NAOPL-E

January 1986

COMMENTS ON WATER LEVELS AND DISCHARGES IN THE DISMAL SWAMP CANAL

Operation of the Dismal Swamp Canal project is directed toward maintaining a water level in the canal that is suitable for navigation which is about elevation 11 NHD (Norfolk Harbor Datum). Water is released from the spillways at Deep Creek and/or South Mills whenever necessary to prevent overfilling of the canal. Water is released from Lake Drummond (a) as necessary to prevent overfilling of the lake above its normal elevation at gage height 5.0 feet (18.65 NHD) and (b) withdrawing water from the lake to supplement natural inflow to the canal as necessary to provide a water level in the canal suitable for navigation.

Area and storage capacity of Lake Drummond are shown in the following table.

Table 1. LAKE DRUMMOND AREA AND CAPACITY

Elevation		Area,	Capacity	
GH	Ft. NHD	acres	Acre-ft	Million gallons (MG)
6	19.65	3,340	17,990	5,865
5(a)	18.65	3,265	14,690	4,789
4	17.65	3,200	11,450	3,733
3.6(b)	17.25	3,152	10,190	3,322
3	16.65	3,060	8,320	2,712
2	15.65	2,850	5,360	1,747
1	14.65	2,450	2,690	877
0	13.65	1,660	595	194

(a) Normal gage height.
(b) Gage height below which no water is withdrawn from Lake Drummond.

Storage in the 22-mile canal and 3-mile Feeder Ditch from Lake Drummond is relatively small with an estimated area of roughly 300 acres or 300 acre feet (100 million gallons) per foot of elevation.

Pertinent elevations and spillway data are shown in the following table.

Table 2. PERTINENT ELEVATIONS AND SPILLWAY DATA

Item	Gage height	Elevation NHD(a)	Elevation NGVD(b)
Dismal Swamp Canal			
(Deep Creek & South Mills)			
Normal water level	1.0	11 1/2	10
Gage zero	0	10.44	8.94
Spillway crests	-2.44	8.00	6.50
(8-4 ft. H X 6 ft L gates)			
Downstream water level		1.5±	0±
Lake Drummond			
Normal water level	5.0	18.65	17.15
Minimum level for navigation	3.6	17.25	15.75
Gage zero	0	13.65	12.15
Spillway crest	-0.65	13.00	11.50
(10- 3 ft. sq gates)			

(a) NHD is Norfolk Harbor Datum which is 1.5 ft. lower than NGVD.
(b) National Geodetic Vertical Datum of 1929.

Exhibit 1 is a graph indicating the elevation of the water surface of Lake Drummond from 1926 to date. It also indicates periods in which the Dismal Swamp Canal was closed to navigation. Note the very infrequent closings but frequent low lake levels prior to 1977 and the reverse situation from 1977 to date. The chart also shows the canal levels which occurred during periods of closure to navigation from 1976 to date. During other periods, the canal level would be near normal level at gage height of about 1.0 feet.

Prior to 1977, the level of the lake was drawn down to relatively low levels in order to provide water for navigation. Public Law 93-402, 93rd Congress, HR 3620, August 30, 1974, provided for establishment of the Great Dismal Swamp National Wildlife Refuge. This act specified

navigational or other uses of the canal should not adversely affect the refuge. Consultation with the Refuge Manager led to the conclusion that the water level be maintained above a gage height of 3.0 feet in order that the refuge not be seriously affected. It was considered necessary to stop withdrawals from the lake when the water level reached 3.6 feet to be reasonably sure it would not drop below 3.0 feet during the continuation of the drought period. Consequently, withdrawal of water to support navigation is stopped when the lake level falls to a gage height of 3.6 feet. The level has fallen as low as 2.8 feet since 1976. This occurred in 1980 when withdrawal was stopped at 3.6 feet.

It can readily be seen that if the present procedure would have been followed, the number of closures would have been much greater--actually about 25 times in 51 years. On the other hand, if unrestricted use could have been made from 1977 to date, there would have been no closures, but the lake level would have fallen to about 2 feet in the droughts of 1977, 1980, and 1985.

