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Chapter 19 Hydrology Tools for Wetland Determination

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Preface

This chapter of the Engineering Field Handbook is an outgrowth of a meeting of hydraulic and water management engineers in Wilmington, Delaware, in October 1991. The participants developed a list of hydrology tools that help delineate wetlands. Various task groups were formed for each tool. Send comments to the Natural Resources Conservation Service (NRCS), Conservation Engineering Division, Washington, DC, or the Wetland Sciences Institute, Beltsville, Maryland.

The membership in the task group is as follows:

Stream and Lake Gage	**Bill Merkel,** NRCS, Beltsville, MD
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650.1900 Introduction

This chapter of the Engineering Field Handbook presents seven tools or procedures to use in the evaluating the hydrology of potential wetlands. Each tool is used in one or more states to assist in the determination of wetlands. These tools are analytical techniques that can be used to supplement the documentation of wetland hydrology determination.

The use of each tool depends on local conditions. The technical discipline leaders in each state office should determine the applicability of the individual tool(s) in their area. The selection of the appropriate tool(s) should be coordinated with the Environmental Protection Agency, Corps of Engineers, and Fish and Wildlife Service. Each procedure or tool is described in a separate section of this chapter.

The criteria for duration and frequency of inundation and saturation are in Section 527.4 of the National Food Security Act Manual (NFSAM). Different durations were used with the various procedures to indicate that the procedure is independent of the criteria.

The seven tools are:

- Stream gage data to establish the hydrology of over- or out-of-bank flooding.
- Water budget analysis to estimate daily runoff values, which can be used to determine the water balance of any wetland. A curve of drainage area versus depressional surface area to determine the frequency and duration of inundation of playas.
- Aerial photographic analysis to establish the frequency of occurrence and duration of inundation.
- DRAINMOD computer program to establish the degree of saturation of a wetland under a wide range of drained and nondrained conditions.
- Scope and effect equations to evaluate the effects of drainage measures on wetlands.
- Drainage guides, which provide useful information for evaluating drainage systems.
- Observation well data to establish the saturated conditions of a wetland.

650.1901 Use of stream and lake gages

(a) Applicable situations for use

Stream and lake gage data can be used to document the timing duration and frequency of inundation of the area adjacent to streams and lakes. Daily flow or stage data are used to determine the duration and frequency of overbank inundation. For a riverine situation, duration and frequency information at stream gage locations may be extended upstream or downstream using water surface profile information. Procedures for gathering stream gage data and computing water surface profiles are found in standard references.

Even if a site near a stream gage does not have sufficient topographic or stream gage data, some knowledge of the site can be obtained from analyses of the stream gage.

(b) Data required

The following data are required:

- Daily flow values or lake levels for a minimum of 10 years of data.
- Cross section information, and relationship of discharge versus stage if discharges are used.
- Topographic information for area of concern.
- Water surface profile information (if point of concern is not at the gage site).

(c) Sources of data

Various Federal, State, and county agencies have placed gages on many streams and lakes. Stream and lake gage data are available from the Corps of Engineers (COE), Tennessee Valley Authority (TVA), U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), Bureau of Reclamation (BOR), various highway departments, and state or local public works agencies.

Various types of gage data are published. They include mean daily discharge, mean daily stage, peak stage and discharge for flood events, and mean daily lake level.

The primary source of data is the USGS Water Resources Data publication for each state.

(d) Limitations

(1) Knowledge and experience required

General knowledge of water surface profile computations and stream hydraulics and statistical techniques is required.

(2) Climatic regions of applicability

This procedure is applicable to all climate regions.

(3) Factors affecting the accuracy of results

The concept in this procedure is that the hydrograph can indicate what discharge or stage is exceeded for a particular duration, frequency, or both. At least 10 years of data are needed to apply this procedure. The accuracy of the procedure increases as the length of record increases.

If discharges are used, a relationship of stage versus discharge is needed to convert discharge into stage. The accuracy is a function of the cross section information. The stage is most accurately determined at the gage site. To accurately determine inundated areas using this information along the stream, the water surface profiles and topographic maps must be accurate. Even at the gage site, some topographic survey information may be needed to determine the limits of inundation if the topographic map is insufficient. The accuracy is a function of the contour interval of the map. Stream gage data may be extended upstream or downstream up to 1,000 feet without the use of a water surface profile.

Stream gage data may be used in the following situations:

1. A stream overflows and stays out of bank for the time required to meet wetland hydrology criteria.
2. A stream overflows and returns within banks in a time period less than the wetland hydrology criteria duration. The out-of-bank area must then be considered to confirm if over-bank-flow time plus time remaining ponded or saturated meets the wetland hydrology criteria. A simple water budget for the area may determine if ponding meets the ponding wetland criteria. This type of analysis is outside the scope of this chapter.
3. Areas next to a lake that may be subject to inundation because of periodic fluctuation in water level.
4. The water level in the lake may return to a normal level in less time than that required to meet the wetland hydrology criteria. The lake shore area must then be considered to confirm if the time flooded by the lake plus the time remaining ponded, saturated, or flooded meets the wetland hydrology criteria.

This section discusses situations 1 and 3. Situations 2 and 4 involve combining the methodology in situations 1 or 3 with analysis from other technical documents. Situations 2 and 4 involve analysis of the soil moisture in the soil profile using a standard water budget technique.

(e) Methodology

Methodology is a 9-step process.

