STORMWATER MANAGEMENT AND CONSERVATION

by
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Introduction

This paper reports on a preliminary analysis of a hydrologic balance within the Econlockhatchee River Basin. The work was completed to indicate the need for conservation of our water resources within the river basin. Specifically, the analysis documents increasing runoff from urban developed areas relative to rural areas.

Once urbanization takes place without regard to conservation of an existing hydrologic balance, water can be lost to our rivers and oceans, flooding potential increases, groundwaters are depleted, and pollution of the waters occurs. These consequences have been documented using a hydrologic balance for other areas within the State of Florida (Wanielista, 1990). The hydrologic cycle can be used to document some consequences resulting from urban development in the Econlockhatchee River.

Common sense would dictate that water falling on impervious surfaces that is not diverted to pervious surfaces will run off to streams and rivers. This runoff water is lost from the impervious surfaces of urban lands to the Econlockhatchee River. However, not all the runoff water has to be discharged, part of it can be reused within the watershed as a source of water for non-potable uses.

River Flow

Using the last 10 years of streamflow data in the River as reported by the U.S.G.S. at the Union Park and the Magnolia Ranch gaging sites, the streamflows are compared. The Magnolia Ranch station records data from the rural environment, while the Union Park site represents an urban area. The data are reported in units of inches over each square mile per year and compared to rainfall volumes as shown in Table 1. The rural area river flow averaged about 23% of the rainfall while the urban area river flow averaged about 33% of the rainfall and was approximately 45% greater than the rural.

TABLE 1

Hydrologic Balance Comparisons for Two Sites on the Econlockhatchee River (using 1979-1988 Data)*

	Urban	Rural
Precipitation (inches/year) (at Orlando International, adjusted by data from U.C.F.)	49	49
Riverflow (inches/year)	16	11
Evapotranspiration/Recharge (inches/year)	33	38

*Data rounded to nearest inch

The contribution of the urban areas also can be documented by showing graphically the cumulative amount of water being discharged in the river at both sites (Figure 1). Over a ten year period, the quantity of discharged water per square mile at the urban site is greater than the quantity from the rural site. The difference is

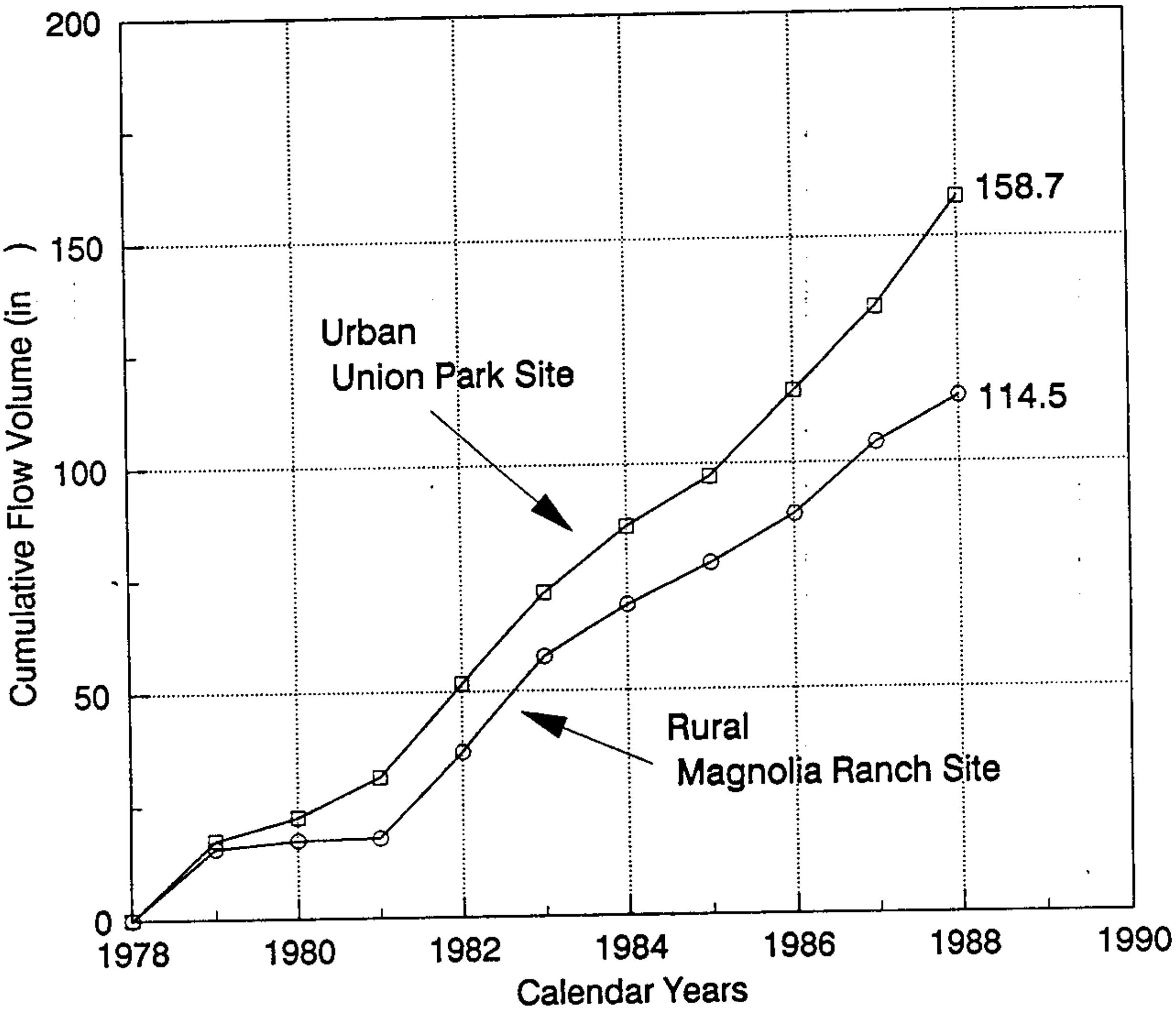


Figure 1. Cumulative Flow Volume Comparison / Econlockhatchee River

about 44 inches which is almost equal to the average yearly rainfall. About every 10-11 years based on recent data, we are loosing about one year of rainfall. The loss of water from the 27.1 square mile urban watershed is equivalent to the water used by 570,000 people at a rate of 100 gallons per day for one full year.

Also, there is an increasing "gap" or divergence between the flows from the urban and rural sites as time increases due presumably to urbanization activities. We are loosing water and increasing pollution loads to the river. Also the potential for flooding is increasing. This increased flow is directly attributed to the impervious surface of the urban areas. Rainfall on these surfaces that are hydraulically connected to the river will be discharged to the river unless stormwater management to reuse the stormwater is practiced.

Stormwater Management and Reuse

Extensive research with practiced applications are underway at the University of Central Florida to help design and operate stormwater reuse systems. The objectives of the designs are to reduce both pollution and the volume of water in stormwater discharges. This can be accomplished by reusing the stormwater for car washing, surficial aquifer recharge, cooling water make-up, ornamental foliage, and irrigation.

Irrigation systems have been used before in the local area. We have documented 12 sites in the urban area, but no specific design and operational criteria have been acceptable to the scientific, engineering and regulatory communities. Other irrigation sites are being used in the rural environment, primarily for agricultural purposes. In other areas of the State, design and operation criteria have been developed, for example in Tallahassee and Manatee County.

The benefits of reuse are both environmentally acceptable and are economical. If irrigation with potable water is being done at 2 inches per week over 100 acres (golf course size), and the potable water cost $1.00/1000 gallons, the annual cost is over $300,000 for the water alone. The stormwater is free. The only additional cost for both systems is electricity and the irrigation system. With stormwater, the pumping cost and the pumps would cost about $30,000/year.

Conclusions

The Econlockhatchee River flow is increasing at a greater rate every year. Runoff from urban areas must be controlled and reused to conserve our water resources. There are currently available design criteria for stormwater management ponds that are being used by the technical and regulatory community. These criteria and other environmental factors should be given serious consideration if we are to maintain reasonable hydrologic and economic conditions within the River. The Saint Johns River Water Management District has permitted a few reuse systems and the Florida Department of Environmental Regulation is currently promoting their use as conservation and mitigation methods. It is highly recommended that stormwater reuse systems be implemented in the Econlockhatchee River Basin. The time is now!

Acknowledgements

Some of the technical and financial support for this work was provided by the Florida Department of Environmental Regulation, the Environmental Protection Agency, and the Saint Johns River Water Management District. It is a continuing effort and the help of individuals within these agencies is appreciated.

References

Wanielista, M. P., 1990, Evers Reservoir Hydrologic Balance, University of Central Florida, Orlando, Fl.

Wanielista, M. P., 1990a, Hydrology and Water Quantity Control, J. Wiley and Sons, New York, N. Y.

Discharge, in cubic feet per second.

Magnolia Ranch ($32.9\ mi^2$)		Union Park ($27.1\ mi^2$)	
Water Year	~~Mean~~ (cfs/yr)	Water Year	~~Mean~~ (cfs/yr)
1987	38	1987	48.7
1988	24.8	1988	37.4
1989	26.3	1989	21.3
1990	5.01	1990	13.4
1991	43.5	1991	55.3
1992	41	1992	47.9
1993	31.1	1993	29.7

inches | 1 | inches

$\frac{38}{32.9} \times 13.6 = 15.7$ | $\frac{48.7}{27.1} \times 13.6 = 24.4$

$\frac{24.8}{32.9} \times 13.6 = 10.25$ | $\frac{37.4}{27.1} \times 13.6 = 18.76$

$\frac{26.3}{32.9} \times 13.6 = 10.8$ | $\frac{21.3}{27.1} \times 13.6 = 10.68$

$\frac{5.01}{32.9} \times 13.6 = 2.07$ | $\frac{13.4}{27.1} \times 13.6 = 6.72$

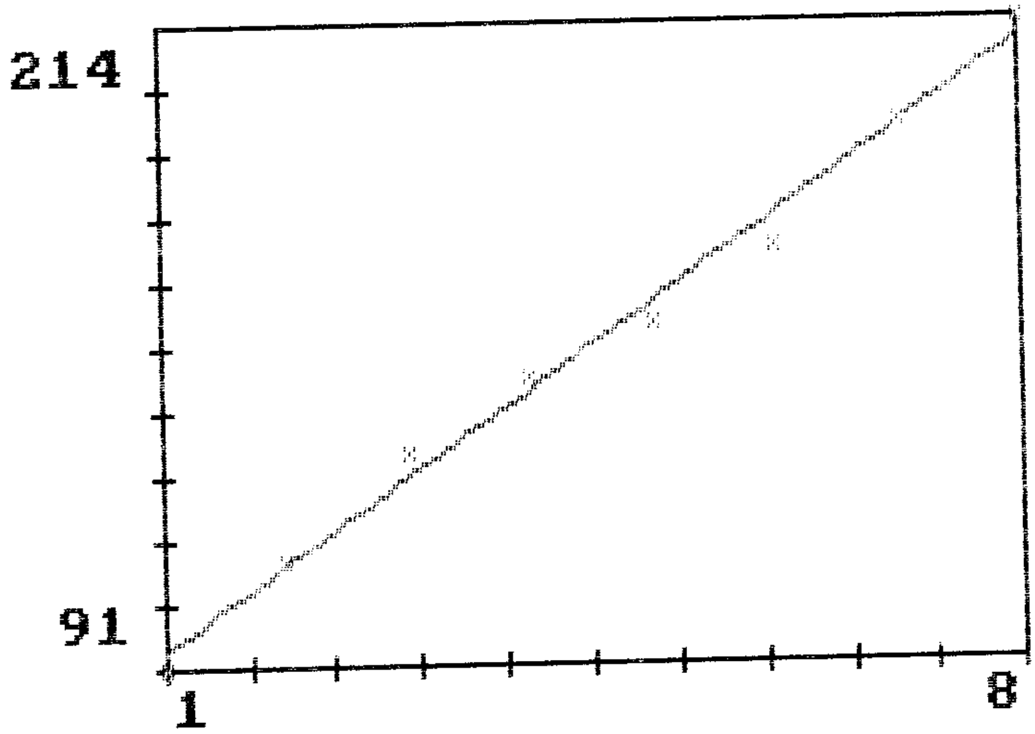
$\frac{43.5}{32.9} \times 13.6 = 17.98$ | $\frac{55.3}{27.1} \times 13.6 = 27.75$

$\frac{41}{32.9} \times 13.6 = 16.94$ | $\frac{47.9}{27.1} \times 13.6 = 24.03$

$\frac{31.1}{32.9} \times 13.6 = 12.85$ | $\frac{29.7}{27.1} \times 13.6 = 14.9$

LINEAR EQUATION

UNION PARK

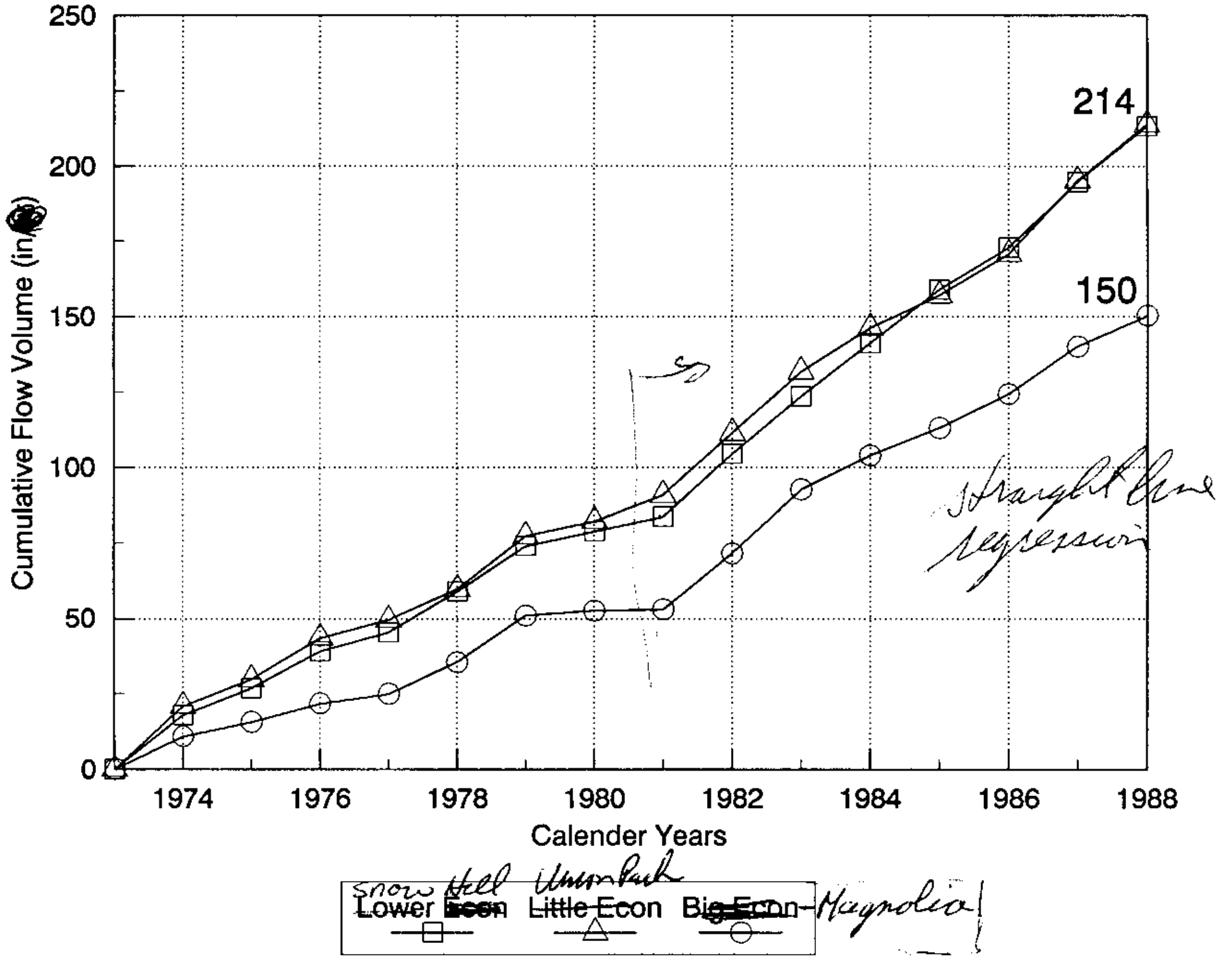


Y = 76.72144 + 16.7519 X
R^2 = .9914158
PRESS PrtSc FOR HARD COPY OR <cr>
PRESS ANY KEY TO RESTART

CURVE FIT

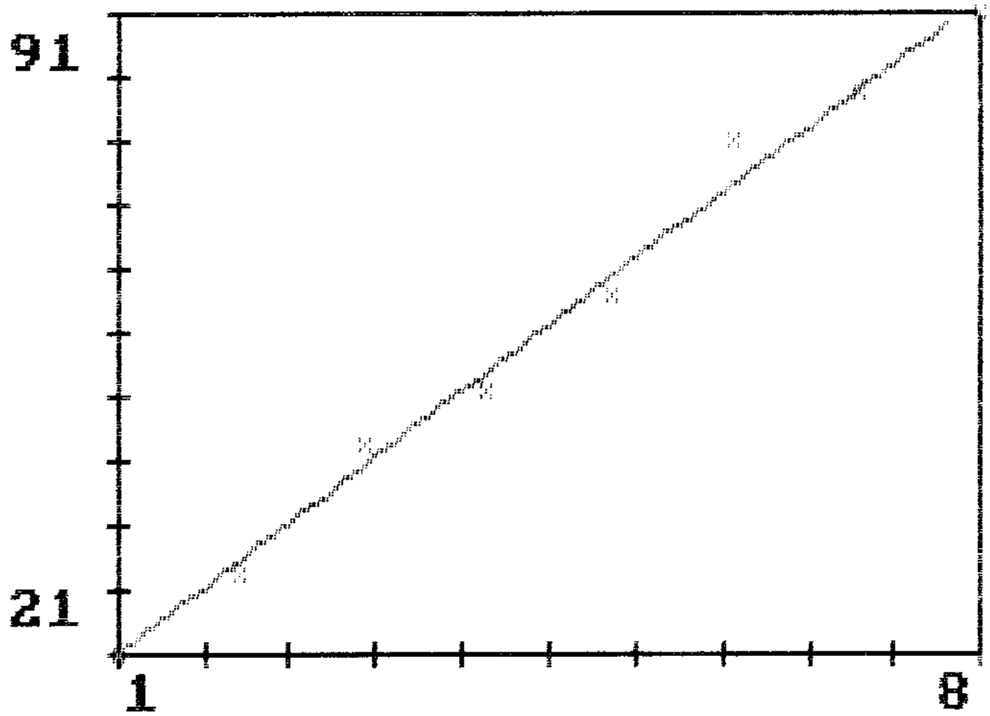
NODE	X	Y
1	1	90.92
2	2	111.42
3	3.	131.67
4	4	146.15
5	5	156.99
6	6	170.69
7	7	195.1
8	8	213.90
9 ?		