The volume of water released from the lock chamber had previously been estimated at 1.25 million gallons based on a maximum head of about 10 1/2 feet. However, recent investigations to estimate the possible leakage through the lock gates led to the realization that the average difference in elevation between the canal and river level is about 8.5 feet at both South Mills and Deep Creek. This represents about 1.00 million gallons instead of 1.25 million gallons previously used in these analyses. Also, as noted in the prior memorandum, the lock chamber is frequently filled in locking boats into the canal and then emptied in locking boats out of the canal on the next locking. This results in the use of one lockful of water for two recorded lockings. Examination of a typical year of record indicates that only 80 lockfuls of water are used in 100 lockings. Therefore 80% or 0.8 million gallons are considered appropriate for each recorded locking in this analysis. This is not reflected in the computer runs made up to this time and illustrated in exhibits 2 through 4.

A daily record of canal and lake releases and water levels were developed by a computer program for the period 1955 to date. The following sample of data tabulated is attached as follows:

Exhibit 2 - November 1984 by days
Exhibit 3 - 1984 by months
Exhibit 4 - 1955-1984 by years

Examination of the record indicates that during periods when Lake Drummond is releasing water for navigation only (no water being spilled from the spillway) the amount of water being released from Lake Drummond is more than actually used in locking operations. This indicates loss of water somewhere in the system below Lake Drummond. Exhibits 5 and 6 are graphs showing pertinent data in drought periods in 1977 and 1985, respectively. The apparent loss is shown in the following table:

Table 3. APPARENT WATER LOSS

Item	Period	
	Jun-Jul 77	Apr-Aug 85
Number of days	43	68
Water volume in MG		
Release from Lake Drummond	988	1,347
Used in locking	287	356
Apparent loss		
Million gallons	701	991
Million gallons per day	16.5	14.6

Similar losses are indicated in analysis of other drought periods.

Further indication of loss is evident from the fall in level of the canal when there is no inflow from Lake Drummond or water spilled or used in locking operations. Exhibits 5 and 6 indicate the canal level falls

about 4 feet in a month immediately following closure of the canal to navigation. Assuming a storage of about 100 MG per foot in the canal a drop of 4 feet represents an apparent loss of 400 MG or 13 MGD.

The advance memorandum furnished in October 1985 inferred that this loss was principally due to infiltration to ground water. Since the canal was filled at the end of October it has been possible to make some observations of water levels in the canal, lock chamber and river, with the lock gates closed under filling and emptying conditions. Investigations indicate that there is leakage from the gates.

Since the canal has been filled and there have been few lockings of boats to interfere with the procedure, it has been possible to make reasonable approximations of the amount of such leakage. A staff gage has been placed in the lock chambers and with the existing gages in the canal and river it is possible to determine the relative elevation of the water surfaces in the canal, lock chamber and river. Observations are made to determine the rate at which the water level falls in the lock chamber following a filling of the lock chamber and all valves closed. It has been determined the total leakage from canal is about 17 million gallons per day. It is believed that this could be reduced to 8 MGD if the gates and valves were overhauled. A number of other Corps offices were contacted. While no specific measurements have been made, information from those offices indicated that losses of 3 to 7 MGD would be expected under normal conditions at these types and size of locks.

There is no way to estimate other losses except that due to evaporation which is about 1 to 2 MGD. There are losses due to infiltration into the sides of the canal which cannot be measured. There are also unmeasurable quantities of groundwater entering the canal as well as unknown quantities which enter the canal from the west. In drought periods, ground water level in the Lake Drummond area is near the level of Lake Drummond and that in the canal area is near that in the canal. This would indicate the likelihood of continued inflow into the canal from the upper end of the feeder ditch and

other ditches draining into the canal from the west. Therefore, it is likely that there is a continuous inflow into the canal from ground water and loss due to infiltration both of these being of varying amounts and not capable of being measured.

It appears to be a coincidence that the estimated leakage from the lock gates closely approximates that indicated by the difference between the amounts released from Lake Drummond and that utilized in locking operation. This would indicate that the amount of water entering the canal from groundwater from the west and leaving the canal by infiltration are about equal.

A further indication of the difficulty in analyzing the movement of water in the canal system is based on analyses by the U.S. Geological Survey in 1978-81 which was based on three series of surface water inflow-outflow measurements. It was concluded that the measured outflow was 10 times greater than the inflow during the drier summer and late fall months. In other words, about 10% of the water enters the system by surface means with the other 90% entering by sub-surface or ground water flows.

