40	12.50	[illegible]	0.55	0.33	3.36
Amelanchier arborea (Michx.) Fern. / shadbush					0.55												6.25	1.51	0.55	0.32	1.83
Solidago ulmifolia Muhl. / elm leaf goldenrod					8.00			0.50								0.90	18.75	4.54	9.40	5.53	10.07[7]
Monarda russeliana Nutt. / horsemint					0.70			5.20						2.80			18.75	4.54	8.70	5.19	9.73
Strophostyles helvola (L.) Britt. / wild bean						0.40						0.30	0.75	6.55	1.10	0.55	37.50	9.09	9.65	5.76	14.85[2]
Quercus alba[g] L. and var. / white oak						1.10						0.30					12.50	3.03	1.40	0.83	3.86

Sheet 1

APPENDIX A-28 (continued)

Scientific Name / Common Name	Subplots - presence indicated by dry weights (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency[b] (%)	Relative[c] Frequency(%)	Dry[d] Weight for Species	Relative[e] Weight(%)	Importance[f] Value
Cornus florida L. flowering dogwood								10.50									6.25	1.51	10.50	6.27	7.78
Celastrus scandens L. American bittersweet								0.40									6.25	1.51	0.40	0.23	1.74
Quercus rubra L. red oak										2.55					1.25		12.50	3.03	3.80	2.27	5.30
Parthenocissus quinquefolia (L) Planch. Virginia creeper										0.35							6.25	1.51	0.35	0.20	1.71
Amorpha canescens Pursh lead plant										0.65							6.25	1.51	0.65	0.38	1.09
Antennaria plantaginifolia (L.) Hook. pussy's toes												0.55		1.30			12.50	3.03	1.85	1.10	4.13
Linum sp. L. flax													2.10				6.25	1.51	2.10	1.25	2.76
Euphorbia corollata L. flowering spurge															0.85		6.25	1.51	0.85	[illegible]	[illegible]
Aster anomalus Engelm. aster																2.65	6.25	1.51	2.65	1.58	3.09
Sassafras albidum (Nutt.) Nees sassafras																0.40	6.25	1.51	0.40	0.23	1.74
Panicum sphaerocarpon Ell. ---																1.15	6.25	1.51	1.15	0.68	2.19
TOTALS	6.00	11.85	16.45	8.05	30.90	5.75	2.80	25.00	7.45	8.10	7.10	2.90	2.85	10.95	22.55	12.05	412.50	100.37	167.40	99.83	200.20

[a] Includes woody and herbaceous plants of less than 20 inches in height.

[g] Includes species and varieties

[b] = (Numbers of subplots the species occurs / Number of subplots samples (16)) x 100

[c] = (Frequency of a species occurrence / Cumulative frequency of all species) x 100

[d] = Cumulative weights (16 subplots) by species

[e] = (Cumulative weight (a species) / Cumulative weight (all species)) x 100

[f] = Relative frequency + relative weight

APPENDIX A-19

DATA SUMMARY OF FOREST GROUND VEGETATION[a] CLIPPED FROM SUBPLOTS OF SAMPLING STATION F-4, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, MAY-JUNE 1974