B25 - B39
C25 - C39
D25 - D39



UNION PARK
1974 - 1981

LINEAR EQUATION



Y = 10.23609 + 10.31976 X
R^2 = .9900667
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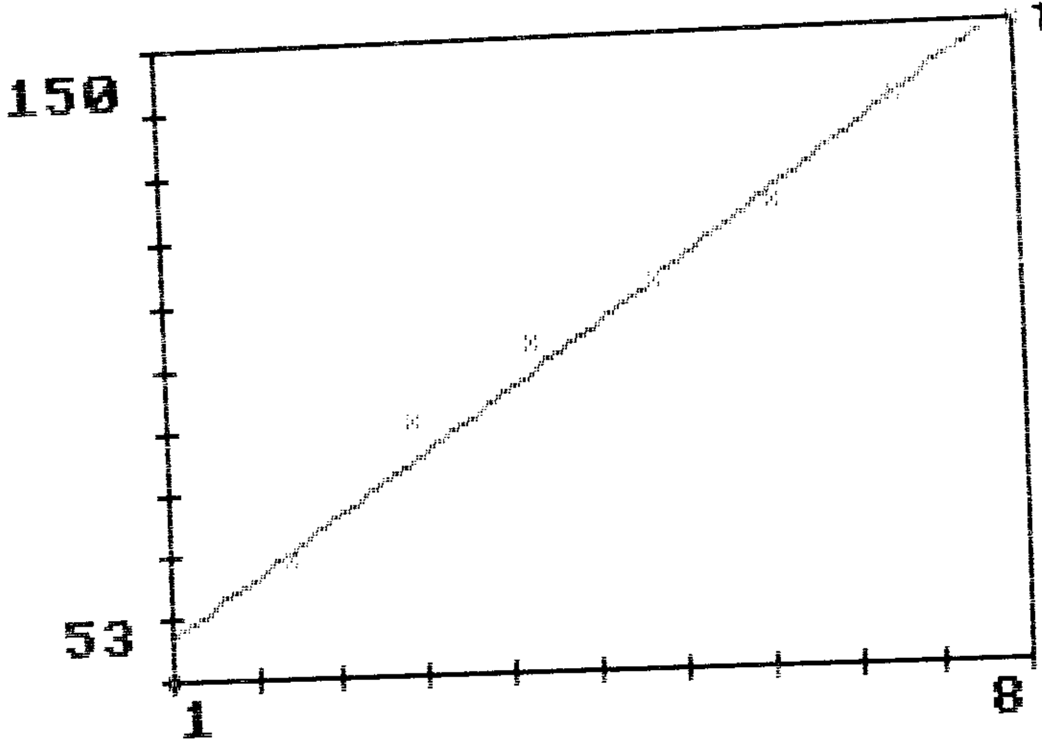
CURVE FIT

NODE	X	Y
1	1	20.75
2	2	29.57
3	3	43.36
4	4	49.47
5	5	59.75
6	6	77.29
7	7	82.29
8	8	? 90.92

F9-RET TO CLEAR REMAINING ENTRIES AND RETURN TO MENU

LINEAR EQUATION

MAGNOLIA RANCH



Y = 45.74497 + 13.42 X
R^2 = .9845837
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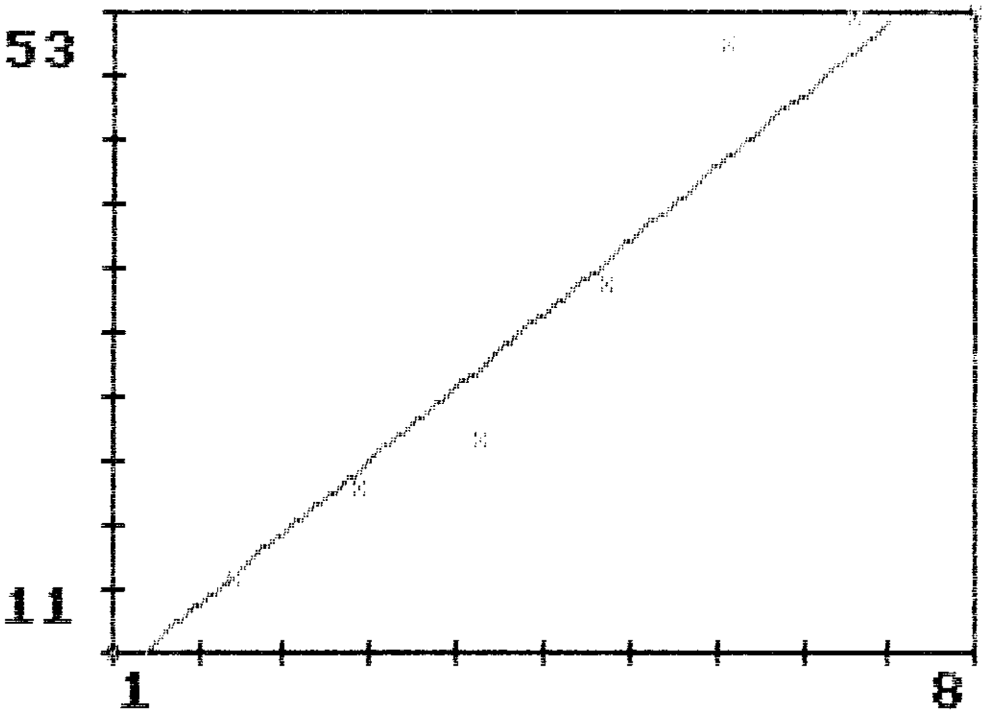
CURVE FIT

NODE	X	Y
1	1	52.91
2	2	71.65
3	3.	92.75
4	4	104.02
5	5	113.11
6	6	124.35
7	7	140.01
8	8	150.28
9	?	

F9-RET TO CLEAR RE

LINEAR EQUATION

MAGNOLIA RANCH 1974-1981



Y = 1.98286 + 6.894642 X
R^2 = .9480612
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PRESS ANY KEY TO RESTART

CURVE FIT

NODE	X	Y
1	1	10.73
2	2	15.44
3	3	21.59
4	4	24.76
5	5	35.2
6	6	50.89
7	7	52.55
8	8	? 52.91

F9-RET TO CLEAR REMAINING ENTRIES AND RETURN TO MENU

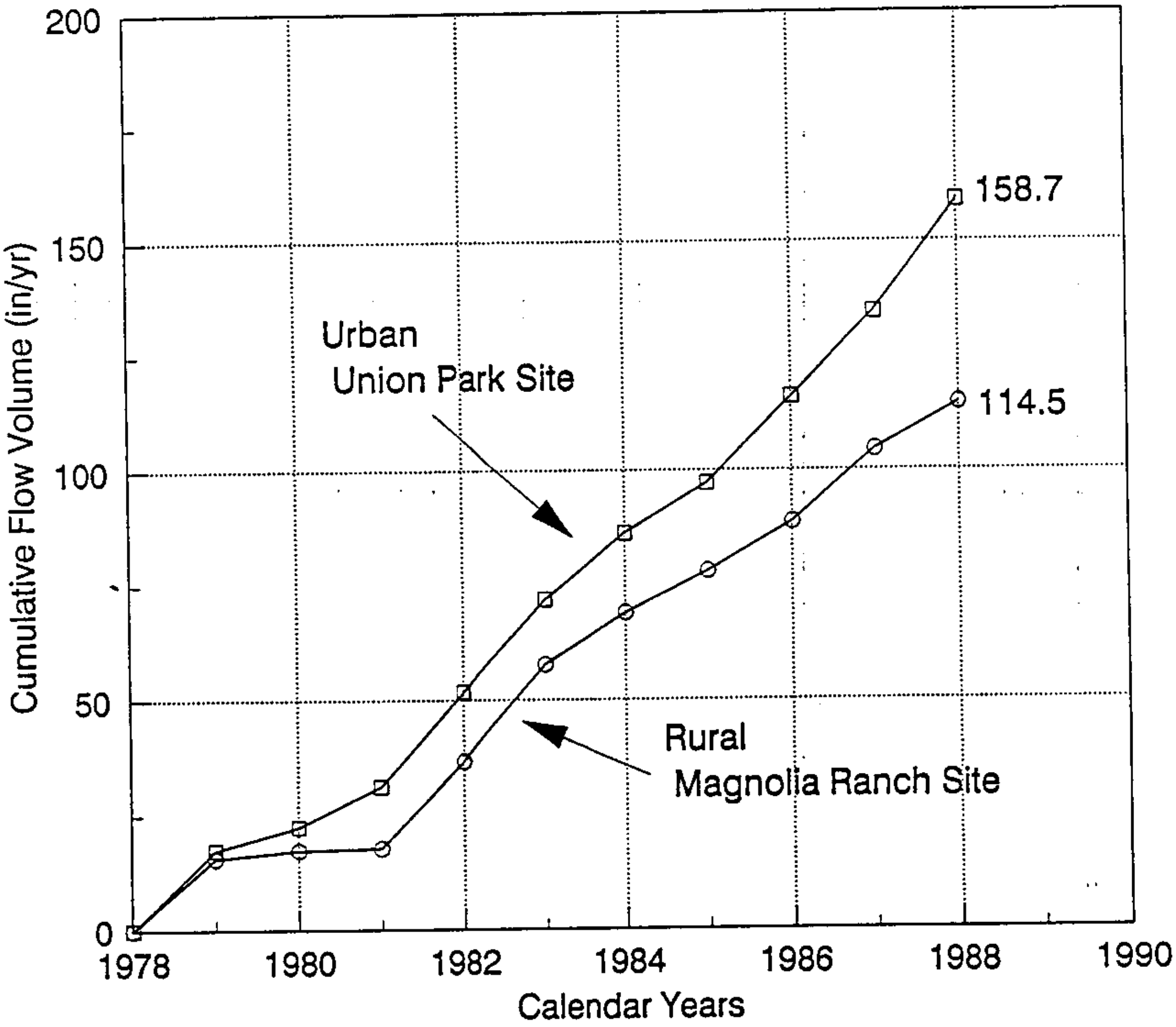
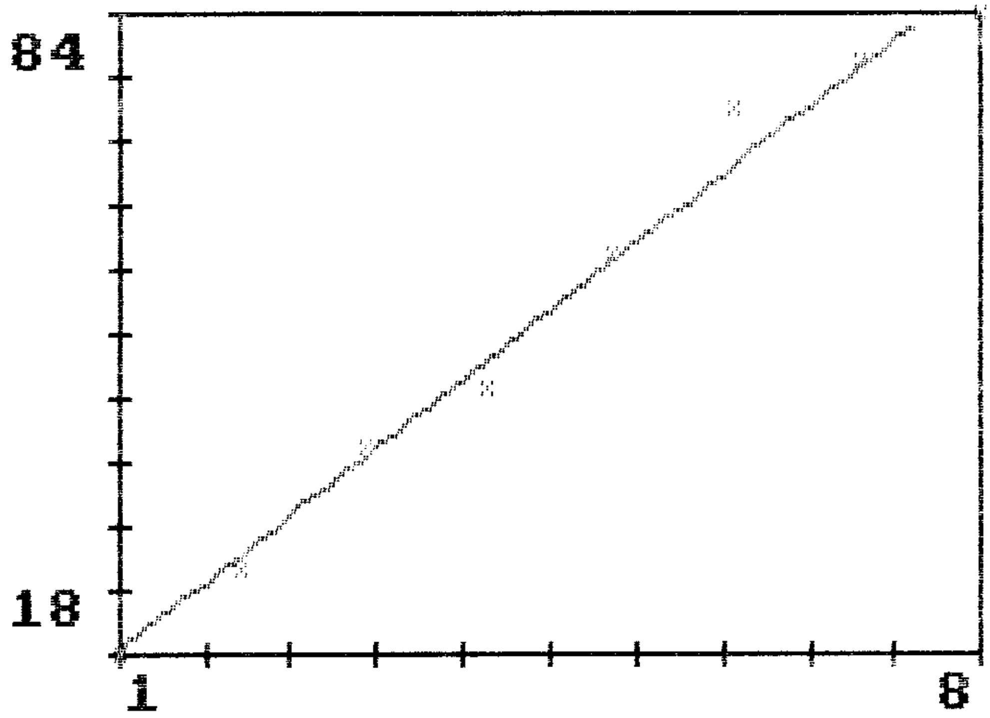


Figure 1. Cumulative Flow Volume Comparison / Econlockhatchee River

LINEAR EQUATION

SNOW HILL
1974-1981



Y = 7.891068 + 10.03226 X
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PRESS ANY KEY TO RESTART

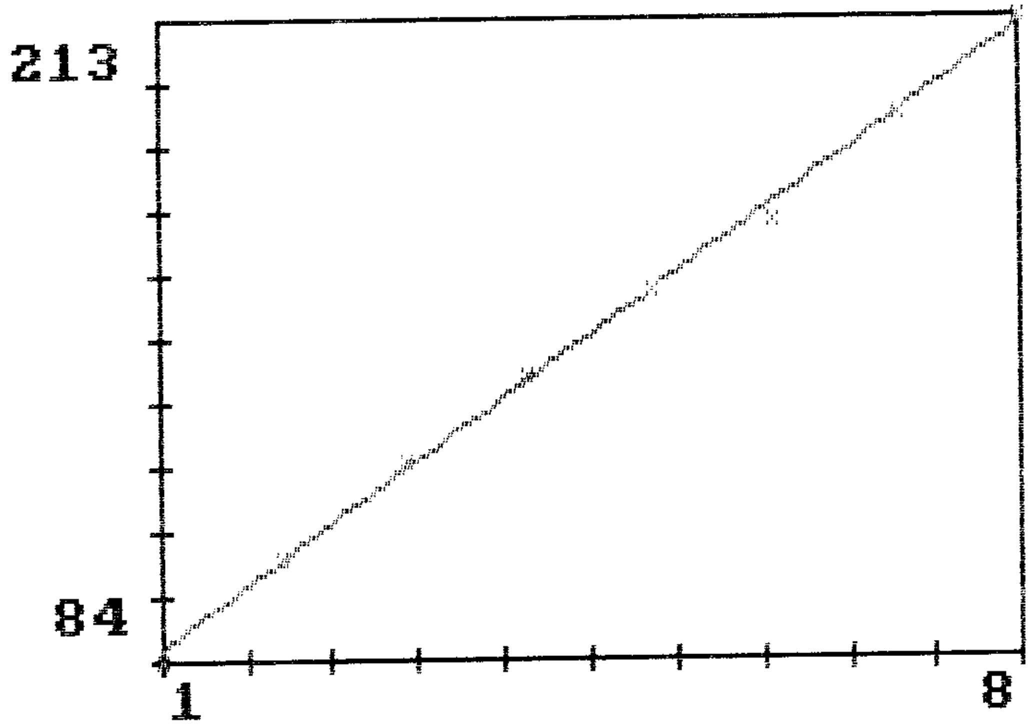
CURVE FIT

NODE	X	Y
1	1	17.70
2	2	26.65
3	3	38.93
4	4	45.3
5	5	58.97
6	6	74.1
7	7	78.9
8	8	83.74
9	?	