Step 1. Determine growing season and duration as defined in Part 527.4 of the National Food Security Act Manual. The WETS table can be used to determine the growing season.

Step 2. Obtain available data or develop data relating to stream hydrology and hydraulics. This includes gage records, both upstream and downstream (if possible), of the site being evaluated. If the gage records are daily discharges, data relating discharge to stage must be obtained. See National Engineering Handbook, Section 4 (NEH-4), Chapter 14, Stage-Discharge Relationships. Other useful data available on many streams include water surface profiles. Water surface profiles are important where only one stream gage is located on the stream or where the potential wetland is not close to the gaging station.

Step 3. Develop a water surface profile, which is a plot of water surface elevation versus distance along a stream. The water surface elevation can represent a specific discharge or a flow frequency, such as a 2-year or 100-year discharge. A water surface profile is developed using computer programs that use cross section data, roughness data, distance along a stream, and bridge and culvert information. WSP2 and HEC2 are typical water surface computer programs used by NRCS and COE respectively.

Step 4. Use as many continuous years of gage records as can be obtained. The record should be representative of current conditions. For example, if a major dam has been installed and flow conditions have changed or channel excavation has occurred that would influence gage readings, then the gage records may be invalid and should not be used.

Step 5. Determine the highest stage of each year that is exceeded for the duration set by NFSAM or relevant criteria. Consider only gage records during the growing season. For example, if the inundation criterion is 10 days, record the lowest stage occurring within 10 days of high flow. Next, move the 10-day period forward 1 day and record the lowest stage occurring during those 10 days of high flow. It is assumed that all flows larger than the smallest flow within the criteria duration will be out of bank. Repeat this process for the entire growing season. The highest of these recorded stages is the value to use for that year. This search could be done on the larger flood events that would be expected to produce the highest 10-day stages and not for every 10-day interval of the growing season.

Repeat this process for as many years of gage data as daily records are available. If the record is broken, then determine if the discontinuous record is really representative of the site's hydrology.

Example 19–1 illustrates the determination of the elevation exceeded for 10 consecutive days on the Smith River at Brooking, Oregon, for 1989. The growing season is from March 1 to October 31. Figure 19–1 is a plot of mean daily elevation for March and April 1989, which represents the part of the growing season with the highest overall stage levels.

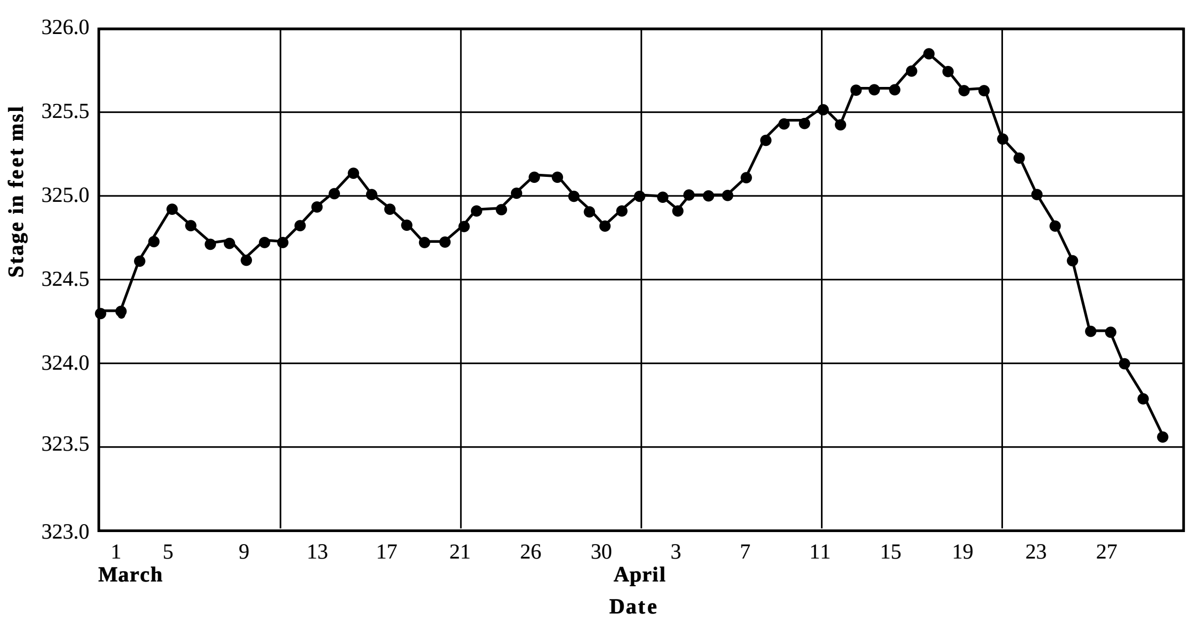
Example 19–1 Determination of elevation exceeded for 10 consecutive days

March 1–10, the lowest elevation = 324.3 feet
March 2–11, the lowest elevation = 324.3 feet.

Elevations exceed 325 in April, so these days should be checked.
April 7–16, the lowest elevation = 325.1 feet.
April 8–17, the lowest elevation = 325.3 feet.

Thus the lowest elevation that was exceeded for 10 consecutive days during 1989 was 324.3 feet.

Figure 19–1 Mean daily elevation for March and April 1989 for Smith River at Brookings, Oregon



Step 6. Tabulate the stage readings determined for each year of record for the gage in descending order (highest elevation first). The median value is the value where half of the stage readings are higher and half are lower. If an odd number of years of record is used, the middle event is the median elevation. If an even number of years of record is used, then compute the average elevation between the two middle years as the median. Example 19–2 shows the selection of the median.