Scientific Name / Common Name	Subplots - presence indicated by dry weights (grams/0.25-milacre plots) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency (%)[a]	Relative Frequency[b]	Dry Weight Per Species[c]	Relative Weight (%)[d]	Importance Value[e]
Symphoricarpos orbiculatus Moench, coral berry	0.01																6.25	1.19	0.01	.003	1.19
Cynanchum laeve Michx. angle pod	0.02																6.25	1.19	0.02	0.01	1.20
*Quercus marilandica*** Muenchh. black jack oak		1.43	32.05						13.91 (15.98)								18.75	3.57	38.44	14.92	18.49
Potentilla simplex Michx. cinquefoil		9.84															6.25	1.19	9.84	3.72	4.91
Smilax tamnoides L. bristly greenbriar		0.08															6.25	1.19	0.08	0.03	1.22
Rosa carolina L. pasture rose		0.11	1.91	0.58			0.17		1.73		11.74						37.50	7.14	15.76	5.95	13.09
Desmodium dillenii Darl. tick trefoil		0.08						0.03	0.02					0.33		1.36	31.25	5.95	1.82	0.69	6.64
Prunus sp. L. cherry			0.07														6.25	1.19	0.07	0.03	1.22
Psoralea psoralioides (Walt.) Cory var. *eglandulosa* (Ell.) Freeman Sampson's snakeroot			0.59			3.26	7.31			1.58	3.19	2.48	24.27	19.16		1.11	56.25	10.71	32.83	17.32	28.03
Vitis cinerea Engelm. grayback grape			0.17							0.01							12.50	2.38	0.18	0.07	2.45
Rhus aromatica Ait. fragrant sumac				4.66	0.12	0.01		2.28	3.82			11.54	3.15		5.53		50.00	9.52	30.01	11.35	20.87
Dioscorea villosa L. yam				0.17													6.25	1.19	0.17	0.06	1.25
Botrychium virginianum (L.) Sw. rattlesnake fern				0.02													6.25	1.19	0.02	0.01	1.20
Helianthus sp. L. sunflower					3.95											0.85	12.50	2.38	3.80	2.33	4.61
Crataegus danielsii Palmer hawthorn					5.79												6.25	1.19	5.79	2.19	3.38
Sanicula canadensis L. black snakeroot					0.01												6.25	1.19	0.01	.003	1.19
Lespedeza violacea (L.) Pers. bush clover					0.06										0.02		12.50	2.38	0.08	0.03	2.41
Strophostyles helvola (L.) Britt. wild bean					0.05										2.17		12.50	2.38	2.22	0.84	3.22
Cornus florida L. flowering dogwood					0.05											0.10	12.50	2.38	0.15	0.06	2.44
Carex bushii Mack. ---					1.82											2.88	12.50	2.38	4.48	1.64	4.07
Quercus macrocarpa Michx. X *Q. marilandica* bur oak hybrid					32.32												6.25	1.19	32.32	12.22	13.41
Carex rosea Schk. ---						3.31											12.50	2.38	3.43	1.30	3.68
Viola triloba Schwein. f. *dilatata* Ell. three-lobed violet							0.01										6.25	1.19	0.01	.003	1.19
Parthenocissus quinquefolia (L.) Planch. Virginia creeper								0.27					0.28				12.50	2.38	0.55	0.21	2.59
Quercus alba L. white oak								32.99									6.25	1.19	12.99	4.91	6.10
*Quercus velutina*** Lam. X *Q. bushii* Sarg. black oak hybrid										0.21	(3.65)						12.50	2.38	3.86	1.46	3.84
Solidago sp. L. solidago											0.88						6.25	1.19	0.88	0.33	1.52
Aster sp. L. aster											0.80		1.17		0.66	5.02	25.00	4.76	7.48	2.83	7.59
Diospyros virginiana L. persimmon											0.49						6.25	1.19	0.49	0.19	1.38
Parthenium integrifolium Ait. American feverfew												10.95					6.25	1.19	10.95	4.14	5.33
Amelanchier arborea (Michx. f.) Fern. shadbush													9.93				6.25	1.19	9.93	3.75	4.94
Panicum linearifolium Scribn. ---													0.26		1.64		12.50	2.38	1.90	0.72	3.10
Sassafras albidum (Nutt.) Nees sassafras													0.22				6.25	1.19	0.22	0.08	1.27
Hieracium sp. hawkweed														0.02			6.25	1.19	0.02	0.01	1.20
Carex albicans Torr. & Gray ---															0.43		6.25	1.19	0.43	0.17	1.36
Panicum subvillosum Ashe ---															0.01	0.07	12.50	2.38	0.08	0.03	2.41
Antennaria plantaginifolia (L.) Hook. pussy's toes																2.47	6.25	1.19	2.67	1.01	2.20
Elymus villosus Muhl. wild rye																3.61	6.25	1.19	3.61	1.36	2.55
Euphorbia sp. L. spurge																0.10	6.25	1.19	0.10	0.04	1.23
Lactuca sp. L. wild lettuce																0.28	6.25	1.19	0.28	0.11	1.30

APPENDIX A-29 (continued)

Scientific Name** / Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Frequency (%)[a]	Relative Frequency[b]	Dry Weight Per Species[c]	Relative Weight (%)[d]	Importance Value[e]
	Subplots - presence indicated by dry weights (grams/0.25-milacre plots)																				
Desmodium nudiflorum L. DC. (tick trefoil)																0.61	6.25	1.19	0.61	0.13	1.32
Compositae (genus unident.) ---																0.37	6.25	1.19	0.37	0.14	1.33
Quercus shumardii Buckl. Shumard oak																9.27	6.25	1.19	9.27	3.39	6.65
Panicum boscii Poir. ---																0.15	6.25	1.19	0.15	0.06	1.25
Totals	0.93	11.56	24.59	4.23	43.27	3.76	7.49	12.57	21.95	1.80	23.05	24.95	29.26	12.53	10.53	38.23	525.00	99.96	986.58	100.00	199.96

*Includes woody and herbaceous plants of less than 20 inches in height.
**Includes the species and/or its hybrids.