F9-RET TO CLEAR REMAINING ENTRIES AND RETURN TO MENU

LINEAR EQUATION

SNOW HILL



Y = 67.4557 + 18.13346 X
R^2 = .9984549
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PRESS ANY KEY TO RESTART

CURVE FIT

NODE	X	Y
1	1	83.74
2	2	104.51
3	3.	123.56
4	4	141.08
5	5	158.81
6	6	172.79
7	7	194.6
8	8	213.36
9	?	

ST. JOHNS RIVER

ST. JOHNS RIVER BASIN ABOVE OKLAWAHA RIVER

02233200 LITTLE ECONLOCKHATCHEE RIVER NEAR UNION PARK, FL

LOCATION.--Lat 28°31'29", long 81°14'39", in SW¼ sec.32, T.22 S., R.31 E., Orange County, Hydrologic Unit 03080101, near right bank at Berry-Deese Road, 3,300 ft upstream from a tributary, 3 mi south of Union Park, 8.5 mi east of Orlando, and 13 mi upstream from mouth.

DRAINAGE AREA.--27.1 mi^2.

PERIOD OF RECORD.--October 1959 to current year.

GAGE.--Water-stage recorder. Datum of gage is 56.19 ft above National Geodetic Vertical Datum of 1929. Prior to Jan 12, 1960, and Oct. 21, 1972 to Nov. 14, 1983, nonrecording gage at same site and datum.

REMARKS.--Records fair.

AVERAGE DISCHARGE.--29 years, 25.9 ft^3/s, 12.98 in/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 1,640 ft^3/s, Mar. 17, 1960, gage height, 11.64 ft; minimum discharge, 0.10 ft^3/s, June 6,7, 1961; minimum gage height, 4.33 ft, May 14, 1967, May 6, 1971.

EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 200 ft^3/s (revised) and maximum (*):

Date	Time	Discharge (ft^3/s)	Gage height (ft)	Date	Time	Discharge (ft^3/s)	Gage height (ft)
Nov. 4	0521	388	8.76	Mar. 19	0923	222	8.27
Nov. 19	2400	370	8.72	Sept. 9	0700	*450	*9.03
Nov. 27	0914	420	8.85				

Minimum discharge, 7.7 ft^3/s, May 11; gage height, 5.72 ft.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	80	22	122	17	28	12	23	39	13	12	28	66
2	83	26	102	17	25	12	20	21	12	18	32	63
3	54	71	87	17	23	12	19	14	11	15	51	50
4	43	327	75	17	22	12	19	12	11	13	40	46
5	35	205	63	16	20	13	17	11	10	11	40	65
6	29	144	53	16	19	52	15	10	34	22	36	205
7	25	112	48	15	21	40	14	9.5	36	18	40	225
8	23	91	44	15	22	28	13	0.9	53	14	38	202
9	20	77	41	16	25	23	13	8.6	28	12	45	393
10	19	84	39	23	22	46	12	8.1	21	13	38	256
11	21	72	36	21	20	43	21	8.0	23	16	32	166
12	50	55	38	19	19	31	17	10	18	13	27	124
13	146	46	50	18	17	47	15	26	15	15	26	102
14	111	41	52	18	16	156	13	24	31	41	22	88
15	87	37	53	16	16	119	12	22	51	99	21	77
16	72	34	56	16	33	98	12	15	28	46	23	69
17	58	44	46	15	25	85	11	12	21	29	28	61
18	47	193	39	15	21	78	11	11	18	23	35	54
19	41	199	33	14	19	196	11	10	16	20	100	48
20	39	293	30	14	18	158	12	9.5	16	20	69	46
21	49	182	28	14	18	120	11	9.1	16	21	62	44
22	45	136	27	33	20	99	10	8.8	15	25	77	41
23	36	114	24	26	17	84	9.9	8.6	14	50	71	39
24	30	100	23	20	16	71	9.6	11	13	162	57	36
25	26	93	22	42	15	60	9.3	70	12	116	46	34
26	24	97	21	130	14	51	9.3	33	11	67	45	37
27	22	371	20	74	14	46	8.9	32	12	48	76	64
28	21	260	20	50	13	39	8.5	22	15	37	124	44
29	19	189	19	40	13	34	8.3	18	16	32	88	37
30	17	148	17	35	---	29	8.7	15	14	27	85	33
31	17	---	17	31	---	26	---	14	---	24	70	---
TOTAL	1389	3863	1345	830	571	1920	393.5	531.1	604	1079	1572	2815
MEAN	44.8	129	43.4	26.8	19.7	61.9	13.1	17.1	20.1	34.8	50.7	93.8
MAX	146	371	122	130	33	196	23	70	53	162	124	393
MIN	17	22	17	14	13	12	8.3	8.0	10	11	21	33
CFSM	1.65	4.75	1.60	.99	.73	2.29	.48	.63	.74	1.28	1.87	3.46
IN.	1.91	5.30	1.85	1.14	.78	2.64	.54	.73	.83	1.48	2.16	3.86

CAL YR 1987 TOTAL 17785.3 MEAN 48.7 MAX 744 MIN 4.7 CFSM 1.80 IN. 24.41
WTR YR 1988 TOTAL 16912.6 MEAN 46.2 MAX 393 MIN 8.0 CFSM 1.71 IN. 23.22

ST. JOHNS RIVER

ST. JOHNS RIVER BASIN ABOVE OKLAWAHA RIVER

02233200 LITTLE ECONLOCKHATCHEE RIVER NEAR UNION PARK, FL

LOCATION.--Lat 28°31'29", long 81°14'39", in SW¼ sec.32, T.22 S., R.31 E., Orange County, Hydrologic Unit 03080101, near right bank at Berry-Deese Road, 3,300 ft upstream from a tributary, 3 mi south of Union Park, 8.5 mi east of Orlando, and 13 mi upstream from mouth.

DRAINAGE AREA.--27.1 mi^2.

PERIOD OF RECORD.--October 1959 to current year.

GAGE.--Water-stage recorder. Datum of gage is 56.19 ft above National Geodetic Vertical Datum of 1929. Prior to Jan 12, 1960, and Oct. 21, 1972 to Nov. 14, 1983, nonrecording gage at same site and datum.

REMARKS.--Records fair.

AVERAGE DISCHARGE.--30 years, 25.8 ft^3/s, 12.93 in/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 1,640 ft^3/s, Mar. 17, 1960, gage height, 11.64 ft; minimum discharge, 0.10 ft^3/s, June 6,7, 1961; minimum gage height, 4.83 ft, May 14, 1967, May 6, 1971.

EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 200 ft^3/s and maximum (*):

Date	Time	Discharge (ft^3/s)	Gage height (ft)	Date	Time	Discharge (ft^3/s)	Gage height (ft)
Nov. 23	1200	*625	*9.57	Sept. 2	0500	211	8.10
Jan. 22	1400	401	8.95				

Minimum discharge, 3.7 ft^3/s, May 9, June 5,6, gage height, 5.16 ft.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1988 TO SEPTEMBER 1989
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	31	13	56	18	49	13	9.6	17	8.1	7.7	12	20
2	28	14	48	17	45	16	8.7	13	6.3	10	12	155
3	34	14	43	17	42	19	8.6	9.4	5.1	15	12	71
4	78	29	39	17	40	18	8.4	8.1	4.4	11	15	47
5	57	27	36	16	36	16	8.4	7.5	3.9	8.0	12	34
6	46	30	33	16	34	16	9.4	6.5	4.7	5.9	9.9	51
7	40	21	30	16	31	15	9.4	5.8	20	11	9.0	59
8	35	19	28	16	29	17	9.3	5.0	77	9.6	10	38
9	33	18	26	16	26	16	8.4	4.7	55	7.9	11	37
10	30	16	25	15	24	15	8.1	4.6	26	6.6	15	33
11	28	16	29	15	22	14	8.2	4.9	18	7.7	92	28
12	26	16	71	15	20	14	7.7	5.3	14	26	38	24
13	24	16	49	15	19	13	6.9	4.5	12	35	44	25
14	21	14	39	14	19	12	6.7	4.6	10	27	34	26
15	21	13	35	14	17	12	11	20	9.1	17	24	24
16	22	13	31	14	17	12	16	9.4	8.2	13	19	20
17	20	13	29	14	17	12	11	6.8	7.8	13	16	54
18	21	15	27	13	16	12	9.3	5.8	8.7	16	14	33
19	19	14	24	13	16	11	8.1	5.1	13	37	14	38
20	19	13	22	13	16	11	7.7	4.7	11	56	18	31
21	18	13	22	18	15	11	7.6	4.3	11	34	37	27
22	17	14	21	270	15	11	7.7	4.5	11	26	23	23
23	17	417	21	228	14	11	6.9	9.6	9.9	25	19	23
24	16	282	21	139	14	11	6.5	6.4	11	21	16	27
25	16	152	20	106	13	11	6.0	5.0	15	20	16	40
26	15	107	19	89	13	10	5.7	4.6	11	17	40	39
27	15	86	19	79	13	10	5.6	4.1	8.9	15	46	36
28	14	85	19	70	13	9.9	5.3	3.9	7.8	14	34	33
29	14	77	19	63	---	10	5.4	9.6	8.3	13	26	29
30	13	62	18	57	---	9.9	13	7.0	8.0	12	22	26
31	13	---	18	53	---	9.7	---	11	---	12	20	---
TOTAL	801	1639	937	1476	645	398.5	250.6	222.7	424.2	549.4	729.9	1151
MEAN	25.8	54.6	30.2	47.6	23.0	12.9	8.35	7.18	14.1	17.7	23.5	38.4
MAX	78	417	71	270	49	19	16	20	77	56	92	155
MIN	13	13	18	13	13	9.7	5.3	3.9	3.9	5.9	9.0	20
CFSM	.95	2.02	1.12	1.76	.85	.47	.31	.27	.52	.65	.87	1.42
IN.	1.10	2.25	1.29	2.03	.89	.55	.34	.31	.58	.75	1.00	1.58

CAL YR 1988 TOTAL 13692.6 MEAN 37.4 MAX 417 MIN 8.0 CFSM 1.38 IN. 18.80
WTR YR 1989 TOTAL 9224.3 MEAN 25.3 MAX 417 MIN 3.9 CFSM .93 IN. 12.66

ST. JOHNS RIVER

ST. JOHNS RIVER BASIN ABOVE OKLAWAHA RIVER

02233200 LITTLE ECONLOCKHATCHEE RIVER NEAR UNION PARK, FL

LOCATION.--Lat 28°31'29", long 81°14'39", in SW¼ sec.32, T.22 S., R.31 E., Orange County, Hydrologic Unit 03080101, near right bank at Berry-Deese Road, 3,300 ft upstream from a tributary, 3 mi south of Union Park, 8.5 mi east of Orlando, and 13 mi upstream from mouth.

DRAINAGE AREA.--27.1 mi^2.

PERIOD OF RECORD.--October 1959 to current year.

GAGE.--Water-stage recorder. Datum of gage is 56.19 ft above National Geodetic Vertical Datum of 1929. Prior to Jan 12, 1960, and Oct. 21, 1972 to Nov. 14, 1983, nonrecording gage at same site and datum.

REMARKS.--Records fair.

AVERAGE DISCHARGE.--31 years, 25.6 ft^3/s, 12.83 in/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 1,640 ft^3/s, Mar. 17, 1960, gage height, 11.64 ft; minimum, 0.10 ft^3/s, June 6,7, 1961; minimum gage height, 4.83 ft, May 14, 1967, May 6, 1971.

EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 200 ft^3/s and maximum (*):

Date	Time	Discharge (ft^3/s)	Gage height (ft)	Date	Time	Discharge (ft^3/s)	Gage height (ft)
Feb. 23	2400	*123	*7.81				

Minimum discharge, 2.7 ft^3/s, May 18,19, gage height, 5.07 ft.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	25	11	8.0	29	13	29	29	7.2	7.0	9.2	12	12
2	24	11	7.7	28	14	26	18	6.5	11	8.6	11	10
3	22	11	7.6	26	14	24	14	6.4	7.7	8.8	12	10
4	20	10	6.8	25	13	22	12	5.6	20	11	12	9.4
5	19	9.8	6.7	25	12	21	10	6.7	15	10	10	8.8
6	18	9.4	6.7	26	12	20	10	6.1	17	9.7	9.0	8.1
7	19	9.4	7.3	27	12	19	10	4.9	73	9.0	8.4	7.6
8	53	9.1	8.3	27	12	19	10	4.9	35	9.2	7.6	7.5
9	44	9.0	33	27	12	19	10	4.8	26	7.9	7.6	7.2
10	39	9.0	30	26	12	17	10	4.7	21	7.7	11	6.4
11	35	8.8	31	25	24	16	18	4.7	19	6.9	54	6.2
12	32	8.4	30	25	24	14	21	4.2	21	5.9	35	6.1
13	32	8.3	35	24	18	13	15	3.8	16	27	22	6.0
14	29	8.2	32	24	17	12	12	3.7	12	22	25	5.9
15	24	7.9	27	23	16	12	11	4.1	11	28	24	5.7
16	21	12	23	23	15	11	10	3.3	9.3	65	20	5.8
17	19	13	22	22	16	11	9.4	3.0	9.6	34	36	7.4
18	18	9.8	32	22	16	11	8.9	2.7	23	26	26	6.7
19	16	8.9	36	22	14	10	10	2.7	15	22	22	6.2
20	15	8.6	32	20	13	9.9	10	8.4	11	19	23	5.6
21	14	8.1	54	19	13	9.1	8.8	6.7	9.9	17	19	5.1
22	13	8.1	42	19	13	8.7	8.1	4.7	8.6	14	19	4.9
23	12	9.0	77	17	56	8.2	15	6.7	10	13	42	4.7
24	12	11	70	16	96	7.8	24	5.2	14	12	32	4.4
25	11	9.9	60	16	57	7.6	16	4.3	12	12	23	3.9
26	11	9.9	52	15	47	7.6	11	3.7	21	27	20	3.8
27	13	10	46	14	38	7.4	11	3.5	31	28	17	3.8
28	13	10	41	13	33	6.9	9.6	6.1	17	21	15	3.8
29	13	10	37	13	---	7.4	8.7	5.5	12	16	13	8.4
30	12	8.7	33	13	---	21	7.7	4.9	10	16	12	24
31	12	---	31	13	---	36	---	4.7	---	18	13	---
TOTAL	660	287.3	965.1	664	652	463.6	378.2	154.4	525.1	540.9	612.6	215.4
MEAN	21.3	9.58	31.1	21.4	23.3	15.0	12.6	4.98	17.5	17.4	19.8	7.18
MAX	53	13	77	29	96	36	29	8.4	73	65	54	24
MIN	11	7.9	6.7	13	12	6.9	7.7	2.7	7.0	5.9	7.6	3.8
CFSM	.79	.35	1.15	.79	.86	.55	.47	.18	.65	.64	.73	.26
IN.	.91	.39	1.32	.91	.89	.64	.52	.21	.72	.74	.84	.30

CAL YR 1989 TOTAL 7759.7 MEAN 21.3 MAX 270 MIN 3.9 CFSM .78 IN. 10.65
WTR YR 1990 TOTAL 6118.6 MEAN 16.8 MAX 96 MIN 2.7 CFSM .62 IN. 8.40

ST. JOHNS RIVER BASIN ABOVE OKLAWAHA RIVER

02233200 LITTLE ECONLOCKHATCHEE RIVER NEAR UNION PARK, FL

LOCATION.--Lat 28°31'29", long 81°14'39", in SW¼ sec.32, T.22 S., R.31 E., Orange County, Hydrologic Unit 03080101, near right bank at Berry-Deese Road, 3,300 ft upstream from a tributary, 3 mi south of Union Park, 8.5 mi east of Orlando, and 13 mi upstream from mouth.

DRAINAGE AREA.--27.1 mi^2.

PERIOD OF RECORD.--October 1959 to current year.

GAGE.--Water-stage recorder. Datum of gage is 56.19 ft above National Geodetic Vertical Datum of 1929. Prior to Jan 12, 1960, and Oct. 21, 1972 to Nov. 14, 1983, nonrecording gage at same site and datum.

REMARKS.--Estimated daily discharges: Feb. 5-10, June 19-22, Sept. 3-28. Records fair except for periods of estimated daily discharges, which are poor.

AVERAGE DISCHARGE.--32 years, 26.4 ft^3/s, 13.23 in/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 1,640 ft^3/s, Mar. 17, 1960, gage height, 11.64 ft; minimum, 0.10 ft^3/s, June 6,7, 1961; minimum gage height, 4.83 ft, May 14, 1967, May 6, 1971.

EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 200 ft^3/s and maximum (*):

Date	Time	Discharge (ft^3/s)	Gage height (ft)	Date	Time	Discharge (ft^3/s)	Gage height (ft)
Apr. 6	2400	322	8.59	July 13	1800	*786	*9.89
Apr. 24	0200	551	9.22	July 30	0200	513	9.19
May 27	0600	314	8.57	Aug. 4	0600	204	8.28
May 31	0400	232	8.31	Aug. 16	0100	214	8.32
July 2	1500	244	8.35				

Minimum discharge, 3.3 ft^3/s, all or part of each day, Jan. 13,14,15, gage height, 5.20 ft.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1990 TO SEPTEMBER 1991
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	17	5.2	6.2	5.3	11	3.8	34	52	159	83	190	70
2	11	5.9	6.0	4.9	9.7	3.8	20	61	193	212	194	67
3	8.7	7.2	5.6	5.3	9.9	5.6	16	49	130	167	166	64
4	7.9	9.0	5.4	5.8	9.6	13	14	38	99	137	194	60
5	7.7	8.4	5.4	5.5	9.2	8.3	14	32	81	120	147	58
6	7.5	7.2	5.0	4.9	8.3	7.3	194	28	79	106	119	56
7	6.6	6.1	5.6	4.6	7.7	5.4	220	26	98	85	98	53
8	7.6	5.6	14	4.3	7.0	4.7	101	24	98	72	84	50
9	7.0	5.3	12	4.2	6.4	7.0	64	21	83	61	74	45
10	21	7.4	8.8	3.9	5.4	14	81	19	67	60	74	48
11	23	7.1	8.3	3.9	5.2	9.4	60	18	58	85	70	52
12	15	5.9	7.4	3.8	4.6	7.0	42	17	51	111	82	50
13	11	5.4	6.6	3.6	4.6	7.4	33	17	47	495	191	48
14	8.6	5.2	6.0	3.3	5.1	6.9	28	26	45	547	172	46
15	7.6	5.0	5.7	5.0	10	6.8	24	19	44	421	138	44
16	7.5	5.1	5.6	21	6.8	6.9	22	34	44	311	178	42
17	6.5	5.5	5.4	13	5.0	17	22	64	42	234	117	41
18	6.2	5.6	5.5	8.6	4.9	94	43	45	40	252	91	41
19	6.0	5.8	5.6	6.8	4.9	94	31	61	46	154	76	40
20	6.0	6.4	5.8	6.2	4.7	47	44	64	45	116	69	38
21	7.8	6.6	6.2	5.8	4.5	40	64	62	43	98	65	38
22	9.6	6.7	6.1	5.4	4.5	28	43	54	40	85	60	38
23	17	7.0	6.0	4.7	4.5	22	120	65	39	71	56	37
24	14	7.0	5.8	4.3	4.3	19	444	109	37	69	60	35
25	10	6.9	5.6	5.7	4.1	17	242	145	38	74	78	33
26	7.9	6.3	5.3	7.0	4.8	16	201	134	51	78	93	32
27	6.8	6.1	5.3	5 9	4.4	14	137	283	109	96	90	31
28	6.1	6.9	5.9	5.5	3.8	13	100	205	112	101	78	30
29	5.7	6.6	7.3	5.5	---	13	76	131	82	274	70	29
30	5.4	6.4	6.4	5.4	---	14	62	109	65	405	77	29
31	5.3	---	6.0	5.5	---	21	---	205	---	226	74	---
TOTAL	295.0	190.8	201.8	184.6	174.9	586.3	2596	2217	2165	5406	3325	1345
MEAN	9.52	6.36	6.51	5.95	6.25	18.9	86.5	71.5	72.2	174	107	44.8
MAX	23	9.0	14	21	11	94	444	283	193	547	194	70
MIN	5.3	5.0	5.0	3.3	3.8	3.8	14	17	37	60	56	29
CFSM	.35	.23	.24	.22	.23	.70	3.19	2.64	2.66	6.43	3.96	1.65
IN.	.40	.26	.28	.25	.24	.80	3.56	3.04	2.97	7.42	4.56	1.85

CAL YR 1990 TOTAL 4893.8 MEAN 13.4 MAX 96 MIN 2.7 CFSM .49 IN. 6.72
WTR YR 1991 TOTAL 18687.4 MEAN 51.2 MAX 547 MIN 3.3 CFSM 1.89 IN. 25.65

ST. JOHNS RIVER

ST. JOHNS RIVER BASIN ABOVE OCKLAWAHA RIVER

02233200 LITTLE ECONLOCKHATCHEE RIVER NEAR UNION PARK, FL

LOCATION.--Lat 28°31'29", long 81°14'39", in SW¼ sec.32, T.22 S., R.31 E., Orange County, Hydrologic Unit 03080101, near right bank at Berry-Deese Road, 3,300 ft upstream from a tributary, 3 mi south of Union Park, 8.5 mi east of Altamonte Springs, and 13 mi upstream from mouth.

DRAINAGE AREA.--27.1 mi^2.

PERIOD OF RECORD.--October 1959 to current year.

GAGE.--Water-stage recorder. Datum of gage is 56.19 ft above National Geodetic Vertical Datum of 1929. Prior to Jan 12, 1960, and Oct. 21, 1972 to Nov. 14, 1983, nonrecording gage at same site and datum.

REMARKS.--Estimated daily discharges: Oct. 21 to Nov. 5, Nov. 13 to Jan. 22. Records fair except for periods of estimated daily discharges, which are poor.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1991 TO SEPTEMBER 1992
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	40	23	11	7.6	7.0	14	24	28	19	35	9.7	51
2	46	22	11	7.8	7.3	13	22	25	17	33	11	50
3	56	21	10	8.4	8.2	13	20	23	19	29	19	67
4	124	20	10	7.7	8.4	13	18	21	78	25	49	104
5	82	19	10	7.3	20	12	17	20	49	22	43	82
6	89	17	9.9	6.8	36	12	16	18	40	20	38	62
7	86	17	9.8	6.6	26	20	16	18	37	20	72	52
8	68	15	9.6	6.4	19	41	17	20	34	24	76	56
9	57	14	9.5	5.8	16	24	16	17	31	20	131	55
10	51	14	9.3	5.7	15	18	15	15	45	18	162	50
11	47	13	9.1	5.6	14	21	19	14	40	17	101	64
12	43	13	9.0	5.5	13	19	369	14	40	15	89	58
13	40	13	8.8	5.2	13	17	181	13	54	14	149	56
14	39	13	8.6	8.8	12	15	106	14	44	14	113	64
15	38	13	8.5	9.0	12	14	74	15	37	33	104	70
16	60	13	8.3	8.3	11	13	58	13	33	23	85	60
17	51	13	8.1	7.4	11	12	48	12	30	20	83	54
18	45	13	8.0	6.9	11	12	42	11	28	18	410	48
19	41	12	8.0	6.6	12	11	37	11	25	19	601	51
20	39	12	8.0	7.8	12	11	42	10	22	27	464	71
21	37	12	7.8	7.8	12	9.8	109	9.4	23	24	310	80
22	36	12	7.8	7.2	12	9.4	185	9.1	21	21	222	188
23	35	12	7.8	8.6	13	10	109	8.9	19	19	157	207
24	34	12	7.7	19	13	9.0	80	8.5	18	17	125	235
25	33	12	7.0	11	17	12	63	7.9	17	17	102	210
26	32	12	7.4	8.8	25	208	52	7.5	18	15	85	164
27	31	11	9.0	8.1	20	82	44	7.2	23	13	72	144
28	29	11	8.5	8.1	15	47	38	12	33	12	65	111
29	27	11	8.0	8.6	14	37	34	12	32	11	63	107
30	26	11	7.8	8.0	---	32	30	30	27	10	63	149
31	25	---	7.4	7.5	---	28	---	25	---	10	55	---
TOTAL	1487	426	270.7	243.9	424.9	809.2	1901	469.5	953	615	4128.7	2820
MEAN	48.0	14.2	8.73	7.87	14.7	26.1	63.4	15.1	31.8	19.8	133	94.0
MAX	124	23	11	19	36	208	369	30	78	35	601	235
MIN	25	11	7.0	5.2	7.0	9.0	15	7.2	17	10	9.7	48
CFSM	1.77	.52	.32	.29	.54	.96	2.34	.56	1.17	.73	4.91	3.47
IN.	2.04	.58	.37	.33	.58	1.11	2.61	.64	1.31	.84	5.67	3.87

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1960 - 1992, BY WATER YEAR (WY)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	27.0	18.6	14.9	19.8	22.9	27.2	17.8	10.1	23.8	38.5	50.0	57.8
MAX	114	129	52.9	82.2	69.6	193	86.5	71.5	137	174	133	171
(WY)	1970	1988	1970	1986	1983	1960	1991	1991	1968	1991	1992	1960
MIN	3.16	2.67	2.22	2.73	3.58	3.61	1.64	.69	1.14	5.29	5.94	4.12
(WY)	1971	1971	1961	1968	1968	1961	1961	1961	1962	1980	1980	1970

SUMMARY STATISTICS	FOR 1991 CALENDAR YEAR		FOR 1992 WATER YEAR		WATER YEARS 1960 - 1992	
ANNUAL TOTAL	20183.5		14548.9			
ANNUAL MEAN	55.3		39.8		27.4	
HIGHEST ANNUAL MEAN					56.0	1960
LOWEST ANNUAL MEAN					7.41	1971
HIGHEST DAILY MEAN	547	Jul 14	601	Aug 19	1570	Mar 17 1960
LOWEST DAILY MEAN	3.3	Jan 14	•5.2	Jan 13	.10	Jun 7 1961
ANNUAL SEVEN-DAY MINIMUM	3.9	Jan 8	5.8	Jan 7	.20	Jun 3 1961
INSTANTANEOUS PEAK FLOW			734	Aug 19	1640	Mar 17 1960
INSTANTANEOUS PEAK STAGE			9.74	Aug 19	11.64	Mar 17 1960
INSTANTANEOUS LOW FLOW			5.2	Jan 13	.10	Jun 6,7 1961
ANNUAL RUNOFF (CFSM)	2.04		1.47		1.01	
ANNUAL RUNOFF (INCHES)	27.71		19.97		13.72	
10 PERCENT EXCEEDS	130		85		61	
50 PERCENT EXCEEDS	34		19		13	
90 PERCENT EXCEEDS	5.4		8.0		3.2	

• Estimated

ST. JOHNS RIVER
ST. JOHNS RIVER BASIN ABOVE OCKLAWAHA RIVER
02233200 LITTLE ECONLOCKHATCHEE RIVER NEAR UNION PARK, FL

LOCATION.--Lat 28°31'29", long 81°14'39", in SW 1/4 sec.32, T.22 S., R.31 E., Orange County, Hydrologic Unit 03080101, near right bank at Berry-Deese Road, 3,300 ft upstream from a tributary, 3 mi south of Union Park, 8.5 mi east of Altamonte Springs, and 13 mi upstream from mouth.

DRAINAGE AREA.--27.1 mi².

PERIOD OF RECORD.--October 1959 to current year.

GAGE.--Water-stage recorder. Datum of gage is 56.19 ft above sea level. Prior to Jan 12, 1960, and Oct. 21, 1972 to Nov. 14, 1983, nonrecording gage at same site and datum.

REMARKS.--Records fair.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1992 TO SEPTEMBER 1993
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	122	32	33	17	47	27	51	14	20	19	18	79
2	98	31	31	16	44	26	50	14	16	18	16	72
3	249	30	29	16	40	24	39	13	29	17	16	64
4	432	30	27	16	38	46	35	13	19	16	16	50
5	315	30	26	17	36	38	37	18	16	15	15	41
6	195	32	25	16	33	31	37	16	14	15	14	41
7	230	30	24	16	33	28	31	14	12	15	13	113
8	205	28	24	17	32	27	35	13	11	14	12	359
9	153	28	23	29	29	25	35	12	10	13	11	199
10	120	27	30	25	32	23	28	12	9.5	26	11	130
11	132	26	33	24	31	19	23	11	8.8	44	12	106
12	153	26	28	39	42	16	19	11	14	36	11	123
13	120	26	25	32	35	89	17	10	39	29	10	93
14	97	25	23	29	30	77	16	9.7	49	29	10	74
15	82	23	23	55	28	59	15	9.1	28	36	19	62
16	71	22	23	116	25	49	29	8.9	20	39	17	50
17	65	22	22	107	22	47	23	8.7	17	46	15	44
18	60	22	22	80	25	69	18	8.3	14	45	12	39
19	54	22	22	65	25	52	16	8.0	13	37	11	35
20	49	24	22	56	23	44	15	7.7	12	30	9.9	32
21	46	26	21	49	22	44	14	7.3	11	43	25	31
22	44	26	20	44	26	46	14	6.8	10	74	20	28
23	44	27	20	41	45	41	20	6.4	12	75	19	24
24	47	55	20	39	33	98	20	6.4	11	53	16	22
25	45	78	18	36	30	108	19	6.3	11	47	28	20
26	42	69	18	64	33	85	18	6.2	28	37	47	23
27	40	50	18	101	36	62	17	5.9	30	34	32	38
28	38	44	19	88	30	48	16	6.0	21	28	50	29
29	37	39	19	71	---	40	15	9.6	19	24	55	24
30	34	36	18	60	---	35	15	41	19	22	103	21
31	33	---	17	52	---	31	---	33	---	20	76	---
TOTAL	3452	986	723	1433	905	1454	737	366.3	543.3	996	739.9	2066
MEAN	111	32.9	23.3	46.2	32.3	46.9	24.6	11.8	18.1	32.1	23.9	68.9
MAX	432	78	33	116	47	108	51	41	49	75	103	359
MIN	33	22	17	16	22	16	14	5.9	8.8	13	9.9	20
CFSM	4.11	1.21	.86	1.71	1.19	1.73	.91	.44	.67	1.19	.88	2.54
IN.	4.74	1.35	.99	1.97	1.24	2.00	1.01	.50	.75	1.37	1.02	2.84

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1960 - 1993, BY WATER YEAR (WY)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	29.5	19.0	15.2	20.6	23.2	27.7	18.0	10.1	23.7	38.3	49.2	58.1
MAX	114	129	52.9	82.2	69.6	193	86.5	71.5	137	174	133	171
(WY)	1970	1988	1970	1986	1983	1960	1991	1991	1968	1991	1992	1960
MIN	3.16	2.67	2.22	2.73	3.58	3.61	1.64	.69	1.14	5.29	5.94	4.12
(WY)	1971	1971	1961	1968	1968	1961	1961	1961	1962	1980	1980	1970

SUMMARY STATISTICS	FOR 1992 CALENDAR YEAR		FOR 1993 WATER YEAR		WATER YEARS 1960 - 1993	
ANNUAL TOTAL	17526.2		14401.5			
ANNUAL MEAN	47.9		39.5		27.7	
HIGHEST ANNUAL MEAN					56.0	1960
LOWEST ANNUAL MEAN					7.41	1971
HIGHEST DAILY MEAN	601	Aug 19	432	Oct 4	1570	Mar 17 1960
LOWEST DAILY MEAN	5.2	Jan 13	5.9	May 27	.10	Jun 7 1961
ANNUAL SEVEN-DAY MINIMUM	5.8	Jan 7	6.3	May 22	.20	Jun 3 1961
INSTANTANEOUS PEAK FLOW			488	Oct 4	1640	Mar 17 1960
INSTANTANEOUS PEAK STAGE			9.04	Oct 4	11.64	Mar 17 1960
INSTANTANEOUS LOW FLOW			5.7	May 27	.10	Jun 6,7 1961
ANNUAL RUNOFF (CFSM)	1.77		1.46		1.02	
ANNUAL RUNOFF (INCHES)	24.06		19.77		13.90	
10 PERCENT EXCEEDS	109		75		61	
50 PERCENT EXCEEDS	24		28		14	
90 PERCENT EXCEEDS	8.9		12		3.3	

ST. JOHNS RIVER

ST. JOHNS RIVER BASIN ABOVE OCKLAWAHA RIVER

02233200 LITTLE ECONLOCKHATCHEE RIVER NEAR UNION PARK, FL

LOCATION.--Lat 28°31'29", long 81°14'39", in SW$^1/_4$ sec.32, T.22 S., R.31 E., Orange County, Hydrologic Unit 03080101, near right bank at Berry-Deese Road, 3,300 ft upstream from a tributary, 3 mi south of Union Park, 8.5 mi east of Orlando, and 13 mi upstream from mouth.

DRAINAGE AREA.--27.1 mi^2.

PERIOD OF RECORD.--October 1959 to current year.

GAGE.--Water-stage recorder. Datum of gage is 56.19 ft above sea level. Prior to Jan 12, 1960, and Oct. 21, 1972 to Nov. 14, 1983, nonrecording gage at same site and datum.