The effect increased storage space and possible leakage would have on periods navigation would have to be stopped in recent drought periods have been studied in some detail. The effect in the 1985 drought period is shown on this exhibit which is a copy of that furnished with the advance memorandum. Data pertinent to the various operations are shown thereon.

The solid, dark line represents recorded data. Shortly after 1 July the water level in Lake Drummond fell to near 3.6 feet, navigation was stopped, release from Lake Drummond was stopped, the canal level began to fall rapidly and no more water was used in locking operations. Lake Drummond water level rose slightly then fell to a minimum gage height of 3.3 feet.

The performance of pertinent elements of the canal is shown if navigation would have been continued regardless of lake elevation. The lockages after canal closure was estimated based on other years and water used is shown on

the bottom graph. Water released from Lake Drummond to support this continued navigation was based on the recorded losses and water required for locking operations. The canal would have remained at normal level. The lake would have fallen to a gage height of 2.3 feet.

Also shown is the performance if it is assumed the losses could be reduced by 50%. In this case navigation would be extended to 1 September if stopped at 3.6 gage height and fallen to gage height 3.1 if navigation had been continued.

A similar analysis was made of all drought periods from 1977 to date and is summarized on table 4 which shows the periods of closure and the number of days navigation could be extended under various alternate operations. This table shows that in 1983 and 1984 the canal would not have been closed if any of the alternatives were followed. Some extension of the navigation period would have been made with reduction to losses by 50%. However, closure in the 1977, 1980, and 1985 drought periods in 1977, could not have been avoided under the operations shown.

Table 4. POSSIBLE INCREASE IN NAVIGATION

Status	Number of days navigation might be extended in recorded periods of closure					
	7/30/77 to 11/25/77	10/18/78 to 11/30/78	7/23/80 to 2/27/81	8/26/83 to 10/4/83	11/8/84 to 1/8/85	7/4/85 to 11/1/85
	118(a)	43(a)	219(a)	39(a)	61(a)	119(a)
Lake Drummond at GH 5.5(b) Navigation stopped at GH 3.6 recorded losses	21	7	18	39(c)	61(c)	42
Lake Drummond at GH 5.0(b) Navigation stopped at GH 3.3 recorded losses	27	7	9	39(c)	61(c)	34
Lake Drummond at GH 5.0(b) Navigation stopped at GH 3.6 50% recorded losses	26	43(c)	8	39(c)	61(c)	58
Lake Drummond at GH 5.0(b) Navigation stopped at GH 3.3 50% recorded losses	43	43(c)	23	39(c)	61(c)	73

(a) Total number of days navigation stopped (at GH 3.6) as recorded.
(b) Gage Height indicating elevation of water surface in Lake Drummond at beginning of drought period.
(c) Closure to navigation not necessary.

LIST OF EXHIBITS

1. Lake Drummond Outlet Gage (in two sheets).

2. Daily Summary for November 1984.

3. Monthly Summary for 1984.

4. Yearly Summary for 1955-1984.

5. Dismal Swamp Record, 1977.

6. Dismal Swamp Record, 1985.

Gage Height, Ft.

6
4
2
0

1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940

LAKE STAGE

NOTE:
Staff gage located on left bank of outlet canal 200 feet upstream from dam. Gage heights below 1 ft. do not necessarily reflect elevation of level of lake. Gage read twice daily for the U.S. Geological Survey. Average elevation of bottom about 1 foot below zero of gage.

Canal closed to navigation

Gage Height, Ft.

6
4
2
0

1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955

LAKE STAGE

6
4
2
0

1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970

LAKE DRUMMOND
OUTLET GAGE 2/11/69
REG. FRP, COM FILE 8212

Exhibit 1 SHEET 1 OF 2

Canal closed to navigation

Gage Height Ft. 6 4 2 0

1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985

LAKE STAGE

Lake Drummond

Average canal level

NOTE:

* Staff gage located on left bank of outlet canal 200 feet upstream from dam. Gage heights below 1 ft. do not necessarilly reflect elevation of level of lake. Gage read twice daily for the U.S. Geological Survey. Average elevation of bottom about 1 foot below zero of gage.