Step 7. Repeat steps (4) through (6) for the second gage, if available.

Step 8. If there are two gages and if water surface profiles are not available, use the following procedure to determine median elevation. Measure the distance between the two gages along the stream and the distance from the site to the nearest of the two gages. Assume a straight line water surface between the gages and interpolate the elevation at the site based on the proportion of the distance to the gage and the distance between the two gages.

Using the data in table 19–1, the elevation at the site would be:

$$140 – [(5/20) \times 40] = 130 \text{ feet.}$$

If water surface profiles are available, interpolate the elevation at the site based on relationships of stage and discharge (and possibly frequency) at the gage locations and at the site.

Step 9. To relate the water level with the land surface, establish elevations at the site in question by a topographic survey or contour map.

Example 19–2 Selection of median stage reading

11 years of data are available and ordered from highest to lowest.

335 329 326 325.3 324 323.5 320 319 317 314 308

The median is **323.5** because 5 values are higher and 5 are lower.

10 years of data are available and ordered from highest to lowest.

335 331 329 328 325 323 322 321 320 315

The median would be **324** because it is the average of the 5th and 6th value.

Table 19–1 Example data to figure elevation

Location	Distance (miles)	15-day median elevation
Downstream gage	0	100
Site	15	?
Upstream gage	20	140

(f) Sample documentation

An area on the banks of the Tar River near Rocky Mount, North Carolina, is to be evaluated. It is assumed that the area must be inundated for 15 days during the growing season of March 1 to October 31 to have wetland hydrology present.

A stream gage is located on the Tar River at North Carolina Highway 97 in Rocky Mount, North Carolina. The USGS Water Resources Data for North Carolina include records from August 1976 to the present time. Average daily discharge data are published along with peak discharges and associated stages.

The first step is to determine the 15-day duration elevation for each year of record. Normally, the complete record is used, but in this example only 6 years are shown (table 19–2). Data for 6 years (1986 to 1991) are duplicated in the following pages with the 15-day duration discharge marked.

Example 19–3 shows records for Pamlico River Basin. The selection of the lowest flow during the high flow period is shown on pages 19–7 through 19–12.

These discharges are then ranked and the median calculated. The values ranked are 2,529, 1,300, 1,240, 679, 513, and 444. Because the number of years is even, the average of the third and fourth values is calculated. The median is 960 cubic feet per second. Because of the large difference between these values, a better estimate would result if more years were analyzed.

The next steps are to determine the stage and elevation that apply to the discharge of 960 cubic feet per second. From the publications of USGS Water Resources Data, the stage versus discharge for peak discharges is plotted and a smooth curve drawn through the points (figure 19–2). The discharge-stage curves can also be obtained from the agency responsible for the gage.

The stage associated with 960 cubic feet per second is 6.1 feet. This stage is then added to the gage datum of 53.88 feet to get an elevation of 60 feet. This elevation is then compared to the elevation of the land where the wetland determination is to be made. Any land below the elevation 60 on the flood plain would be inundated for at least 15 days by out-of-bank flooding during the growing season in 50 percent of the years, thus meeting the wetland criterion used.

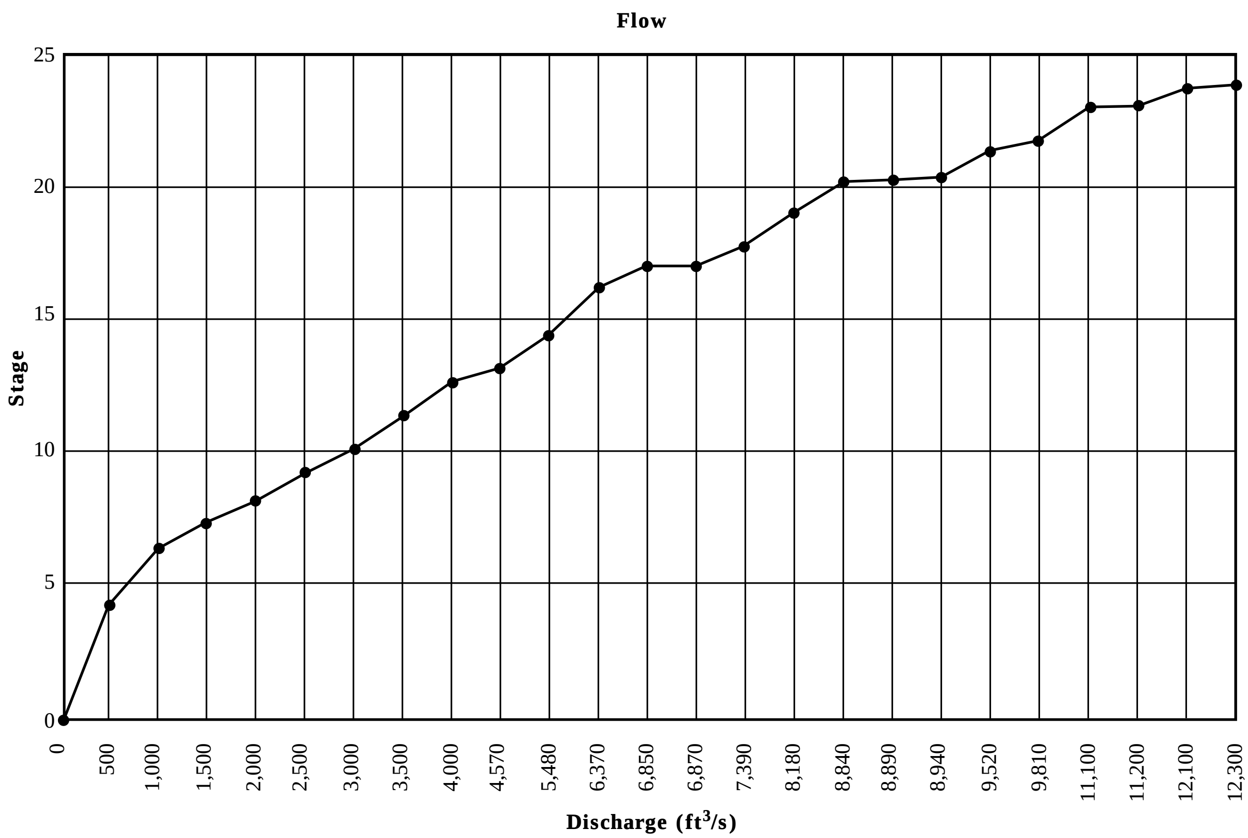
It should be noted that this elevation applies only in the immediate vicinity of the stream gage. If the area in question extends either far downstream or upstream of the road, water surface profiles would be required to determine the elevation.