REMARKS.--Records fair.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1993 TO SEPTEMBER 1994
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	19	26	13	10	30	27	10	15	11	27	54	67
2	19	23	13	13	25	50	10	12	10	54	45	95
3	18	22	13	19	23	58	9.4	12	9.5	55	43	75
4	16	21	13	18	21	45	9.1	13	8.7	79	46	62
5	16	20	13	14	19	38	8.7	12	8.7	57	37	62
6	18	19	12	13	19	32	8.5	10	27	49	66	52
7	19	18	12	12	19	29	8.2	9.2	34	129	192	45
8	17	17	12	12	18	27	8.0	8.4	69	90	154	42
9	17	18	12	12	17	26	7.9	7.6	89	64	137	73
10	21	18	12	11	16	28	7.6	7.4	58	51	187	76
11	19	18	12	11	15	24	7.4	7.2	42	42	138	67
12	17	17	11	11	22	22	7.1	6.7	51	35	127	59
13	15	16	11	12	84	20	7.7	6.4	41	30	135	117
14	14	16	11	32	48	19	7.0	6.5	38	30	158	208
15	16	16	11	21	36	18	7.5	6.2	40	46	149	151
16	34	15	11	17	30	17	7.3	5.7	41	40	144	129
17	27	15	11	15	28	16	6.6	6.6	162	33	112	188
18	23	16	11	44	55	15	6.1	9.5	355	29	99	125
19	20	16	10	39	69	15	6.1	7.0	172	38	138	143
20	18	15	10	28	62	14	10	11	114	30	104	234
21	17	15	11	24	53	14	11	7.3	91	34	82	166
22	20	14	11	21	46	14	43	6.0	73	38	69	123
23	58	15	11	19	42	13	23	5.4	65	28	67	98
24	46	15	11	18	42	13	17	5.1	56	24	72	85
25	38	15	15	17	43	12	14	4.9	46	35	101	175
26	34	15	14	17	37	12	15	4.7	39	40	120	435
27	31	15	12	17	32	12	17	4.5	35	57	146	331
28	28	15	11	17	29	11	15	4.4	30	72	140	219
29	25	14	12	16	---	12	13	8.9	28	76	118	160
30	23	13	11	19	---	14	13	25	28	63	90	130
31	28	---	10	44	---	12	---	12	---	65	71	---
TOTAL	731	508	363	593	980	679	341.2	267.6	1871.9	1540	3341	3992
MEAN	23.6	16.9	11.7	19.1	35.0	21.9	11.4	8.63	62.4	49.7	108	133
MAX	58	26	15	44	84	58	43	25	355	129	192	435
MIN	14	13	10	10	15	11	6.1	4.4	8.7	24	37	42
CFSM	.87	.62	.43	.71	1.29	.81	.42	.32	2.30	1.83	3.98	4.91
IN.	1.00	.70	.50	.81	1.35	.93	.47	.37	2.57	2.11	4.59	5.48

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1960 - 1994, BY WATER YEAR (WY)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	29.3	19.0	15.1	20.5	23.5	27.6	17.9	10.1	24.8	38.6	50.9	60.2
MAX	114	129	52.9	82.2	69.6	193	86.5	71.5	137	174	133	171
(WY)	1970	1988	1970	1986	1983	1960	1991	1991	1968	1991	1992	1960
MIN	3.16	2.67	2.22	2.73	3.58	3.61	1.64	.69	1.14	5.29	5.94	4.12
(WY)	1971	1971	1961	1968	1968	1961	1961	1961	1962	1980	1980	1970

SUMMARY STATISTICS	FOR 1993 CALENDAR YEAR		FOR 1994 WATER YEAR		WATER YEARS 1960 - 1994	
ANNUAL TOTAL	10842.5		15207.7			
ANNUAL MEAN	29.7		41.7		28.1	
HIGHEST ANNUAL MEAN					56.0	1960
LOWEST ANNUAL MEAN					7.41	1971
HIGHEST DAILY MEAN	359	Sep 8	435	Sep 26	1570	Mar 17 1960
LOWEST DAILY MEAN	5.9	May 27	4.4	May 28	.10	Jun 7 1961
ANNUAL SEVEN-DAY MINIMUM	6.3	May 22	5.0	May 22	.20	Jun 3 1961
INSTANTANEOUS PEAK FLOW			548	Jun 17	1640	Mar 17 1960
INSTANTANEOUS PEAK STAGE			9.21	Jun 17	11.64	Mar 17 1960
INSTANTANEOUS LOW FLOW			4.2	May 27	.1	Jun 6,7 1961
ANNUAL RUNOFF (CFSM)	1.10		1.54		1.04	
ANNUAL RUNOFF (INCHES)	14.88		20.88		14.10	
10 PERCENT EXCEEDS	55		113		62	
50 PERCENT EXCEEDS	20		19		14	
90 PERCENT EXCEEDS	11		8.8		3.3	

ST. JOHNS RIVER

ST. JOHNS RIVER BASIN ABOVE OKLAWAHA RIVER

02233001 ECONLOCKHATCHEE RIVER AT MAGNOLIA RANCH, NEAR BITHLO, FL

LOCATION.--Lat 28°25'27", long 81°07'10", in SE¼ sec.4, T.24 S., R.32 E., Orange County, Hydrologic Unit 03080101, near center of span on downstream side of bridge on Wewahootee Road, 250 ft downstream from Disston Canal, and 7 mi south of Bithlo.

DRAINAGE AREA.--32.9 mi^2.

PERIOD OF RECORD.--1960, 1964-67 (one discharge measurement each year), October 1972 to current year.

GAGE.--Water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929.

REMARKS.--Estimated daily discharges: Oct. 13-28. Records fair.

AVERAGE DISCHARGE.--16 years, 24.9 ft^3/s, 10.28 in/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 474 ft^3/s June 21,22, 1982, gage height, 62.58 ft; maximum gage height 63.42 ft, Mar. 31, 1987; no flow for many days in most years; river dry at gage for many days in most years.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 179 ft^3/s, Nov. 4, gage height, 62.22 ft; no flow many days, river dry at gage many days.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	29	16	142	24	38	12	36	.95	.19	.25	.00	65
2	45	19	132	23	36	11	32	1.5	.09	.21	.03	64
3	41	45	123	22	34	10	29	1.5	.02	.18	.54	55
4	34	150	114	22	32	9.7	26	1.1	.00	.10	.49	46
5	29	172	106	21	30	9.7	24	.69	.00	.02	.33	41
6	24	161	98	19	29	19	21	.42	.00	.07	1.6	41
7	20	156	91	18	29	24	18	.25	.04	.06	8.2	51
8	16	152	85	18	31	22	16	.17	2.9	.01	4.7	63
9	13	144	80	19	35	20	14	.13	7.2	.00	6.8	98
10	11	137	75	22	35	43	13	.10	7.6	.00	6.8	114
11	14	130	72	25	33	52	16	.06	5.2	.00	6.2	102
12	43	121	68	26	31	46	18	.03	3.2	.00	13	89
13	85	111	64	26	29	53	16	.01	1.8	.00	16	79
14	100	103	60	25	27	110	14	.01	1.1	.00	15	71
15	75	95	57	24	26	112	12	.01	9.3	.33	13	64
16	52	88	59	23	26	98	10	.00	19	.22	26	58
17	37	85	57	22	25	87	8.7	.00	13	.12	118	51
18	31	127	52	21	24	83	7.2	.00	7.7	.16	129	46
19	25	138	49	20	23	119	5.9	.00	4.7	.11	106	41
20	23	146	46	19	21	124	4.8	.00	3.1	.03	88	37
21	36	144	44	20	21	111	3.9	.00	2.6	.00	79	34
22	32	136	42	31	21	99	3.1	.00	3.2	.00	67	30
23	30	128	39	32	20	89	2.4	.00	3.5	.06	64	27
24	28	121	37	30	20	80	1.8	.00	3.0	.50	97	24
25	26	115	36	42	19	73	1.3	.00	1.8	.85	99	21
26	25	111	34	51	17	66	1.0	.62	.96	.38	86	19
27	23	154	32	50	16	59	.78	1.8	.83	.19	90	24
28	22	172	31	46	14	54	.52	1.6	1.3	.14	90	31
29	19	162	29	43	13	49	.34	1.0	.81	.08	83	27
30	17	151	27	41	---	45	.30	.63	.51	.04	76	23
31	15	---	25	40	---	40	---	.36	---	.00	68	---
TOTAL	1020	3690	2006	865	755	1829.4	357.04	12.94	104.65	4.11	1458.69	1536
MEAN	32.9	123	64.7	27.9	26.0	59.0	11.9	.42	3.49	.13	47.1	51.2
MAX	100	172	142	51	38	124	36	1.8	19	.85	129	114
MIN	11	16	25	18	13	9.7	.30	.00	.00	.00	.00	19
CFSM	1.00	3.74	1.97	.85	.79	1.79	.36	.01	.11	.00	1.43	1.56
IN.	1.15	4.17	2.27	.98	.85	2.07	.40	.01	.12	.00	1.65	1.74

CAL YR 1987 TOTAL 13852.37 MEAN 38.0 MAX 358 MIN .00 CFSM 1.15 IN. 15.66
WTR YR 1988 TOTAL 13638.83 ~~MEAN 37.3~~ MAX 172 MIN .00 CFSM 1.13 IN. 15.42

38.

ST. JOHNS RIVER

ST. JOHNS RIVER BASIN ABOVE OKLAWAHA RIVER

02233001 ECONLOCKHATCHEE RIVER AT MAGNOLIA RANCH, NEAR BITHLO, FL

LOCATION.--Lat 28°25'27", long 81°07'10", in SE¼ sec.4, T.24 S., R.32 E., Orange County, Hydrologic Unit 03080101, near center of span on downstream side of bridge on Wewahootee Road, 250 ft downstream from Disston Canal, and 7 mi south of Bithlo.

DRAINAGE AREA.--32.9 mi^2.

PERIOD OF RECORD.--1960, 1964-67 (one discharge measurement each year), October 1972 to current year.

GAGE.--Water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929.

REMARKS.--Estimated daily discharges: July 2-19. Records fair except for estimated daily discharges, which are poor.

AVERAGE DISCHARGE.--17 years, 24.9 ft^3/s, 10.28 in/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 474 ft^3/s June 21,22, 1982, gage height, 62.58 ft; maximum gage height 63.42 ft, Mar. 31, 1987; no flow for many days in most years; river dry at gage for many days in most years.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 217 ft^3/s, Aug. 22, gage height, 62.52 ft; no flow many days; river dry at gage many days.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1988 TO SEPTEMBER 1989
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	21	3.4	43	9.1	50	4.6	.48	.00	.00	.16	5.6	124
2	19	3.0	39	8.5	46	4.9	.32	.00	.00	.29	8.4	116
3	30	2.7	34	8.1	41	6.7	.22	.00	.00	.00	11	110
4	75	4.9	31	7.5	38	8.5	.59	.00	.00	.00	26	104
5	86	8.0	28	6.8	35	8.2	3.5	.00	.00	2.5	33	99
6	74	12	26	6.2	32	7.4	3.5	.00	.00	1.3	29	98
7	63	13	24	5.7	29	7.6	2.2	.00	.00	.74	22	94
8	55	12	23	5.3	27	10	1.3	.00	.00	.46	17	89
9	48	11	21	4.9	24	11	.83	.00	.00	.30	13	85
10	43	9.4	20	4.5	22	11	.53	.00	.00	.18	13	80
11	38	8.3	20	4.3	20	10	.35	.00	.00	.10	33	76
12	33	7.4	27	4.0	19	9.1	.26	.00	.00	.06	53	72
13	29	6.7	29	3.7	18	8.3	.19	.00	.00	.12	65	68
14	25	6.1	28	3.5	17	7.4	.14	.00	.00	.24	81	65
15	22	5.5	26	3.2	16	6.5	.54	.00	.00	.44	95	61
16	20	5.0	24	3.0	15	5.7	1.5	.00	.00	1.1	103	57
17	18	4.6	23	2.8	14	5.0	1.1	.00	.00	2.2	106	52
18	16	4.3	21	2.6	13	4.2	.73	.00	.00	4.0	113	49
19	15	3.9	19	2.3	12	3.6	.48	.00	.00	2.9	150	50
20	13	3.6	18	2.2	11	3.1	.32	.00	.00	2.2	169	50
21	12	3.3	17	4.4	10	2.7	.24	.00	.00	3.4	192	47
22	11	3.5	16	70	9.7	2.3	.20	.00	.00	4.0	212	43
23	9.5	60	16	106	9.0	2.1	.14	.00	.00	3.9	210	41
24	8.4	88	15	98	7.8	2.2	.07	.00	.00	3.1	205	42
25	7.5	82	14	89	6.9	2.2	.01	.00	.00	2.4	202	43
26	6.4	72	13	83	6.2	2.0	.00	.00	.00	1.5	199	45
27	5.6	64	12	78	5.5	1.7	.00	.00	.00	.98	187	44
28	4.9	59	12	72	5.1	1.3	.00	.00	.00	.75	172	42
29	4.3	53	11	67	---	.98	.00	.00	.00	.40	159	39
30	3.8	48	10	61	---	.80	.00	.00	.00	.22	147	37
31	3.6	---	9.8	56	---	.63	---	.00	---	.73	135	---
TOTAL	820.0	667.6	669.8	882.6	559.2	161.71	19.74	0.00	0.00	40.67	3166.0	2022
MEAN	26.5	22.3	21.6	28.5	20.0	5.22	.66	.00	.00	1.31	102	67.4
MAX	86	88	43	106	50	11	3.5	.00	.00	4.0	212	124
MIN	3.6	2.7	9.8	2.2	5.1	.63	.00	.00	.00	.00	5.6	37
CFSM	.80	.68	.66	.87	.61	.16	.02	.00	.00	.04	3.10	2.05
IN.	.93	.75	.76	1.00	.63	.18	.02	.00	.00	.05	3.58	2.29

CAL YR 1988 TOTAL 9080.23 MEAN 24.8 MAX 129 MIN .00 CFSM .75 IN. 10.27
WTR YR 1989 TOTAL 9009.32 MEAN 24.7 MAX 212 MIN .00 CFSM .75 IN. 10.19

ST. JOHNS RIVER

ST. JOHNS RIVER BASIN ABOVE OKLAWAHA RIVER

02233001 ECONLOCKHATCHEE RIVER AT MAGNOLIA RANCH, NEAR BITHLO, FL

LOCATION.--Lat 28°25'27", long 81°07'10", in SE¼ sec.4, T.24 S., R.32 E., Orange County, Hydrologic Unit 03080101, near center of span on downstream side of bridge on Wewahootee Road, 250 ft downstream from Disston Canal, and 7 mi south of Bithlo.

DRAINAGE AREA.--32.9 mi^2.

PERIOD OF RECORD.--1960, 1964-67 (one discharge measurement each year), October 1972 to current year.

GAGE.--Water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929.

REMARKS.--Estimated daily discharges: June 1-12. Records fair except for estimated daily discharges, which are poor.

AVERAGE DISCHARGE.--18 years, 24.2 ft^3/s, 9.99 in/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 474 ft^3/s, June 21,22, 1982, gage height, 62.58 ft; maximum gage height, 63.42 ft, Mar. 31, 1987; no flow for many days in most years; river dry at gage for many days in most years.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 91 ft^3/s, Oct. 13,14, gage height, 61.24 ft; no flow for many days; river dry at gage for many days.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	36	25	10	55	9.8	36	23	.32	.20	.45	.00	.00
2	34	23	9.4	50	9.5	34	17	.18	.00	1.8	.00	.00
3	31	21	8.6	45	8.8	33	13	.09	.04	1.3	.00	.00
4	28	20	7.8	42	8.4	31	9.6	.05	.01	.70	.00	.00
5	25	18	7.2	39	7.8	28	7.3	.00	.00	.36	.00	.00
6	23	17	6.7	37	7.2	26	5.6	.00	.01	.15	.00	.00
7	22	16	6.2	35	6.7	24	4.4	.00	.01	.05	.00	.00
8	28	15	7.0	33	6.3	22	3.4	.00	.90	.00	.00	.00
9	27	14	18	31	5.8	20	2.8	.00	.50	.00	.00	.00
10	23	13	23	29	5.6	18	2.3	.00	.35	.00	.00	.00
11	21	12	22	28	10	16	9.6	.00	.25	.00	.00	.00
12	27	11	20	26	14	15	11	.00	.17	.00	.00	.00
13	80	11	25	24	13	13	8.6	.00	.10	.00	.00	.00
14	88	9.7	26	22	13	12	6.2	.00	.01	.00	.00	.00
15	76	9.0	25	21	12	11	4.5	.00	.00	.08	.00	.00
16	66	12	23	20	11	9.8	3.4	.00	.00	.57	.00	.00
17	59	14	21	19	10	8.8	2.6	.00	.00	.33	.00	.00
18	54	14	26	18	9.1	7.8	2.0	.00	.00	.14	.00	.00
19	51	13	33	17	8.2	6.7	2.3	.00	.00	.05	.00	.00
20	46	12	40	16	7.6	5.8	2.2	.00	.00	.00	.00	.00
21	41	11	52	15	7.1	5.1	1.6	.00	.00	.00	.00	.00
22	36	10	56	14	6.9	4.4	1.1	.00	.00	.00	.00	.00
23	33	10	77	13	20	3.7	1.9	.00	.00	.00	.00	.00
24	29	11	86	13	42	3.2	3.2	.00	.00	.00	.00	.00
25	26	11	84	12	47	2.7	2.5	.00	.00	.00	.00	.00
26	25	11	81	11	43	2.2	1.8	.00	.00	.00	.00	.00
27	28	11	77	11	39	1.9	1.2	.00	.00	.00	.00	.00
28	30	12	74	10	37	1.6	.89	.00	.00	.00	.00	.00
29	29	11	70	9.7	---	1.8	.69	.00	.00	.00	.00	.00
30	28	11	65	9.4	---	12	.51	.00	.00	.00	.00	.00
31	26	---	60	9.6	---	23	---	.00	---	.00	.00	---
TOTAL	1176	408.7	1146.9	734.7	425.8	439.5	156.19	0.64	2.55	5.98	0.00	0.00
MEAN	37.9	13.6	37.0	23.7	15.2	14.2	5.21	.021	.085	.19	.000	.000
MAX	88	25	86	55	47	36	23	.32	.90	1.8	.00	.00
MIN	21	9.0	6.2	9.4	5.6	1.6	.51	.00	.00	.00	.00	.00
CFSM	1.15	.41	1.12	.72	.46	.43	.16	.00	.00	.01	.00	.00
IN.	1.33	.46	1.30	.83	.48	.50	.18	.00	.00	.01	.00	.00

CAL YR 1989 TOTAL 9583.52 MEAN 26.3 MAX 212 MIN .00 CFSM .80 IN. 10.84
WTR YR 1990 TOTAL 4496.96 MEAN 12.3 MAX 88 MIN .00 CFSM .37 IN. 5.08

ST. JOHNS RIVER

ST. JOHNS RIVER BASIN ABOVE OKLAWAHA RIVER

02233001 ECONLOCKHATCHEE RIVER AT MAGNOLIA RANCH, NEAR BITHLO, FL

LOCATION.--Lat 28°25'27", long 81°07'10", in SE¼ sec.4, T.24 S., R.32 E., Orange County, Hydrologic Unit 03080101, near center of span on downstream side of bridge on Wewahootee Road, 250 ft downstream from Disston Canal, and 7 mi south of Bithlo.