Lake Drummond Gage 0=13.65 ft. NHD 12.15 ft. SLD
Canal Gages 0=10.44 ft. NHD 8.94 ft. SLD

LAKE DRUMMOND
OUTLET GAGE
KNB

FILE 6.2.12

Exhibit 1 SHEET 2 OF 2

DISMAL SWAMP CANAL
DAILY SUMMARY FOR NOVEMBER 1984

		** DEEP CREEK **				** SOUTH MILLS *						** LAKE DRUMMOND *		
		NO. LOCK	RELEASE FROM LOCKING MIL GAL	SPILLWAY MIL GAL	AVG. GAUGE FEET	NO. LOCK	RELEASE FROM LOCKING MIL GAL	SPILLWAY MIL GAL	AVG. GAUGE FEET	RELEASE AT SPLWAY MIL GAL	RELEASE AT LOCKS MIL GAL	SPILLWAY RELEASE MIL GAL	AVG. GAUGE FEET	AREA RAIN-FALL INCH
YEAR	MO													
DAY	1	2	2.	0.	0.5	1	1.	0.	0.4	0.	3.	17.	3.8	0.0
DAY	2	2	2.	0.	0.4	1	1.	0.	0.4	0.	3.	17.	3.8	0.0
DAY	3	2	2.	0.	0.4	4	4.	0.	0.4	0.	6.	17.	3.8	0.0
DAY	4	4	4.	0.	0.3	1	1.	0.	0.3	0.	5.	16.	3.7	0.0
DAY	5	1	1.	0.	0.3	2	2.	0.	0.2	0.	3.	17.	3.7	0.0
DAY	6	1	1.	0.	0.3	0	0.	0.	0.3	0.	1.	33.	3.6	0.3
DAY	7	2	2.	0.	0.3	2	2.	0.	0.3	0.	4.	16.	3.6	0.0
DAY	8	1	1.	0.	0.3	1	1.	0.	0.2	0.	2.	16.	3.6	0.0
DAY	9	0	0.	0.	0.1	1	1.	0.	0.0	0.	1.	0.	3.6	0.0
DAY	10	0	0.	0.	-0.2	0	0.	0.	-0.3	0.	0.	0.	3.6	0.0
DAY	11	0	0.	0.	-0.4	0	0.	0.	-0.5	0.	0.	0.	3.6	0.0
DAY	12	0	0.	0.	-0.6	0	0.	0.	-0.6	0.	0.	0.	3.6	0.5
DAY	13	0	0.	0.	-0.8	0	0.	0.	-0.8	0.	0.	0.	3.6	T 0
DAY	14	0	0.	0.	-0.9	0	0.	0.	-1.0	0.	0.	0.	3.6	0.0
DAY	15	0	0.	0.	-1.1	0	0.	0.	-1.2	0.	0.	0.	3.6	0.0
DAY	16	0	0.	0.	-1.3	0	0.	0.	-1.3	0.	0.	0.	3.6	0.0
DAY	17	0	0.	0.	-1.4	0	0.	0.	-1.4	0.	0.	0.	3.6	0.0
DAY	18	0	0.	0.	-1.5	0	0.	0.	-1.5	0.	0.	0.	3.6	0.0
DAY	19	0	0.	0.	-1.6	0	0.	0.	-1.5	0.	0.	0.	3.6	0.1
DAY	20	0	0.	0.	-1.8	0	0.	0.	-1.8	0.	0.	0.	3.6	0.7
DAY	21	0	0.	0.	-1.9	0	0.	0.	-1.8	0.	0.	0.	3.6	0.0
DAY	22	0	0.	0.	-1.9	0	0.	0.	-1.8	0.	0.	0.	3.6	0.0
DAY	23	0	0.	0.	-2.1	0	0.	0.	-2.1	0.	0.	0.	3.6	0.0
DAY	24	0	0.	0.	-2.2	0	0.	0.	-2.1	0.	0.	0.	3.6	0.0
DAY	25	0	0.	0.	-2.3	0	0.	0.	-2.3	0.	0.	0.	3.6	0.0
DAY	26	0	0.	0.	-2.4	0	0.	0.	-2.4	0.	0.	0.	3.6	0.0
DAY	27	0	0.	0.	-2.5	0	0.	0.	-2.5	0.	0.	0.	3.6	0.0
DAY	28	0	0.	0.	-2.5	0	0.	0.	-2.5	0.	0.	0.	3.6	0.0
DAY	29	0	0.	0.	-2.5	0	0.	0.	-2.6	0.	0.	0.	3.7	0.9
DAY	30	0	0.	0.	-2.6	0	0.	0.	-2.6	0.	0.	0.	3.7	0.0
1984	11	15	15.	0.	-1.1	13	13.	0.	-1.1	0.	28.	148.	3.6	2.9