In this procedure we assume that there are no levees between the stream and potential wetland.

Table 19–2 15-day duration elevation, 1986–1991

Year	Month-day	Discharge	Ranked
1986	3–25	444	2529
1987	4–15	1,300	1300
1988	4–27	513	1240
1989	5–11	2,529	679
1990	4–12	1,240	513
1991	3–12	679	444

Figure 19–2 Stage versus discharge plot for Tar River at Rocky Mount, North Carolina



Example 19–3 Water discharge records for Pamlico River Basin

Pamlico River Basin—02082585 Tar River at NC 97 at Rocky Mount, NC

Location—Lat 35°57'15", long 77°47'15", Edgecombe County, Hydrologic Unit 03020101, on left bank 20 feet downstream from bridge on NC 97, 0.5 mile upstream from Cowlick Branch, and 1.0 mile north-northeast of Rocky Mount.

Drainage area—925 square miles.

Water-Discharge Records

Period of Record—August 1976 to current year.

Revised Records—WDR NC-81-1: Drainage area.

Gage—Water-stage recorder. Datum of gage is 53.88 ft. above National Geodetic Vertical Datum of 1929.

Remarks—No estimated daily discharges. Records good except those below 10 ft^3/s, which are fair. Some regulation at low flow by mill above station. The city of Rocky Mount diverted an average of 17.8 ft^3/s for municipal water supply, most of which was returned as sewage below station.

Cooperation—Chemical and biological data shown in last table were provided by the North Carolina Department of Natural Resources and Community Development.

Average Discharge—10 years, 906 ft^3/s, 13.30 in/yr.

Extremes for Period of Record—Maximum discharge, 12,300 ft^3/s May 1, 1978, gage height, 23.66 ft; minimum, 6.1 ft^3/s Oct. 2, 1983, gage height, 2.84 ft.

Extremes for Current Year—Maximum discharge, 8,180 ft^3/s Nov. 26, gage height, 19.06 ft; minimum, 8.3 ft^3/s July 3, gage height, 2.96 ft.

Discharge, in cubic feet per second, water year October 1985 to September 1986 (mean values)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	75	138	2670	403	655	897	494	249	264	101	46	696
2	242	140	3980	406	597	98	473	223	194	109	51	490
3	413	139	4430	444	542	710	459	211	164	20	210	368
4	234	419	2870	458	529	189	441	197	149	16	123	252
5	78	876	1280	472	512	102	440	158	139	26	77	202
6	116	2400	968	439	484	145	441	127	134	43	66	246
7	129	3200	834	378	495	152	502	138	135	54	226	197
8	139	2140	746	358	500	153	617	97	153	58	124	239
9	134	721	658	339	527	154	681	83	142	60	88	197
10	127	456	612	319	518	155	579	83	134	62	98	118
11	162	361	565	313	550	245	587	82	129	64	182	155
12	65	322	547	347	582	360	357	82	126	64	423	213
13	110	738	738	337	632	407	421	82	123	64	363	188
14	102	34	930	332	665	717	400	102	118	30	491	134
15	104	77	1650	313	597	1430	391	106	128	51	1060	210
16	104	119	1310	304	549	2880	330	106	106	50	823	58
17	104	148	907	298	532	3510	185	105	108	55	449	114
18	106	197	742	296	520	2440	240	112	106	53	313	109
19	109	136	630	344	1590	1160	302	113	105	54	715	106
20	111	247	571	467	932	1070	327	125	104	54	1230	108
21	141	369	528	553	1670	1420	344	175	106	53	1150	107
22	143	1670	499	512	1140	1580	338	840	93	54	2440	104
23	146	3990	474	423	675	1330	356	1410	57	49	3250	102
24	132	5250	481	374	576	883	341	790	61	47	2950	99
25	143	6640	482	361	549	444	323	441	83	46	899	96
26	159	7970	470	612	549	657	312	319	88	45	519	95
27	154	6170	425	1100	569	634	297	260	90	53	299	120
28	143	1300	393	1750	584	592	276	315	92	58	1260	73
29	133	868	395	1420	—	560	269	300	260	53	1260	173
30	128	1370	399	960	—	529	257	274	140	52	2520	55
31	128	—	391	757	—	505	—	299	—	48	1940	—
Total	4312	48605	32575	16189	18820	26977	11780	8004	3841	1676	25635	5454
Mean	139	1620	1051	522	672	870	393	258	128	54.1	827	182
Max	413	7970	4430	1750	1670	3510	681	1410	264	109	3250	696
Min	65	34	391	296	484	102	185	82	57	16	46	55
CFSM	.15	1.75	1.14	.56	.73	.94	.42	.28	.14	.06	.89	.20
In	.17	2.0	1.3	.65	.76	1.1	.47	.32	.15	.07	1.0	.22