DRAINAGE AREA.--32.9 mi^2.

PERIOD OF RECORD.--1960, 1964-67 (one discharge measurement each year), October 1972 to current year.

GAGE.--Water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929.

REMARKS.--Records fair.

AVERAGE DISCHARGE.--19 years, 24.8 ft^3/s, 10.24 in/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 474 ft^3/s, June 21,22, 1982, gage height, 62.58 ft; maximum gage height, 63.42 ft, Mar. 31, 1987; no flow for many days in most years; river dry at gage for many days in most years.

EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 179 ft^3/s and maximum (*).

Date	Time	Discharge (ft^3/s)	Gage height (ft)	Date	Time	Discharge (ft^3/s)	Gage height (ft)
June 27	2200	*296	*63.01				
Aug. 28	2000	291	62.98				

No flow for many days; river dry at gage many days.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1990 TO SEPTEMBER 1991
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.00	.00	1.8	.31	.34	.00	6.7	22	44	176	126	235
2	.00	.00	2.1	.24	.44	.00	6.9	18	46	161	130	209
3	.00	.00	2.3	.20	.91	.00	5.9	15	44	147	120	186
4	.00	.00	2.2	.17	.87	1.6	4.9	11	42	132	108	174
5	.00	.00	2.0	.15	.68	2.0	4.4	8.7	41	124	97	159
6	.00	.00	1.7	.12	.52	1.9	7.2	6.4	44	136	90	141
7	.00	.00	1.6	.11	.39	1.8	8.5	4.6	45	136	84	124
8	.00	.00	3.0	.15	.30	1.6	8.0	3.5	44	127	75	111
9	.00	.00	3.7	.15	.21	1.8	6.3	2.7	40	120	70	105
10	.00	.00	3.3	.15	.16	2.2	4.8	2.2	36	122	68	97
11	.00	.00	2.7	.14	.12	2.1	3.6	1.7	32	123	61	89
12	.00	.00	2.3	.13	.09	1.8	2.8	1.2	28	119	55	80
13	.00	.00	2.1	.09	.07	1.5	2.1	.89	24	129	59	72
14	.00	.00	1.9	.04	.06	1.3	1.6	1.1	20	123	64	65
15	.00	.00	1.7	.06	.05	1.2	1.2	3.2	17	114	60	58
16	.00	.00	1.6	.69	.00	1.3	.93	10	16	111	53	53
17	.00	.00	1.4	1.1	.00	3.1	.78	20	17	107	46	48
18	.00	.00	1.3	1.0	.00	13	1.3	20	22	101	41	44
19	.00	.78	1.2	.90	.00	22	1.3	17	28	92	37	43
20	.00	1.2	1.1	1.1	.00	23	2.5	15	65	85	35	44
21	.00	1.3	1.0	.98	.00	19	3.8	15	90	92	33	44
22	.00	1.3	.92	.80	.00	14	3.2	16	120	85	30	45
23	.00	1.5	.81	.61	.00	11	9.0	19	126	74	31	45
24	.00	1.5	.67	.49	.00	9.1	43	24	122	68	44	42
25	.00	1.6	.48	.45	.00	7.4	53	33	137	66	81	39
26	.00	1.6	.35	.50	.00	6.0	50	39	251	64	189	38
27	.00	1.5	.30	.52	.00	4.9	43	49	265	63	231	36
28	.00	1.4	.42	.56	.00	3.9	37	57	284	76	275	33
29	.00	1.3	.70	.53	---	3.2	31	55	238	87	289	33
30	.00	1.3	.56	.46	---	2.8	27	50	201	101	273	39
31	.00	---	.43	.37	---	4.1	---	46	---	114	255	---
TOTAL	0.00	16.28	47.64	13.27	5.21	168.60	381.71	587.19	2529	3375	3210	2531
MEAN	.000	.54	1.54	.43	.19	5.44	12.7	18.9	84.3	109	104	84.4
MAX	.00	1.6	3.7	1.1	.91	23	53	57	284	176	289	235
MIN	.00	.00	.30	.04	.00	.00	.78	.89	16	63	30	33
CFSM	.00	.02	.05	.01	.01	.17	.39	.58	2.56	3.31	3.15	2.56
IN.	.00	.02	.05	.02	.01	.19	.43	.66	2.86	3.82	3.63	2.86

CAL YR 1990 TOTAL 1829.28 MEAN 5.01 MAX 55 MIN .00 CFSM .15 IN. 2.07
WTR YR 1991 TOTAL 12864.90 MEAN 35.2 MAX 289 MIN .00 CFSM 1.07 IN. 14.55

ST. JOHNS RIVER BASIN ABOVE OCKLAWAHA RIVER

02233001 ECONLOCKHATCHEE RIVER AT MAGNOLIA RANCH, NEAR BITHLO, FL

LOCATION.--Lat 28°25'27", long 81°07'10", in SE¼ sec.4, T.24 S., R.32 E., Orange County, Hydrologic Unit 03080101, near center of span on downstream side of bridge on Wewahootee Road, 250 ft downstream from Disston Canal, and 7 mi south of Bithlo.

DRAINAGE AREA.--32.9 mi².

PERIOD OF RECORD.--1960, 1964-67 (one discharge measurement each year), October 1972 to current year.

GAGE.--Water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929.

REMARKS.--Records fair.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1991 TO SEPTEMBER 1992
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	44	35	7.4	3.0	1.4	2.6	2.1	9.1	9.6	108	3.6	76
2	51	33	7.3	3.3	1.2	2.3	1.7	7.4	6.2	115	5.1	75
3	63	31	7.1	3.7	1.0	2.1	1.4	6.0	6.7	107	19	72
4	74	29	7.4	3.5	.95	1.8	1.2	4.7	8.3	92	26	72
5	80	27	7.5	3.1	2.1	1.7	.94	4.6	8.4	77	28	73
6	94	26	7.2	2.8	3.7	1.6	.77	4.2	7.4	65	68	67
7	116	24	7.1	2.6	3.6	3.3	.65	3.5	7.4	60	152	60
8	126	23	6.7	2.3	3.1	5.8	.56	3.1	7.4	60	171	54
9	133	21	6.3	2.2	2.6	5.4	.49	2.5	7.7	54	168	54
10	140	20	6.0	2.1	2.4	4.1	.40	2.0	8.4	50	185	56
11	138	19	5.6	2.0	2.3	3.9	.34	1.5	9.2	44	216	62
12	129	18	5.3	1.9	2.3	3.8	13	1.2	12	38	233	111
13	119	17	5.2	1.6	2.2	3.5	21	.94	15	32	288	117
14	109	15	5.2	2.3	2.2	3.1	21	.86	22	28	284	129
15	100	15	4.9	2.8	2.0	2.7	19	.86	25	24	267	136
16	94	14	4.4	2.4	1.9	2.3	16	.68	25	20	245	129
17	86	14	3.9	2.1	1.8	1.9	14	.56	22	17	229	122
18	77	13	3.7	1.8	1.7	1.6	12	.48	20	14	234	118
19	70	13	3.5	1.7	1.6	1.4	10	.36	16	12	297	109
20	64	12	3.2	2.2	1.4	1.2	9.7	.32	15	15	280	102
21	59	12	3.1	2.2	1.2	.96	14	.24	17	20	247	96
22	54	11	3.0	2.0	1.1	.81	25	.12	14	23	216	90
23	49	11	2.8	2.3	1.1	.81	31	.02	11	22	190	85
24	46	10	2.8	2.9	1.3	.72	32	.00	10	20	180	82
25	44	9.2	2.7	2.4	2.5	1.4	28	.00	8.8	16	159	77
26	42	8.5	2.8	2.0	5.2	11	24	.00	11	13	137	73
27	41	8.2	6.4	1.8	5.3	11	19	.00	24	10	121	70
28	42	8.0	5.0	1.7	4.1	7.1	16	.00	44	7.8	106	67
29	42	7.7	4.0	1.7	3.2	4.1	13	.06	46	6.0	96	75
30	40	7.5	3.5	1.7	---	3.1	11	8.2	48	4.7	89	93
31	37	---	3.2	1.6	---	2.6	---	15	---	4.1	82	---
TOTAL	2403	512.1	154.2	71.7	66.45	99.70	359.25	78.50	492.5	1178.6	5021.7	2602
MEAN	77.5	17.1	4.97	2.31	2.29	3.22	12.0	2.53	16.4	38.0	162	86.7
MAX	140	35	7.5	3.7	5.3	11	32	15	48	115	297	136
MIN	37	7.5	2.7	1.6	.95	.72	.34	.00	6.2	4.1	3.6	54
CFSM	2.36	.52	.15	.07	.07	.10	.36	.08	.50	1.16	4.92	2.64
IN.	2.72	.58	.17	.08	.08	.11	.41	.09	.56	1.33	5.68	2.94

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1973 - 1992, BY WATER YEAR (WY)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	34.5	15.9	13.1	18.8	17.2	17.3	18.9	5.19	18.4	29.8	46.8	55.8
MAX	142	123	64.7	80.3	80.9	91.7	91.7	23.7	181	109	162	168
(WY)	1980	1988	1988	1986	1983	1983	1983	1982	1982	1991	1992	1979
MIN	.000	.034	.12	.088	.027	.000	.000	.000	.000	.000	.000	.000
(WY)	1981	1981	1981	1985	1976	1975	1975	1975	1977	1981	1981	1980

SUMMARY STATISTICS	FOR 1991 CALENDAR YEAR		FOR 1992 WATER YEAR		WATER YEARS 1973 - 1992	
ANNUAL TOTAL	15870.28		13039.70			
ANNUAL MEAN	43.5		35.6		24.3	
HIGHEST ANNUAL MEAN					49.5	1983
LOWEST ANNUAL MEAN					.60	1981
HIGHEST DAILY MEAN	289	Aug 29	297	Aug 19	471	Jun 21 1982
LOWEST DAILY MEAN	.00	Feb 16	.00	May 24-28	.00	Many days
ANNUAL SEVEN-DAY MINIMUM	.00	Feb 16	.01	May 23	.00	Many days
INSTANTANEOUS PEAK FLOW			303	Aug 19	474	Jun 21 1982
INSTANTANEOUS PEAK STAGE			63.04	Aug 19	63.42	Mar 31 1987
ANNUAL RUNOFF (CFSM)	1.32		1.08		.74	
ANNUAL RUNOFF (INCHES)	17.94		14.74		10.05	
10 PERCENT EXCEEDS	123		110		71	
50 PERCENT EXCEEDS	19		9.2		7.1	
90 PERCENT EXCEEDS	.23		1.2		.00	

ST. JOHNS RIVER BASIN ABOVE OCKLAWAHA RIVER

02233001 ECONLOCKHATCHEE RIVER AT MAGNOLIA RANCH, NEAR BITHLO, FL

LOCATION.--Lat 28°25'27", long 81°07'10", in SE$^1/_4$ sec.4, T.24 S., R.32 E., Orange County, Hydrologic Unit 03080101, near center of span on downstream side of bridge on Wewahootee Road, 250 ft downstream from Disston Canal, and 7 mi south of Bithlo.

DRAINAGE AREA.--32.9 mi^2.

PERIOD OF RECORD.--1960, 1964-67 (one discharge measurement each year), October 1972 to current year.

GAGE.--Water-stage recorder. Datum of gage is at sea level.

REMARKS.--Records fair.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1992 TO SEPTEMBER 1993
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	86	32	63	19	99	39	72	9.3	17	.79	.00	18
2	83	30	60	19	93	37	78	8.2	11	.69	.00	18
3	114	27	58	19	88	36	76	7.2	9.5	.49	.00	16
4	140	26	55	20	83	40	72	6.4	7.4	.27	.00	12
5	143	24	52	21	78	41	71	5.6	5.3	.46	.00	12
6	140	23	49	21	74	41	68	4.8	3.6	.63	.00	58
7	171	21	46	21	70	39	65	4.0	2.4	.37	.00	83
8	167	20	44	21	66	37	61	3.2	1.8	.31	.00	131
9	156	19	41	26	62	35	57	2.7	1.4	.43	.00	153
10	146	18	43	29	60	33	54	2.5	1.1	.87	.00	160
11	149	17	45	33	58	30	50	2.0	.86	1.6	.00	171
12	156	16	44	42	59	28	46	1.6	.68	1.8	.00	184
13	141	16	41	43	57	60	42	1.3	.58	1.4	.00	186
14	125	16	39	44	53	72	39	1.0	.58	2.1	.00	179
15	111	15	38	49	49	74	36	.73	.65	3.1	.00	168
16	100	14	36	67	45	72	38	.55	.87	2.8	.00	154
17	93	13	34	82	43	69	38	.38	2.6	1.9	.00	139
18	86	13	33	85	43	67	36	.16	1.7	1.1	.00	126
19	80	13	31	85	43	65	34	.07	.87	.57	.00	118
20	73	13	29	85	41	63	31	.00	.38	.24	.00	109
21	68	13	27	83	39	64	29	.00	.07	3.4	.00	99
22	63	14	25	80	41	64	26	.00	.00	6.9	.00	90
23	59	19	24	77	48	68	23	.00	.00	4.4	.00	82
24	56	47	23	73	45	130	21	.00	.00	2.6	.00	74
25	53	67	22	70	41	107	19	.00	.00	1.4	.00	68
26	50	70	21	82	41	94	17	.00	.02	.64	.00	62
27	47	69	20	102	42	86	15	.00	.32	.34	.00	60
28	43	69	20	109	41	78	14	.00	.49	.07	.00	60
29	40	68	20	110	---	72	12	.00	.73	.00	.00	58
30	37	66	20	107	---	66	10	8.3	.83	.00	.01	52
31	35	---	19	103	---	61	---	17	---	.00	11	---
TOTAL	3011	888	1122	1827	1602	1868	1250	86.99	72.73	41.67	11.01	2900
MEAN	97.1	29.6	36.2	58.9	57.2	60.3	41.7	2.81	2.42	1.34	.36	96.7
MAX	171	70	63	110	99	130	78	17	17	6.9	11	186
MIN	35	13	19	19	39	28	10	.00	.00	.00	.00	12
CFSM	2.95	.90	1.10	1.79	1.74	1.83	1.27	.09	.07	.04	.01	2.94
IN.	3.40	1.00	1.27	2.07	1.81	2.11	1.41	.10	.08	.05	.01	3.28

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1973 - 1993, BY WATER YEAR (WY)

MEAN	37.5	16.5	14.2	20.8	19.1	19.3	19.9	5.07	17.6	28.4	44.6	57.7
MAX	142	123	64.7	80.3	80.9	91.7	91.7	23.7	181	109	162	168
(WY)	1980	1988	1988	1986	1983	1983	1983	1982	1982	1991	1992	1979
MIN	.000	.034	.12	.088	.027	.000	.000	.000	.000	.000	.000	.000
(WY)	1981	1981	1981	1985	1976	1975	1975	1975	1977	1981	1981	1980

SUMMARY STATISTICS	FOR 1992 CALENDAR YEAR		FOR 1993 WATER YEAR		WATER YEARS 1973 - 1993	
ANNUAL TOTAL	14991.40		14680.40			
ANNUAL MEAN	41.0		40.2		25.1	
HIGHEST ANNUAL MEAN					49.5	1983
LOWEST ANNUAL MEAN					.60	1981
HIGHEST DAILY MEAN	297	Aug 19	186	Sep 13	471	Jun 21 1982
LOWEST DAILY MEAN	.00	May 24	.00	Many days	.00	Many days
ANNUAL SEVEN-DAY MINIMUM	.01	May 23	.00	Many days	.00	Many days
INSTANTANEOUS PEAK FLOW			187	Sep 13	474	Jun 21 1982
INSTANTANEOUS PEAK STAGE			62.22	Sep 13	63.42	Mar 31 1987
ANNUAL RUNOFF (CFSM)	1.24		1.22		.76	
ANNUAL RUNOFF (INCHES)	16.95		16.60		10.36	
10 PERCENT EXCEEDS	119		96		73	
50 PERCENT EXCEEDS	16		30		7.5	
90 PERCENT EXCEEDS	1.2		.00		.00	

02233001 ECONLOCKHATCHEE RIVER AT MAGNOLIA RANCH, NEAR BITHLO, FL

LOCATION.--Lat 28°25'27", long 81°07'10", in SE$^1/_4$ sec.4, T.24 S., R.32 E., Orange County, Hydrologic Unit 03080101, near center of span on downstream side of bridge on Wewahootee Road, 250 ft downstream from Disston Canal, and 7 mi south of Bithlo.