Exhibit 2

DISMAL SWAMP CANAL
MONTHLY SUMMARY FOR 1984

		** DEEP CREEK **				* SOUTH MILLS *						*LAKE DRUMMOND*		AREA
			RELEASE FROM		AVG.		RELEASE FROM		AVG.	RELEASE	RELEASE	SPILLWAY	AVG.	RAIN-
		NO.	LOCKING	SPILLWAY	GAUGE	NO.	LOCKING	SPILLWAY	GAUGE	AT SPLWAY	AT LOCKS	RELEASE	GAUGE	FALL
YEAR	MO	LOCK	MIL GAL	MIL GAL	FEET	LOCK	MIL GAL	MIL GAL	FEET	MIL GAL	MIL GAL	MIL GAL	FEET	INCH
1984	1	3	3.	3717.	0.7	4	4.	4959.	0.6	8676.	7.	4661.	4.7	3.9
1984	2	3	3.	4758.	0.7	2	2.	5411.	0.5	10169.	5.	4168.	4.8	6.4
1984	3	10	10.	6714.	0.6	10	10.	6223.	0.4	12937.	20.	5702.	4.7	6.5
1984	4	34	34.	10125.	0.6	35	35.	9412.	0.3	19537.	69.	9428.	4.8	7.2
1984	5	73	73.	2523.	0.8	80	80.	3395.	0.7	5918.	153.	3223.	5.0	7.6
1984	6	79	79.	716.	0.7	76	76.	1424.	0.6	2140.	155.	1440.	5.1	0.9
1984	7	62	62.	663.	0.7	70	70.	1185.	0.7	1848.	132.	968.	4.9	13.5
1984	8	59	59.	732.	0.8	53	53.	1325.	0.7	2057.	112.	1251.	5.1	3.5
1984	9	69	69.	0.	0.7	61	61.	0.	0.7	0.	130.	399.	4.9	1.9
1984	10	98	98.	0.	0.7	95	95.	0.	0.7	0.	193.	915.	4.3	0.1
1984	11	15	15.	0.	-1.1	13	13.	0.	-1.1	0.	28.	148.	3.6	2.9
1984	12	0	0.	0.	-0.8	0	0.	0.	-0.8	0.	0.	0.	4.1	2.6
		----	------	-------	AVG	----	------	-------	AVG	-------	-------		AVG	----
SUBTOTALS		505	505.	29948.	0.4	499	499.	33334.	0.3	63282.	1004.	32303.	4.7	57.3