Cal YR 1985 Total 275431 Mean 755 Max 7970 Min 34 CFSM .82 In 11
WRT YR 1986 Total 203870 Mean 559 Max 7970 Min 16 CFSM .60 In 8.2

Example 19–3 Water discharge records for Pamlico River Basin—Continued

Pamlico River Basin—02082585 Tar River at NC 97 at Rocky Mount, NC

Location—Lat 35°57'15", long 77°47'15", Edgecombe County, Hydrologic Unit 03020101, on left bank 20 feet downstream from bridge on NC 97, 0.5 mile upstream from Cowlick Branch, and 1.0 mile north-northeast of Rocky Mount.

Drainage area—925 square miles.

Water-Discharge Records

Period of Record—August 1976 to current year.

Revised Records—WDR NC-81-1: Drainage area.

Gage—Water-stage recorder. Datum of gage is 53.88 ft above National Geodetic Vertical Datum of 1929.

Remarks—No estimated daily discharges. Records good. Some regulation at low flow by mill above station. The city of Rocky Mount diverted an average of 17.8 ft^3/s for municipal water supply, most of which was returned as treated effluent below station.

Cooperation—Chemical and biological data shown in last table were provided by the North Carolina Department of Natural Resources and Community Development.

Average Discharge—11 years, 928 ft^3/s, 13.62 in/yr.

Extremes for Period of Record—Maximum discharge, 12,300 ft^3/s May 1, 1978, gage height, 23.66 ft; minimum, 6.1 ft^3/s Oct. 2, 1983, Oct 10, 1986; minimum gage height, 2.84 ft Oct 2, 1983.

Extremes for Current Year—Maximum discharge, 12,100 ft^3/s Apr 18, gage height, 23.55 ft; minimum, 6.1 ft^3/s Oct 10, minimum gage height, 2.86 ft Dec 4.

Discharge, in cubic feet per second, water year October 1986 to September 1987 (mean values)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	56	74	161	713	1330	6660	1730	1080	313	228	100	69
2	79	80	122	1800	1660	8390	1670	951	247	197	102	45
3	139	134	139	2910	1480	8830	1310	996	296	144	101	46
4	28	11	27	3751	1450	8220	1150	976	379	116	100	46
5	87	145	283	2250	1370	8660	1170	935	395	57	94	268
6	81	34	437	1091	1150	8170	1230	857	456	287	91	115
7	81	86	355	791	959	3370	1110	728	345	346	102	77
8	85	158	283	634	846	1420	964	653	316	269	97	78
9	274	43	246	546	725	1290	569	613	260	210	98	63
10	63	156	260	518	673	2890	777	555	213	172	107	72
11	12	26	216	519	601	4300	725	497	190	164	89	80
12	17	46	310	484	562	5540	738	469	177	165	84	173
13	57	83	710	450	528	5750	844	448	165	144	84	331
14	94	85	959	420	524	4190	835	412	159	127	83	608
15	112	120	632	390	505	1820	1300	395	247	117	94	777
16	16	115	459	376	518	1410	6550	319	161	113	87	503
17	142	106	337	375	783	1270	10100	449	242	110	79	347
18	21	102	317	744	1140	1190	11800	428	415	116	75	211
19	80	109	294	4160	1490	1240	11200	356	948	113	75	155
20	79	111	275	6920	1700	1690	10700	605	635	109	72	664
21	78	111	255	7470	1710	1620	9490	762	414	105	70	514
22	76	110	248	8070	1940	1580	5620	902	322	103	71	418
23	73	111	231	9110	4110	1240	2080	730	325	103	66	273
24	72	193	653	9510	5160	1030	1560	553	350	101	57	226
25	78	25	1040	8850	5880	2000	2930	470	491	107	55	170
26	144	144	1890	6730	5900	156	4730	367	547	107	53	142
27	28	47	3100	3000	5890	466	4560	394	353	102	48	123
28	69	134	1950	1860	5770	1140	2730	405	428	102	44	105
29	84	111	855	1430	—	2270	1970	436	292	103	44	230
30	137	46	589	1250	—	3320	1260	320	270	99	49	88
31	14	—	459	1160	—	2400	—	109	—	98	99.2	—
Total	2456	2855	18092	88280	56354	103222	103402	18380	10261	4434	2470.2	7020
Mean	79.2	95.2	584	2848	2013	3330	3447	593	342	143	79.7	234
Max	274	193	3100	9510	5900	8830	11800	1080	948	346	407	777
Min	12	11	24	675	505	156	725	319	159	57	44	46
CFSM	.09	.10	.63	3.08	2.18	3.60	3.73	.64	.37	.15	.09	.25
Inch	.10	.11	.73	3.55	2.27	4.15	4.16	.74	.41	.18	.10	.28