[a] = Number of subplots the species occurs / Number of subplots sampled (16) X 100

[b] = Frequency of a species occurrence / Cumulative frequency of all species X 100

[c] = Cumulative weight (16 subplots) by species

[d] = Cumulative weight (a species) / Cumulative weight (all species) X 100

[e] = Relative frequency + relative weight

APPENDIX A-30

DATA SUMMARY FOR UNDERSTORY VEGETATION[a] OF SAMPLING STATION F-4, CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974
(based on sixteen 6.25-milacre plots)

Scientific Name Common Name	Frequency[b]	Relative[c] Frequency(%)	Density[d]	Relative[e] Density(%)	Importance[f] Value
Rhus aromatica Ait. fragrant sumac	12.0	13.5	129.0	31.4	44.9
Quercus velutina Lam. black oak	12.0	13.5	75.0	18.2	31.7
Quercus alba[g] L. and var. white oak	10.0	11.2	65.0	15.8	27.0
Cornus florida L. flowering dogwood	4.0	4.5	30.0	7.3	11.8
Quercus rubra L. red oak	4.0	4.5	12.0	2.9	7.4
Fraxinus americana L. white ash	5.0	5.6	5.0	1.2	6.8
Ostrya virginiana (Mill.) K. Koch hop-hornbeam	3.0	3.4	13.0	3.2	6.6
Carya sp. Nutt. hickory	3.0	3.4	12.0	2.9	6.3
Acer saccharum Marsh sugar maple	3.0	3.4	11.0	2.7	6.1
Amelanchier arborea (Michx.f.) Fern. shadbush	3.0	3.4	10.0	2.4	5.8
Prunus serotina Ehrh. black cherry	3.0	3.4	8.0	1.9	5.3

APPENDIX A-30 (continued)

Scientific Name / Common Name	Frequency[b]	Relative Frequency (%)[c]	Density[d]	Relative Density (%)[e]	Importance Value[f]
Rosa carolina L. — pasture rose	3.0	3.4	8.0	1.9	5.3
Vitis cinerea Engelm. — grayback grape	3.0	3.4	7.0	1.7	5.1
Vitis vulpina L. — winter grape	3.0	3.4	6.0	1.5	4.9
Crataegus sp. L. — hawthorn	3.0	3.4	3.0	0.7	4.1
Diospyros virginiana L. — persimmon	2.0	2.2	2.0	0.5	2.7
Juniperus virginiana L. — red cedar	2.0	2.2	2.0	0.5	2.7
Quercus x fernowi Trel. (*Quercus alba x Quercus stellata*) — oak	2.0	2.2	2.0	0.5	2.7
Quercus stellata Wang. — post oak	2.0	2.2	2.0	0.5	2.7
Rubus flagellaris Willd. — dewberry	2.0	2.2	2.0	0.5	2.7
Cercis canadensis L. — redbud	1.0	1.1	3.0	0.7	1.8
Euonymus atropurpureus Jacq. — wahoo	1.0	1.1	1.0	0.2	1.3
Prunus americana Marsh. — wild plum	1.0	1.1	1.0	0.2	1.3

APPENDIX A-30 (continued)

Scientific Name Common Name	Frequency[b]	Relative Frequency(%)[c]	Density[d]	Relative Density(%)[e]	Importance Value[f]
Sassafras albidum (Nutt.) Nees sassafras	1.0	1.1	1.0	0.2	1.3
Ulmus rubra Muhl. slippery elm	1.0	1.1	1.0	0.2	1.3
TOTAL	89.0	99.9	411.0	99.7	199.6

Trees and/or shrubs per quadrat = 25.7
Trees and/or shrubs per acre = 4,163.4

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[a] Tree or shrub less than 2.0 inches diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Summation of relative frequency + relative density.

[g] Includes the species and varieties.