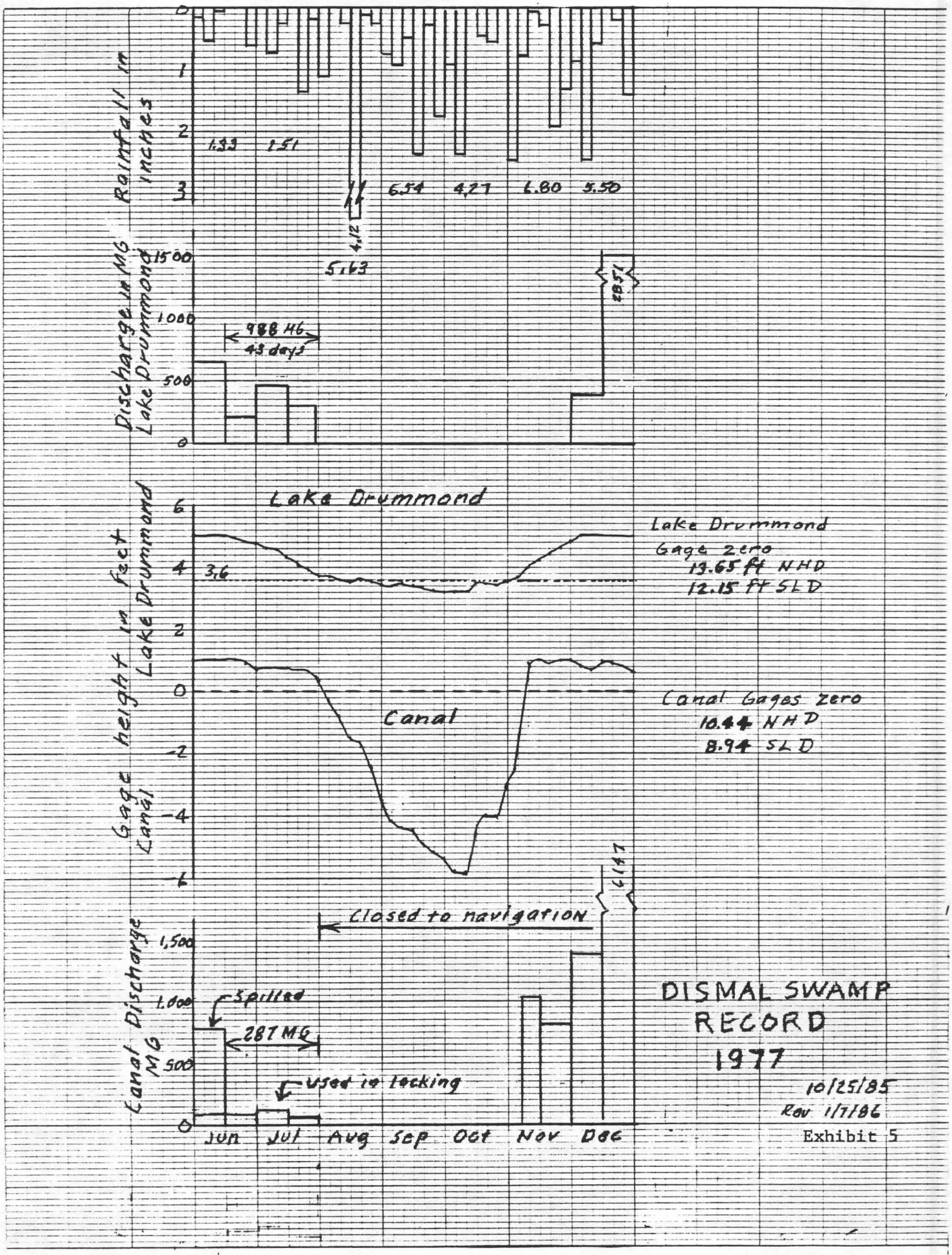
Exhibit 3

DISMAL SWAMP CANAL
YEARLY SUMMARY FOR 1955-1984

8/5/35

YEAR	** DEEP CREEK ** NO. LOCK	RELEASE FROM LOCKING MIL GAL	RELEASE FROM SPILLWAY MIL GAL	AVG. GAUGE FEET	* SOUTH MILLS * NO. LOCK	RELEASE FROM LOCKING MIL GAL	RELEASE FROM SPILLWAY MIL GAL	AVG. GAUGE FEET	TOTAL RELEASE AT SPLWAY MIL GAL	CANAL RELEASE AT LOCKS MIL GAL	*LAKE DRUMMOND* SPILLWAY RELEASE MIL GAL	AVG. GAUGE FEET	AREA RAIN-FALL INCH
1955	1191	1191.	6902.	1.0	966	966.	12125.	0.9	19027.	2157.	25479.	4.4	47.7
1956	1265	1265.	17687.	1.0	1080	1080.	26186.	0.9	43873.	2345.	52071.	5.1	60.9
1957	1066	1066.	17781.	0.9	937	937.	21767.	0.8	39548.	2003.	49759.	4.3	55.2
1958	1303	1303.	22976.	1.0	1112	1112.	17705.	0.9	40681.	2415.	37559.	4.5	54.4
1959	1309	1309.	11075.	1.0	1106	1106.	10882.	0.9	21957.	2415.	24265.	4.9	51.9
1960	1567	1567.	23372.	1.0	1197	1197.	28203.	0.9	51575.	2764.	59617.	5.3	52.5
1961	1779	1779.	17410.	1.0	1335	1335.	35119.	0.8	52529.	3114.	71324.	5.2	49.3
1962	1303	1303.	19522.	0.9	1056	1056.	25647.	0.8	45169.	2359.	41866.	4.6	51.0
1963	1100	1100.	10687.	0.7	836	836.	13536.	0.7	24223.	1936.	41199.	3.8	46.8
1964	1362	1362.	33304.	0.9	1076	1076.	33262.	0.7	66566.	2438.	65989.	5.0	67.9
1965	1483	1483.	6636.	0.9	1065	1065.	26755.	0.7	33391.	2548.	25867.	4.5	39.3
1966	1502	1502.	7800.	0.9	1081	1081.	24706.	0.8	32506.	2583.	21937.	4.7	52.8
1967	1382	1382.	25759.	0.9	1035	1035.	37634.	0.7	63393.	2417.	41925.	4.9	55.1
1968	1509	1509.	11189.	1.0	1128	1128.	23147.	0.7	34336.	2637.	24442.	4.4	40.8
1969	1591	1591.	26632.	1.0	1317	1317.	42729.	0.8	69361.	2908.	44029.	5.0	54.1
1970	1427	1427.	21275.	0.8	1190	1190.	21447.	0.7	42722.	2617.	28703.	4.0	44.1