DRAINAGE AREA.--32.9 mi^2.

PERIOD OF RECORD.--1960, 1964-67 (one discharge measurement each year), October 1972 to current year.

GAGE.--Water-stage recorder. Datum of gage is at sea level.

REMARKS.--Records fair, except for period of estimated daily discharge, which is poor.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1993 TO SEPTEMBER 1994
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	47	39	5.3	1.4	48	60	5.1	.36	.00	47	24	56
2	42	35	4.8	1.9	46	65	4.2	.12	.00	45	22	51
3	39	32	4.4	3.5	42	75	2.8	.00	.00	44	20	46
4	35	28	4.1	8.9	39	75	1.9	.00	.00	42	19	42
5	31	25	3.8	12	36	74	e1.0	.00	.00	40	19	38
6	29	23	3.4	10	34	73	e.70	.00	.00	38	22	34
7	27	21	3.2	9.6	31	69	e.50	.00	1.2	42	30	30
8	25	19	2.9	8.9	29	63	e.34	.00	29	43	31	36
9	26	18	2.6	8.1	26	59	e.20	.00	51	49	31	40
10	27	17	2.5	7.3	22	54	e.10	.00	68	45	31	35
11	27	16	2.4	6.7	21	49	e.00	.00	79	39	35	33
12	24	15	2.4	6.7	20	44	e.00	.00	84	35	45	34
13	21	14	2.2	6.7	23	39	e.00	.00	88	32	51	56
14	18	13	2.0	11	24	36	e.00	.00	99	32	57	84
15	17	12	1.9	12	21	33	.00	.00	88	27	63	81
16	22	11	1.6	11	21	30	.00	.00	84	24	63	84
17	39	11	1.4	9.9	20	24	.00	.00	100	23	66	98
18	44	10	1.3	20	46	21	.00	.00	110	22	67	97
19	43	9.5	.97	30	78	20	.00	.00	99	20	64	92
20	42	9.1	1.0	28	93	18	.00	.00	94	18	61	95
21	41	8.6	.89	24	93	17	.00	.00	94	19	57	125
22	40	8.1	.99	21	90	16	.31	.00	96	19	54	153
23	45	7.6	1.0	20	87	14	.67	.00	98	18	53	167
24	49	7.2	.98	18	82	14	2.5	.00	92	16	53	172
25	56	7.3	1.8	17	81	14	3.1	.00	84	16	50	183
26	60	7.6	2.2	15	76	12	2.2	.00	77	18	52	220
27	59	7.6	2.2	14	70	11	1.6	.00	70	19	58	214
28	56	7.1	1.8	14	63	8.8	1.3	.00	62	17	59	201
29	51	6.5	1.7	12	---	7.6	.82	.00	56	18	61	186
30	45	5.8	1.6	14	---	6.9	.50	.00	52	22	62	172
31	42	---	1.5	39	---	6.0	---	.00	---	26	59	---
TOTAL	1169	451.0	70.83	421.6	1362	1108.3	29.84	0.48	1845.20	915	1439	2955
MEAN	37.7	15.0	2.28	13.6	48.6	35.8	.99	.015	61.5	29.5	46.4	98.5
MAX	60	39	5.3	39	93	75	5.1	.36	110	49	67	220
MIN	17	5.8	.89	1.4	20	6.0	.00	.00	.00	16	19	30
CFSM	1.15	.46	.07	.41	1.48	1.09	.03	.00	1.87	.90	1.41	2.99
IN.	1.32	.51	.08	.48	1.54	1.25	.03	.00	2.09	1.03	1.63	3.34

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1973 - 1994, BY WATER YEAR (WY)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	37.5	16.5	13.6	20.4	20.5	20.1	19.1	4.84	19.6	28.5	44.7	59.6
MAX	142	123	64.7	80.3	80.9	91.7	91.7	23.7	181	109	162	168
(WY)	1980	1988	1988	1986	1983	1983	1983	1982	1982	1991	1992	1979
MIN	.000	.034	.12	.088	.027	.000	.000	.000	.000	.000	.000	.000
(WY)	1981	1981	1981	1985	1976	1975	1975	1975	1977	1981	1981	1980

SUMMARY STATISTICS	FOR 1993 CALENDAR YEAR		FOR 1994 WATER YEAR		WATER YEARS 1973 - 1994	
ANNUAL TOTAL	11350.23		11767.25			
ANNUAL MEAN	31.1		32.2		25.4	
HIGHEST ANNUAL MEAN					49.5	1983
LOWEST ANNUAL MEAN					.60	1981
HIGHEST DAILY MEAN	186	Sep 13	220	Sep 26	471	Jun 21 1982
LOWEST DAILY MEAN	.00	May 20	.00	Many days	.00	Many days
ANNUAL SEVEN-DAY MINIMUM	.00	May 20	.00	Many days	.00	Many days
INSTANTANEOUS PEAK FLOW			222	Sep 26	474	Jun 21 1982
INSTANTANEOUS PEAK STAGE			62.49	Sep 26	63.42	Mar 31 1987
ANNUAL RUNOFF (CFSM)	.95		.98		.77	
ANNUAL RUNOFF (INCHES)	12.83		13.31		10.49	
10 PERCENT EXCEEDS	81		81		74	
50 PERCENT EXCEEDS	17		21		8.0	
90 PERCENT EXCEEDS	.00		.00		.00	

e Estimated

UNIVERSITY OF CENTRAL FLORIDA
CIVIL AND ENVIRONMENTAL ENGINEERING

STORMWATER MANAGEMENT

by
Marty Wanielista

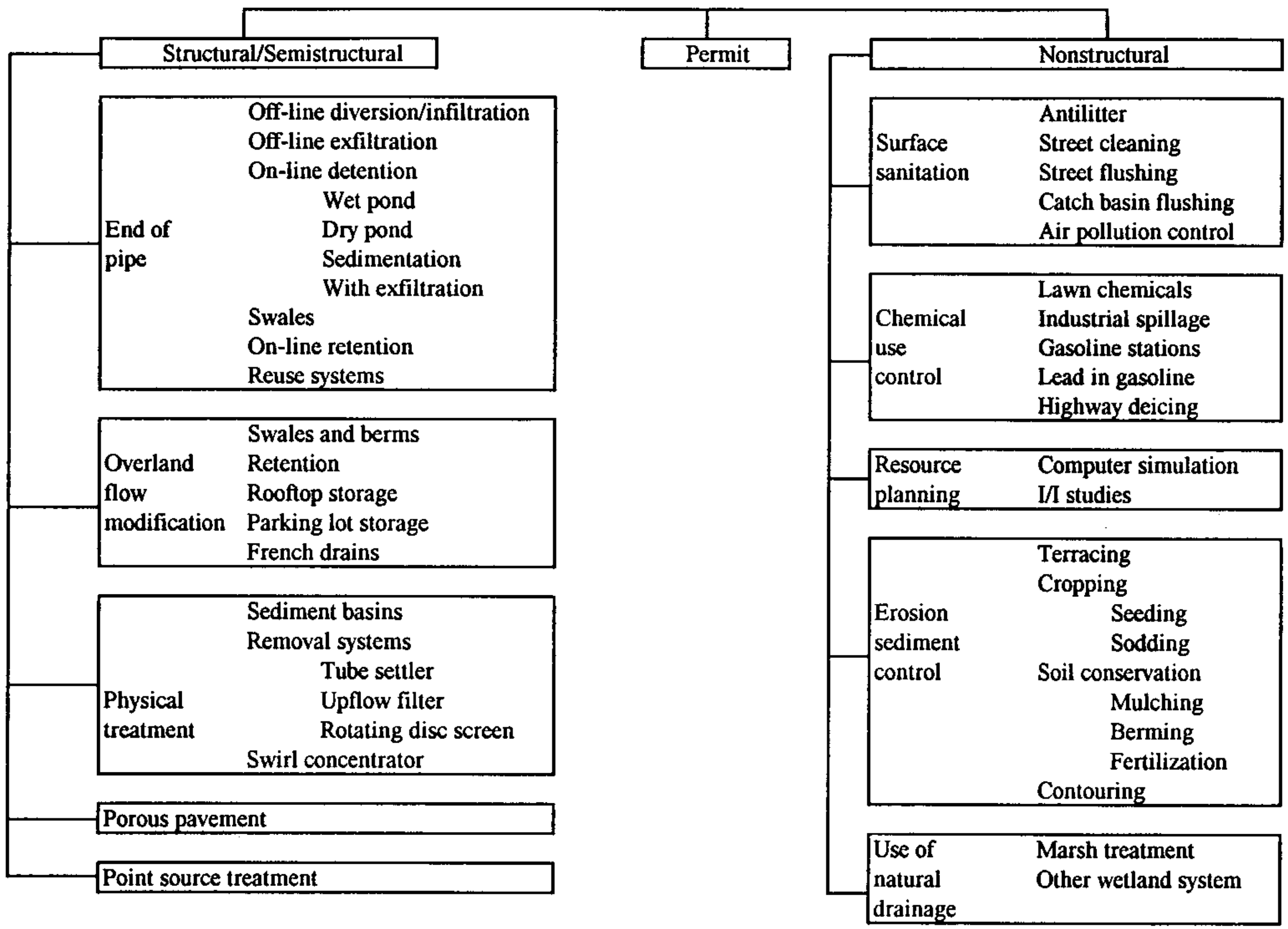
CLASSIFICATION OF TREATMENT SYSTEMS

There are three classifications for stormwater treatment systems as used for water quality improvement; namely, structural, nonstructural, and permit. The structural alternatives are ones that result in some physical alteration of the drainage, such as, detention ponds, ditches, and reuse systems. Nonstructural refers to ones that do not alter existing or natural drainage, such as, antilitter laws, and reduced chemical lawn care. The last and generally the most expensive is a permit to discharge. The permit usually results in large construction projects and is required when the public interest can not be served by other means. A listing of water quality management practices that improve water quality are shown in Figure 1.

STORMWATER MANAGEMENT IN THE STATE

Significant improvements in stormwater management practices have been developed in the State. Facts about the stormwater problem and management of it are attached in a publication by the author of this presentation.

Figure 1 Water Quality Management Practices



United States Environmental Protection Agency
Watershed Management Unit
Water Division, Region V
Chicago, IL
December 1990

EPA

Facts About Stormwater Management Programs in the State of Florida

The Stormwater Problem

Stormwater is that surface and ground water resulting from precipitation. In developed areas, surface water runoff is the major component of sewer and stream flows. The percentage of impervious areas that are directly connected to a sewer or other water conveyance system determine the major portion of the volume and rate of discharge.

As an area becomes more urbanized, the peak rate of discharge, volume of discharge, and pollutant mass discharge increases. These effects are caused in part by modifications to surface drainage patterns, increased impervious areas (less infiltration and depression storage), and increased human and vehicle traffic. Human activities add pesticides, fertilizers, animal wastes, oil, grease, solids, heavy metals, and other potential pollutants to the stormwaters.

The increased urbanization and many existing drainage practices in rural lands have caused flooding, erosion, and water quality degradation. In Florida, stormwater is the largest source of pollutants to lakes, rivers, and estuaries. In many lakes, it is the only major source of pollutants. On a statewide basis, stormwater as compared to regulated discharges (sewage and industrial treatment facilities) is the source of: (1) 80 to 95 percent of heavy metals; (2) 99 percent of all sediment; (3) 90 percent of oxygen demanding substances; and (4) 50 percent of the nutrients. Thus, severe environmental and economic impacts result when stormwaters are not managed.

Stormwater Management Defined

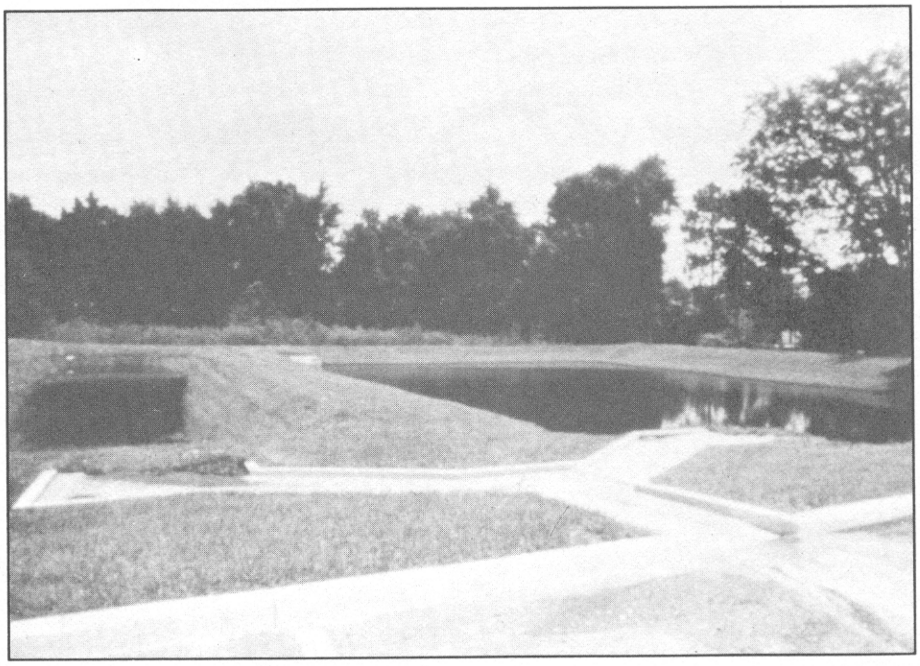
Stormwater management is a comprehensive, interdisciplinary body of knowledge required to design and operate stormwater programs to prevent flooding, reduce land loss due to erosion, maintain water quality, increase water availability, and provide funding sources. A stormwater program must have goals and objectives that are implemented using a stormwater rule that specifies levels of performance. The minimum levels of performance in Florida are based on pre- versus post-peak discharge and 80 percent removal of pollutants. Stormwater management practices have been developed to meet these performance standards.

Stormwater Management Practices

For a stormwater management practice to be successful, it must satisfy water quality and quantity considerations and have the necessary funding to be constructed and operated. There are at least five stormwater management practices that are now used in the State of Florida, namely (1) off-line retention by infiltration ponds and exfiltration trenches; (2) wet-detention ponds; (3) swales that both infiltrate and transport; (4) porous parking areas; and (5) alum injection.

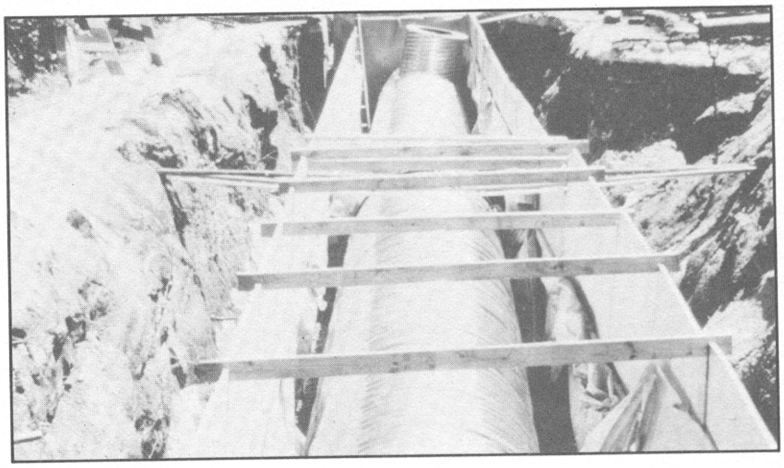
Retention Using Infiltration Ponds

In infiltration pond is one that retains stormwater on-site in a surface pond. The soils beneath the pond must be capable of percolating the infiltrated water, and as such, the water table is usually below the bottom of the pond. The pond is designed to store a specific runoff volume. This volume is determined from an analysis of storm events with their rainfall volume (Wanielista, 1990). In the State of Florida, these rainfall analyses have defined the design criteria for pond volume as the runoff from the first inch of rainfall with a minimum of 1/2 inch over the watershed. The objective for sizing is to remove 80 percent of the runoff mass. The practice incorporates both pollution control and ground water recharge; however, the impact of soluble pollutants on ground water must be carefully considered. The practice is used throughout the State where soils permit infiltration rates of at least 3-5 inches an hour. The infiltration pond is sized for the runoff from the first inch of rainfall; thus, additional runoff is diverted to direct surface water discharge or into a detention pond for peak discharge control.