APPENDIX A-31

DATA SUMMARY FOR OVERSTORY VEGETATION[a] OF SAMPLING STATION F-4,
CALLAWAY PLANT SITE, CALLAWAY COUNTY, MISSOURI, FALL 1974
(based on sixteen 25-milacre plots)

Scientific Name Common Name	Frequency[b]	Relative[c] Frequency(%)	Density[d]	Relative[e] Density(%)	Dominance[f]	Relative[g] Dominance(%)	Value
Quercus alba[i] L. and var. white oak	12.0	28.6	34.0	37.4	1,241.9	26.7	92.7
Quercus velutina Lam. black oak	10.0	23.8	17.0	18.7	2,115.3	45.5	88.0
Quercu stellata Wang. post oak	9.0	21.4	21.0	23.1	954.4	20.5	65.0
Cornus florida L flowering dogwood	3.0	7.1	7.0	7.7	35.1	0.8	15.6
Quercus marilandica Muenchh black-jack oak	1.0	2.4	2.0	2.2	151.6	3.3	7.9
Carya texana Buckl. black hickory	2.0	4.8	2.0	2.2	12.0	0.3	7.3
Acer saccharum Marsh. sugar maple	1.0	2.4	3.0	3.3	19.8	0.4	6.1
Carya ovata (Mill.) K. Koch shagbark hickory	1.0	2.4	1.0	1.1	95.0	2.0	5.5
Amelanchier arborea (Michx.f.) Fern. shadbush	1.0	2.4	2.0	2.2	8.0	0.2	4.8
Ulmus rubra Muhl. slippery elm	1.0	2.4	1.0	1.1	9.6	0.2	3.7
Fraximus americana L. white ash	1.0	2.4	1.0	1.1	4.9	0.1	3.6
TOTAL	42.0	100.1	91.0	100.1	4,647.6	100.0	300.2

Sheet 1

Trees per quadrat	=	5.7
Trees per acre	=	230.9
Basal area per quadrat	=	290.5 sq. in.
Basal area per acre	=	11,765.3 sq. in.

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[a] Tree species 2.0 inches or greater diameter at breast height.

[b] Number of subplots a species occurs.

[c] $\frac{\text{Frequency of a species occurrence}}{\text{Cumulative frequency of all species}} \times 100$

[d] Cumulative number of a species within subplots sampled.

[e] $\frac{\text{Density of a species occurrence}}{\text{Cumulative density of all species}} \times 100$

[f] Cumulative basal area (sq. in.) of a species within subplots sampled.

[g] $\frac{\text{Cumulative basal area of a species}}{\text{Cumulative basal area of all species}} \times 100$

[h] Summation of relative frequency + relative density + relative dominance.

[i] Includes the species and varieties.

APPENDIX B-1

SCIENTIFIC AND COMMON NAMES OF HERPETOFAUNA FOUND ON CALLAWAY PLANT SITE, REFORM, MISSOURI, DURING SPRING AND FALL SAMPLING PERIODS, 1974[a]

Scientific Name	Common Name
Notophthalmus viridescens	Newt
Scaphiopus bombifrons	Plains spadefoot toad
Bufo fowleri	Fowler's toad
Bufo americanus	American toad
Hyla versicolor	Gray treefrog
Hyla crucifer	Spring peeper
Acris crepitans	Northern cricket frog
Rana pipiens	Leopard frog
Rana catesbeiana	Bullfrog
Rana clamitans	Green frog
Cheyldra serpentina	Snapping turtle
Terrapene carolina	Three-toed box turtle
Sceloporus undulatus	Eastern fence lizard
Ophisaurus attenuatus	Slender glass lizard
Lygosoma laterale	Ground skink
Eumeces fasciatus	Five-lined skink
Natrix sipedon	Common water snake
Storeria dekayi	Brown snake
Storeria occipitomaculata	Red-bellied snake
Thamnophis proximus	Western ribbon snake
Thamnophis sirtalis	Common garter snake
Virginia valeriae	Smooth earth snake
Heterodon platyrhinos	Eastern hognose snake
Carphophis amoenus	Worm snake
Diadophis punctatus	Eastern ringneck snake
Coluber constrictor	Racer
Elaphe obsoleta	Rat snake
Lamperopeltis getulus	Common kingsnake
Agkistrodon contortrix	Copperhead

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[a]Phylogeny and taxonomy follow Blair, Blair, Brodkorb, Cagle and Moore, 1968.