1971	1532	1532.	26941.	0.9	1177	1177.	28675.	0.8	55616.	2709.	31393.	4.7	53.6
1972	1645	1645.	25689.	0.9	1335	1335.	32501.	0.8	58190.	2980.	35448.	5.0	57.1
1973	1668	1668.	32001.	0.8	1466	1466.	31091.	0.8	63092.	3134.	35027.	4.7	55.0
1974	1682	1682.	25243.	0.8	1334	1334.	22291.	0.8	47534.	3016.	27847.	4.9	47.1
1975	1705	1705.	29709.	0.8	1476	1476.	26723.	0.7	56432.	3181.	36443.	4.5	54.6
1976	800	800.	10101.	-1.1	709	709.	12487.	-1.1	22588.	1509.	15431.	3.5	34.7
1977	503	503.	14177.	-0.4	425	425.	14302.	-0.4	28479.	928.	15500.	4.4	44.3
1978	723	723.	33826.	0.6	604	604.	33671.	0.6	67497.	1327.	39092.	4.6	50.3
1979	924	924.	33625.	0.9	733	733.	41460.	0.8	75085.	1657.	55203.	4.9	62.5
1980	376	376.	20150.	-0.6	340	340.	17879.	-0.6	38029.	716.	19855.	4.0	35.2
1981	814	814.	39.	0.9	603	603.	2857.	0.8	2896.	1417.	6576.	4.4	44.8
1982	568	568.	18452.	0.9	535	535.	43461.	0.8	61913.	1103.	39265.	4.8	75.2
1983	513	513.	27192.	0.5	478	478.	37119.	0.4	64311.	991.	38957.	4.7	66.4
1984	505	505.	29948.	0.4	499	499.	33334.	0.3	63282.	1004.	32303.	4.7	57.3
	----	------	--------	AVG	----	------	--------	AVG	---------	----------		AVG	----
TOTAL	36097	36097.	607100.	0.7	29231	29231.	778701.	0.6	1385801.	65328.	1084371.	4.6	1563.3

Exhibit 4


Rainfall in Inches
0
1
2
3
1.33
1.51
4.12
5.63
6.54
4.27
6.80
5.50
Discharge in MG Lake Drummond
1500
1000
500
0
988 MG
43 days
1851
Lake Drummond
Gage height in feet Lake Drummond
6
4
3.6
2
0
-2
-4
-6
Lake Drummond Gage Zero
13.65 ft NHD
12.15 ft SLD
Canal
Canal Gages Zero
10.44 NHD
8.94 SLD
1147
Closed to navigation
Canal Discharge MG
1,500
1,000
500
0
Spilled
287 MG
used in locking
Jun
Jul
Aug
Sep
Oct
Nov
Dec
DISMAL SWAMP
RECORD
1977
10/25/85
Rev 1/7/86
Exhibit 5