Cal Yr 1986	Total 141779.0	Mean 388	Max 3510	Min 11	CFSM .42	In. 5.70
WTR Yr 1987	Total 417226.2	Mean 1143	Max 11800	Min 11	CFSM 1.24	In. 16.8

Example 19–3 Water discharge records for Pamlico River Basin—Continued

Pamlico River Basin—02082585 Tar River at NC 97 at Rocky Mount, NC

Location—Lat 35°57'15", long 77°47'15", Edgecombe County, Hydrologic Unit 03020101, on left bank 20 feet downstream from bridge on NC 97, 0.5 mile upstream from Cowlick Branch, and 1.0 mile north-northeast of Rocky Mount.
Drainage area—925 square miles.
Period of Record—August 1976 to current year.
Revised Records—WDR NC-81-1: Drainage area.
Gage—Water-stage recorder. Datum of gage is 53.88 ft above National Geodetic Vertical Datum of 1929.
Remarks—Records good except for estimated daily discharges, which are fair. Some regulation at low flow by mill above station. The city of Rocky Mount diverted an average of 19.9 ft^3/s for municipal water supply, most of which was returned as sewage below station. Minimum discharge for period of record and current water year also occurred on Sep. 24; result of temporary regulation.

Discharge, cubic feet per second, water year October 1987 to September 1988 (daily mean values)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	21	70	499	1120*	587	365	475	482	174	140	67	84
2	82	97	474	*800	566	301	350	319	144	126	111	49
3	104	97	378	*850	722	379	404	408	13	126	39	126
4	107	94	292	*1300	916	407	457	278	207	242	111	98
5	102	140	243	*1880	1229	43	416	600	225	168	118	113
6	103	115	211	*2150	2160	510	396	751	230	82	79	87
7	123	100	170	*1680	1970	488	415	916	209	59	80	86
8	110	96	78	*1180	1210	472	460	816	162	65	93	73
9	109	81	69	*780	924	470	365	668	175	97	130	77
10	119	75	101	*750	815	460	482	530	179	73	83	85
11	126	78	133	*692	876	546	444	474	142	169	26	114
12	114	75	175	*600	1790	710	418	423	158	143	121	101
13	111	121	206	*570	2210	736	523	239	218	127	100	76
14	109	140	208	*560	2430	623	765	239	167	118	54	72
15	105	78	308	526	1840	560	872	276	124	121	60	90
16	108	69	350	377	1310	504	792	291	106	122	133	86
17	111	73	477	448	4080	458	668	315	102	120	121	85
18	111	63	564	695	952	415	520	362	248	103	62	71
19	104	98	458	956	891	484	669	274	250	54	75	57
20	102	96	364	1490	702	518	1190	570	190	107	88	59
21	101	108	342	1910	814	532	1840	486	281	104	99	64
22	102	81	342	2270	684	541	1640	402	358	123	116	162
23	104	79	383	1770	674	505	1071	268	372	124	131	101
24	108	132	415	1160	587	448	819	371	303	111	90	33
25	180	74	388	900	549	420	636	255	241	110	44	149
26	224	93	356	898	520	411	572	356	176	108	45	100
27	115	106	358	1000	510	503	513	243	194	120	47	233
28	107	156	638	1120	405	626	370	245	162	242	95	187
29	85	292	1030	948	454	655	560	243	141	126	64	137
30	20	465	1850	733	—	578	511	243	158	125	121	11
31	32	—	1720	567	—	509	—	240	—	93	64	—
Mean	105	155	438	1054	1047	505	654	406	200	120	86.1	98.9
Max	224	465	1850	2270	2430	736	1840	916	372	242	133	233
Min	20	63	69	377	405	301	350	239	102	54	26	33
Inch	.13	.01	.55	1.31	1.22	.63	.79	.51	.24	.15	.11	.12

*Estimated

Statistics of monthly flow data for period of record, by water year (WY)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	220.2	561.4	819.0	1568	1624	1994	1646	896.2	682.3	384.3	336.1	218.5
Max	566.8	1905	1720	3230	3280	3577	3447	2361	2238	1316	826.9	805.1
(WY)	1980	1980	1984	1978	1983	1983	1987	1978	1982	1984	1986	1979
Min	70.4	74.5	141.9	254.0	546.3	476.9	359.3	258.2	128.0	54.1	79.7	84.3
(WY)	1981	1981	1981	1981	1977	1981	1981	1986	1986	1986	1987	1980

Summary statistics	1988 water year		Period of record	
Average flow	400.4		883.9	
Highest annual mean			1500	1984
Lowest annual mean			261.9	1981
Highest daily mean	2430	Feb 14	12100	May 1, 1978
Lowest daily mean	20	Oct 30	6.6	Oct 3, 1983
Instantaneous peak flow	2510	Feb 14	12300	May 1, 1978

Summary statistics	1988 water year		Period of record	
Instantaneous peak stage	8.94	Feb 14	23.66	May 1, 1978
Instantaneous low flow	5.7	Sep 23	5.7	Sep 23, 1988
Annual runoff (inches)	5.88		13.0	
10 percentile	890		2190	
50 percentile	238		406	
98 percentile	65		70	

Example 19–3 Water discharge records for Pamlico River Basin—Continued

Pamlico River Basin—02082585 Tar River at NC 97 at Rocky Mount, NC

Location—Lat 35°57'15", long 77°47'15", Edgecombe County, Hydrologic Unit 03020101, on left bank 20 feet downstream from bridge on NC 97, 0.5 mile upstream from Cowlick Branch, and 1.0 mile north-northeast of Rocky Mount.
Drainage area—925 square miles.
Period of Record—August 1976 to current year.
Revised Records—WDR NC-81-1: Drainage area.
Gage—Water-stage recorder. Datum of gage is 53.88 ft above National Geodetic Vertical Datum of 1929.
Remarks—Records good except for estimated daily discharges, which are fair. Some regulation at low flow caused by mill above station. The city of Rocky Mount diverted an average of 19.4 ft^3/s for municipal water supply, most of which was returned as treated effluent below station. Minimum discharge for period of record and current water year, result of temporary regulation.