Retention Using Exfiltration Trenches

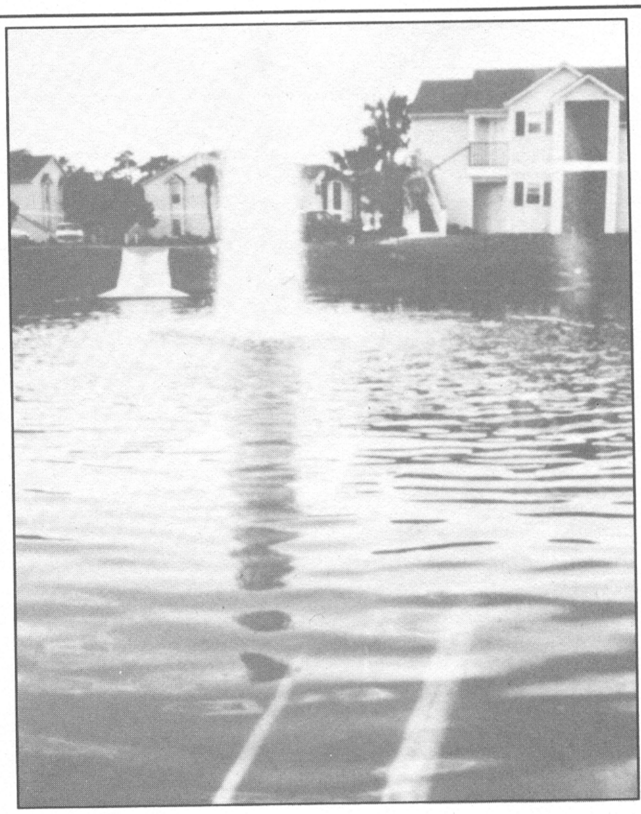
While infiltration ponds are constructed on the surface, exfiltration trenches are subsurface holding areas. They are also referred to as exfiltration pipes or pits. Highly permeable rock (i.e., limestone) or soils (sandy) must be present. The most common construction practice is an excavation trench backfilled with coarse graded rock. Runoff is diverted to the exfiltration system. The system often includes perforated pipe surrounded by aggregate and a filter cloth. The pipe will increase the storage volume, since the rock aggregate has a porosity of about one-half or less that of the pipe. The design volume is calculated as the runoff from the first inch of rainfall, and a diversion structure or inlet control can be used to regulate runoff volumes greater than the design volume.



Exfiltration trenches with pipes, fabric wrap and rock are being used in central Florida. From these operating systems, it was concluded that the treatment volume should not be placed in the water table. In southern Florida, the pipe is frequently not used; however, the systems must be maintained to remove debris. Maintenance will vary directly with the amount of debris.

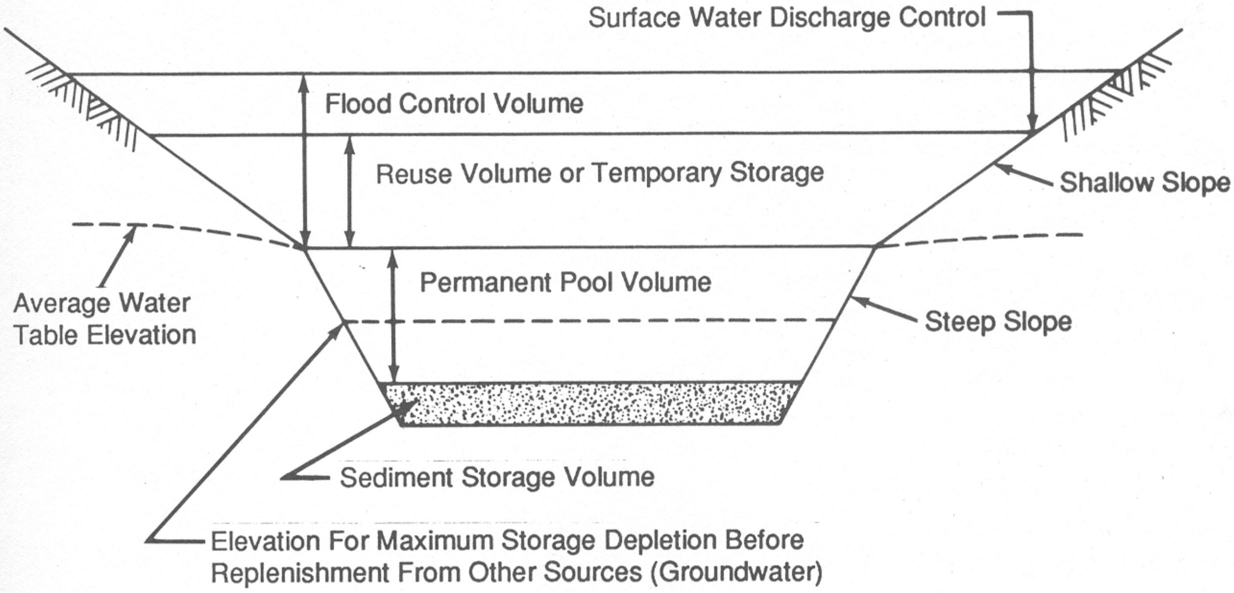
Wet Detention Ponds

Wet detention ponds are excavated areas with a pool of water that exists throughout the year (permanent pool), a debris storage volume, and a temporary storage area. The ponds are used to attenuate (reduce) hydrograph peaks, pollutant loadings and concentrations of pollutants, and to provide water for re-use purposes. Downstream water quality is improved because of sediment removal, plant uptake of nutrients, chemical transformation, and runoff water re-use. Temporary storage volume designs vary depending on the use of storage volume; however, the minimum size is calculated as one inch over the entire watershed. The total pond volume if used for peak attenuation is frequently greater than the temporary storage volume. A maximum depth for the permanent pool has been specified as six feet to minimize recycling of pollutants stored in the bottom muds. A vegetated area that leaves no more than 70 percent of the



permanent pool in open water is recommended. Short-circuiting of flow should be minimized.

These detention systems are found throughout the State in areas where the water table is of sufficient height to maintain the permanent pool. Recycling for irrigation purposes is being used more frequently to minimize the volume of discharge and pollutant loadings. In all cases, the invert elevation for the discharge structure should be above the seasonal high water elevation.

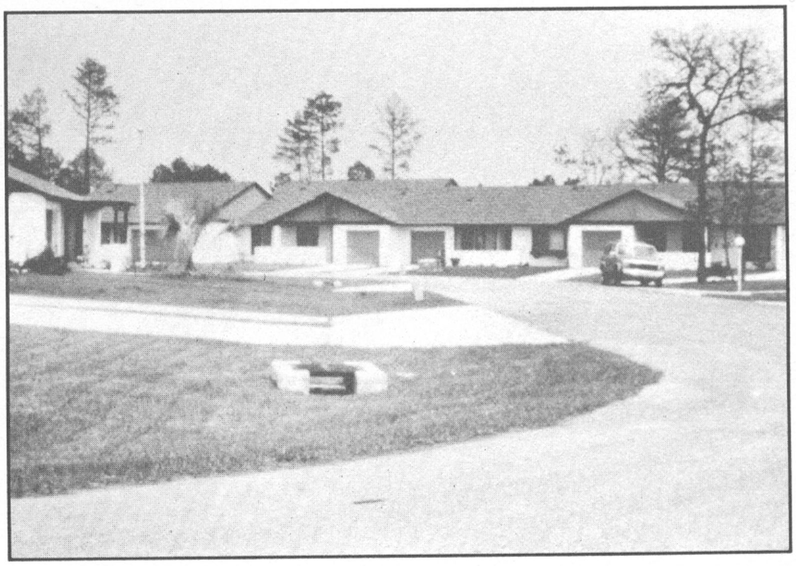


Swales

Swales are vegetated ditches that both infiltrate and transport runoff water. The top width to depth ratio must be equal to or exceed 6 to 1. Generally, the longitudinal slope is shallow to prevent erosion of the ditch. The design infiltration volume is based on a State rule that requires 80 percent of runoff from the three-year, one-hour design storm to be infiltrated over the length of the ditch (Livingston et al., 1988). Design equations are available and were developed by the Florida Department of Transportation (Wanielista, 1988).

Since long swale lengths are necessary to infiltrate runoff waters, swale blocks (berms) have been used to hold the runoff water until infiltration has occurred. The infiltration rate is critical, and care in selecting the rate is important.

Swales are used primarily along major highways within the right-of-way areas. However, some residential areas provide raised inlets to act as swale blocks and have been widely used in low ground water table areas.



Porous Parking Area

Applications included both total and partial coverage using pervious concrete surfaces. They are used to reduce peak runoff and infiltrate rainwater. Pervious concrete has a special formulated mixture of uniform open graded aggregate. Air entraining agents may be used. Proper installation is required. Partial coverage with a concrete grid having regularly interspersed void areas that are filled with sand, gravel, or sod is used in a few areas. Applications are found statewide and have been limited to parking and walkway areas.

Alum Injection

Buffered alum, which is a combination of aluminum sulfate and calcium compounds, is very effective for the reduction of phosphorus and some metals. The injection is being used in Tallahassee and Orlando.

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United States Environmental Protection Agency
Watershed Management Unit
Water Division, Region V
Chicago, IL
February 1991

EPA

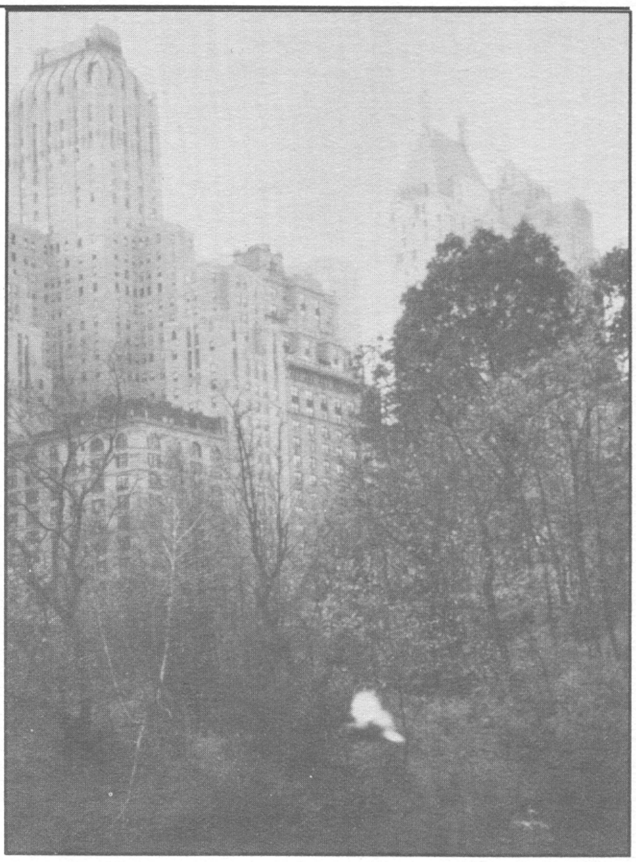
Urban Runoff Impacts to Receiving Waters

Introduction

The EPA-sponsored National Urban Runoff Program (NURP) identified the potential of stormwater to adversely affect receiving waters and aquatic biota through increased frequency and duration of peak flow rates, erosion/sedimentation, eutrophication, or toxic impact. Assessments completed under state clean lakes and nonpoint source programs have identified the extent to which urban runoff is impairing water use.

Stormwater Contaminants

The state assessments identified several categories of potential urban stormwater pollutants: suspended solids, nutrients, bacteria, oils/grease, toxic organics, and toxic inorganics (heavy metals). Critical pollutants were identified by: (1) frequency of occurrence within the stormwater database, and (2) high concentrations relative to the EPA water quality criteria. An additional consideration was the degree to which urbanized stormflow hydrology alone impacted biota in natural stream courses. Potential impacts resulting from the presence of the above pollutants include: (1) physical impairment or habitat disruption to biota, (2) enrichment and subsequent eutrophication of receiving waters, and (3) exposure and physiological response to toxic substances by aquatic biota. The presence of such impacts are considered an impairment of the receiving water resource.



Automobile traffic is a major source of pollutants resulting from urban stormwater runoff.

High Flows/Erosion/ Suspended Solids

Various urban runoff studies have effectively demonstrated the impacts of high flows, erosion, and deposition on urban streams and other sensitive receiving waters. Increased frequency and duration of high flows result in increased erosion-related impacts to (1) eroded sites, (2) conveyance systems including streams, and (3) sites of deposition. In-stream impacts are related to increased streambank erosion during high flows, increased turbidity and suspended solids concentrations, scouring habitat, and downstream depositional impacts that degrade habitat and reduce hydraulic channel capacities. Increased suspended solids concentrations and turbidity in streams can be detrimental to aquatic life (primary producers, benthic invertebrates, and fish) by interfering with photosynthesis, respiration, growth, and reproduction. The deposition of relatively fine-grained sediments in stream beds can dramatically reduce their value for insect production and fish spawning. Erosion/ sedimentation impacts can be costly, requiring removal of deposited materials to restore water supply storage, flood control, habitat, and recreational benefits of impacted resources.

Nutrients

Increased nutrient (phosphorus, nitrogen) concentrations in stormwater have been shown to result in greater nutrient enrichment and associated algal productivity in lakes, embayments, and other quiescent receiving waters, often creating undesirable excessive growth conditions. Phosphorus is often emphasized as the nutrient controlling algal growth; phosphorus loading rates from urban areas have been determined to be three to seven times greater than undeveloped woodland. However, a preponderance of stormwater inflow has been demonstrated to inhibit algal growth as a result of the presence of toxic substances, despite elevated nutrient concentrations.

Toxic Organics

Toxic organic pollutants that are prevalent in urban runoff include pesticides, phenols, phthalates, and polynuclear aromatic hydrocarbons (PAHs). While some exceedances of EPA freshwater chronic water quality criteria have been reported, concentrations in general are sufficiently low to preclude significant impacts to aquatic biota. However, their potential for bioaccumulation and status as human carcinogens warrants continued consideration as pollutants of concern.

Toxic Metals

Toxic metals are the pollutants of greatest concern in urban runoff. Lead, zinc, copper, and cadmium have both a high frequency of occurrence and high absolute concentrations in stormwater; numerous exceedances of water quality criteria for these metals have been reported. Metals have the potential to bioaccumulate and persist in the environment.

EPA water quality criteria have been developed for both acute and chronic toxicity values from bioassays on representative biota; criteria are designed to protect 95 percent of aquatic species. Physiological effects of metals exposure include algal growth inhibition and zooplankton/fish mortality through gill adsorption and respiratory impairment.

Uncertainties of Toxic Impacts

While stormwater impacts related to aesthetics, hydrologic changes to stream habitat, elevated fecal coliform counts, and eutrophication have been adequately demonstrated, the adverse effects of toxicants have been more difficult to establish. Although some water quality degradation may be occurring, such degradation has generally not been perceived to result in significant impairment to aquatic biota. For example, of over 10,000 fish kills investigated by EPA during the period 1970-1979, less than 150 were attributable to urban runoff. If present, potential toxic impacts have been more subtle and more easily overshadowed by larger, definite impacts associated with scour and sedimentation. Other sources of uncertainty regarding toxic pollutant impacts include the following:

1. Water quality metals criteria and most stormwater analyses are based on total concentrations, whereas only the smaller dissolved fraction is directly related to toxicity. Criteria are therefore conservative as they also assume dissolution of the inert particulate fraction.

2. Criteria are based on continuous bioassays for the defined exposure period. In reality, stormwater toxic exposure is intermittent and of short duration, whereupon receiving waters recover to relatively acceptable quality. These are recognized by EPA under the term "Estimated Effect Levels for Intermittent Exposure."

3. Bioassays and water quality criteria are based upon end-of-pipe stormwater concentrations. Criteria therefore do not assume dilution capability by the receiving water.

4. Pollutant forms and concentrations are dynamic relative to product and use trends. For example, lead concentrations in stormwater have declined in recent years with the progressive conversion of the motor vehicle fleet to lead-free combustion engines. Similarly, some pesticide products are being retired in favor of new products being introduced to the market.

Summary Assessment of Urban Runoff Impacts

The majority of pollutant loading attributed to urban stormwater originates from endemic sources such as motor vehicle traffic and atmospheric fallout. While toxic metal criteria established from continuous exposure bioassays are regularly exceeded in stormwater, receiving water resources and local perception often do not reflect a corresponding beneficial use impairment of the resource. Possible reasons for this disparity are due to the conservative nature of water quality criteria designations and the complexity of biochemical cause and effect relationships. Instead, perceived or documented impairments focus on aesthetics from oil and floatable debris, species displacement from erosion/sedimentation in conveyance streams, and enhanced eutrophication potential from nutrient enrichment.

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This project was funded by the U.S. Environmental Protection Agency Office of Water Enforcement and Permits–Water Permits Division and managed by Region V Watershed Management Unit–Water Division. Prepared by Entranco Engineers, Inc. and JT&A, Inc. For copies of this publication, contact The Terrene Institute, 1000 Connecticut Avenue, NW, Suite 300, Washington, DC 20036, (202) 833-3380.

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