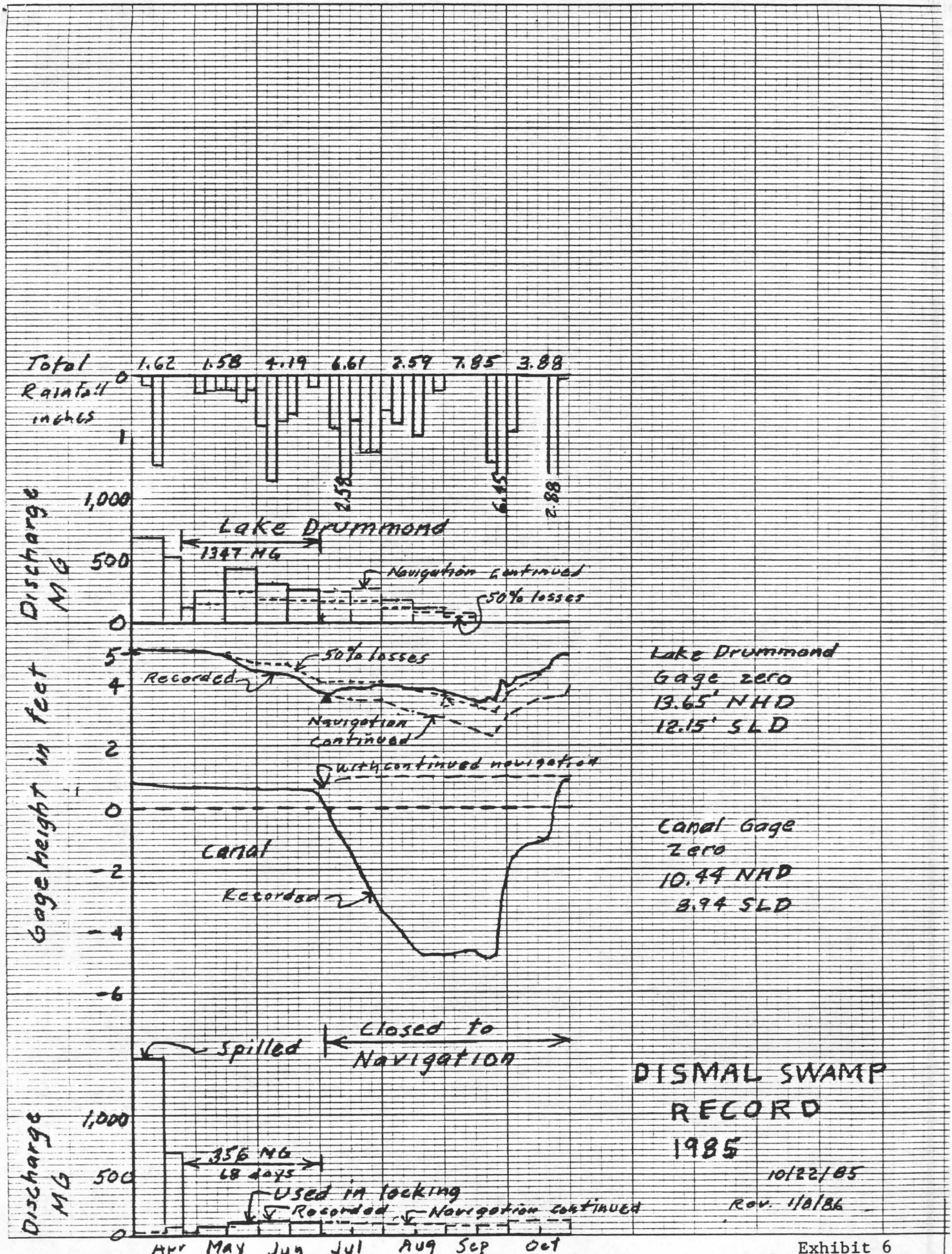

Total Rainfall inches
1.62
1.58
4.19
6.61
2.59
7.85
3.88
2.58
6.45
2.88
Discharge MG
1,000
500
0
Lake Drummond
1347 MG
Navigation continued
50% losses
Gage height in feet
5
4
2
0
-2
-4
-6
50% losses
Recorded
Navigation continued
with continued navigation
Canal
Recorded
Lake Drummond
Gage zero
13.65' NHD
12.15' SLD
Canal Gage
Zero
10.44 NHD
8.94 SLD
Spilled
Closed to Navigation
Discharge MG
1,000
500
0
356 MG
68 days
Used in locking
Recorded
Navigation continued
Apr
May
Jun
Jul
Aug
Sep
Oct
DISMAL SWAMP
RECORD
1985
10/22/85
Rev. 1/8/86

Exhibit 6