Discharge, cubic feet per second, water year October 1988 to September 1989 (mean daily values)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	143	631	1160	350	303	5960	2310	7310	60	1220	509	401
2	103	1440	730	483	302	6680	2890	9200	198	804	813	347
3	20	2900	563	772	306	3750	1940	8920	314	560	1290	301
4	331	2670	420	943	284	7260	1370	7950	338	509	1040	278
5	126	1240	364	727	340	5780	1300	6750	599	473	748	270
6	99	821	305	597	410	5150	2820	5590	1040	491	510	137
7	81	639	272	520	560	6200	4030	4590	1350	524	420	183
8	365	571	248	476	674	4850	6110	4860	1440	643	419	185
9	240	451	249	462	666	5310	6510	4100	1420	893	369	183
10	181	392	262	493	700	5630	6050	2948	1250	653	342	212
11	151	316	259	515	638	4560	5740	2529	1030	489	303	145
12	143	274	264	667	546	3060	3930	2298	775	389	312	155
13	101	249	272	754	472	2290	2090	1780	873	362	353	*150
14	50	226	1100	872	436	2030	1620	1360	1030	402	413	*160
15	50	210	624	1070	406	2510	1790	1100	1200	779	416	*200
16	55	200	119	972	370	2720	2470	1480	1100	1160	751	*250
17	67	233	69	809	411	2360	3400	1560	1770	1610	900	*220
18	66	238	128	680	589	2970	2700	1400	2750	3310	1430	*190
19	126	247	120	601	779	2320	1750	1180	2380	4250	2990	*180
20	89	288	121	546	1040	1910	1450	909	1650	4540	4250	*170
21	136	263	115	488	2010	1740	1130	794	2360	2160	2600	*180
22	150	256	111	447	4920	1400	990	832	3390	872	1020	*170
23	189	245	113	402	6870	2050	937	501	3320	674	711	*180
24	201	235	149	387	7760	4950	864	725	2320	504	503	*170
25	28	210	204	366	7760	6680	770	697	1900	477	463	*160
26	240	204	237	359	8270	7500	1830	560	2000	415	1500	*200
27	188	207	243	342	7080	7170	2590	570	1320	374	2160	*300
28	151	243	259	331	5180	7070	3300	507	904	329	1090	*240
29	130	780	224	329	—	4610	2610	459	720	335	694	*220
30	120	1170	225	318	—	1790	4830	398	803	345	533	*180
31	129	—	261	302	—	1750	—	433	—	392	443	—
Mean	148	592	316	561	2146	4301	2733	2725	1699	998	977	211
Max	365	2900	1160	1070	8270	7500	6510	9200	3390	4540	4250	401
Min	20	200	69	302	284	1400	770	398	198	329	303	137
In.	.18	.71	.39	.70	2.42	5.36	3.30	3.40	1.69	1.24	1.22	.25

* Estimated

Statistics of monthly flow data for period of record, by water year (WY)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	214.7	563.8	780.3	1491	1664	2172	1452	1037	737.5	461.5	385.4	217.9
Max	566.8	1905	1720	3230	3280	4301	3447	2725	2238	1316	977.3	805.1
(WY)	1980	1980	1984	1978	1983	1989	1987	1989	1982	1984	1989	1979
Min	7034	74.5	141.9	254.0	546.3	476.9	359.3	258.2	128.0	54.1	79.7	84.3
(WY)	1981	1981	198=1	1981	1977	1981	1981	1986	1986	1986	1987	1980

Summary statistics	1989 water year		Period of record	
Average flow	1422		925.3	
Highest annual mean		1500	1984	
Lowest annual mean		261.9	1981	
Highest daily mean	9200	May 2	12100	May 1, 1978
Lowest daily mean	20	Oct	6.6	Oct 3, 1983
Instantaneous peak flow	9520	May 2	12300	May 1, 1978

Summary statistics	1989 water year		Period of record	
Instantaneous peak stage	21.23	May 2	23.66	May 1, 1978
Instantaneous low flow	5.9	Oct 6	5.7	Sep 23, 1988
Annual runoff (inches)	20.9		13.6	
10 percentile	4400		2310	
50 Percentile	579		419	
95 percentile	121		72	

Example 19–3 Water discharge records for Pamlico River Basin—Continued

Pamlico River Basin—02082585 Tar River at NC 97 at Rocky Mount, NC

Location—Lat 35°57'15", long 77°47'15", Edgecombe County, Hydrologic Unit 03020101, on left bank 20 feet downstream from bridge on NC 97, 0.5 mile upstream from Cowlick Branch, and 1.0 mile north-northeast of Rocky Mount.
Drainage area—925 square miles.
Period of Record—August 1976 to current year.
Revised Records—WDR NC-81-1: Drainage area.
Gage—Water-stage recorder. Datum of gage is 53.88 ft above National Geodetic Vertical Datum of 1929.
Remarks—Records good except for estimated daily discharges, which are fair. Some regulation at low flow caused by mill above station. The city of Rocky Mount diverted an average of 19.4 ft³/s for municipal water supply, most of which was returned as treated effluent below station. Minimum discharge for period of record and current water year, result of temporary regulation.

Discharge, cubic feet per second, water year October 1989 to September 1990 (mean daily values)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	*513	*388	*410	1020	1350	1100	7160	1360	3140	160	64	1130
2	1010	*400	*320	1230	1180	1070	6330	2430	1390	170	59	657
3	2190	*809	*250	1730	1070	1440	6350	2340	860	222	89	382
4	3640	*1480	*200	1440	1040	1690	5600	2250	1100	315	76	286
5	4300	*1860	*460	1120	865	1830	5770	2250	880	367	101	245
6	2990	*1270	864	1080	1330	1600	5750	2310	732	264	89	202
7	963	*896	274	1110	1550	1220	3640	2330	596	278	79	187
8	673	*608	1260	1720	1200	1070	2170	1850	485	145	73	163
9	798	*758	1980	2300	1090	985	2430	1160	464	157	172	165
10	459	*1210	3270	3130	1780	930	1750	952	414	136	2470	230
11	*395	*1990	2590	3440	2390	627	1650	1270	362	132	1700	231
12	*372	*1400	2140	2070	3530	890	1240	2510	343	127	971	235
13	*340	*966	3550	1390	370	855	1130	2160	320	123	514	01
14	*319	*722	4620	1160	2260	781	1030	1200	302	186	341	252
15	*303	*964	5400	1030	1400	751	973	963	280	318	290	280
16	*296	*869	5580	942	1240	767	978	805	270	329	246	153
17	*289	*1420	4140	905	1570	789	1450	705	263	387	283	158
18	*309	*1100	2260	869	3080	1450	1390	608	256	554	255	315
19	*851	*900	2040	827	4690	1920	1150	551	269	237	239	82
20	*2690	*780	1941	819	5100	1940	1020	447	248	373	316	289
21	*2930	*670	2770	1281	3990	1350	892	444	197	305	307	96
22	*1940	*900	1600	1620	2800	1050	822	586	256	238	252	31
23	*1170	*1200	1100	1720	1940	911	829	846	308	190	375	49
24	*783	*1600	923	1420	2140	828	840	1000	323	83	2620	77
25	*608	*2100	870	1140	2280	789	792	861	315	109	4440	88
26	*515	*2900	797	1260	1800	754	717	683	286	93	3590	135
27	*462	*1700	270	1990	1360	719	664	596	244	81	211	28
28	*433	*1050	211	3160	1170	712	608	663	172	76	1640	32
29	*409	*740	221	2820	—	2320	551	1580	206	92	972	46
30	*400	*530	162	1650	—	5680	829	2430	123	78	1290	74
31	*401	—	774	1420	—	6930	—	3250	—	74	1270	—
Mean	1079	1130	1708	1575	2109	1485	2207	1401	513	205	880	217
Max	4300	2900	5580	3440	5100	6930	7160	3250	3140	554	4440	1130
Min	289	388	162	819	865	712	551	444	123	74	59	28
In.	1.35	1.36	2.13	1.96	2.38	1.85	2.66	1075	.62	.26	1.10	.26

* Estimated

Statistics of monthly flow data for period of record, by water year (WY)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	276.4	604.2	846.6	12497	1696	2123	1805	1063	721.5	415.3	420.8	217.8
Max	1079	1905	1720	3230	3280	4301	3447	2725	2238	1316	977.3	805.1
(WY)	1990	1980	1984	1978	1983	1989	1987	1989	1982	1984	1989	1979
Min	70.1	74.5	141.9	254.0	546.3	476.9	359.3	258.2	128.0	5431	79.7	84.3
(WY)	1981	1981	1981	1981	1977	1981	1981	1986	1986	1986	1987	1980

Summary statistics	1990 water year		Period of record	
Average flow	1204		945.2	
Highest annual mean		1500	1981	
Lowest annual mean		261.9	1981	
Highest daily mean	7160	Apr 1	12100	May 1, 1978
Lowest daily mean	28	Sep 27	6.6	Oct 3, 1983
Instantaneous peak flow	7390	Apr 1	12300	May 1, 1978

Summary statistics	1990 water year		Period of record	
Instantaneous peak stage	7.74	Apr 1	23.66	May 1, 1978
Instantaneous low flow	8.6	Sep 19	5.7	Sep 23, 1988
Annual runoff (inches)	17.7		13.9	
10 percentile	2670		2350	
50 Percentile	860		437	
95 percentile	86		73	

Example 19–3 Water discharge records for Pamlico River Basin—Continued

Pamlico River Basin—02082585 Tar River at NC 97 at Rocky Mount, NC

Location—Lat 35°57'15", long 77°47'15", Edgecombe County, Hydrologic Unit 03020101, on left bank 20 feet downstream from bridge on NC 97, 0.5 mile upstream from Cowlick Branch, and 1.0 mile north-northeast of Rocky Mount.
Drainage area—925 square miles. Period of Record—August 1976 to current year. Revised Records—WDR NC-81-1: Drainage area.
Gage—Water-stage recorder. Datum of gage is 53.88 ft above National Geodetic Vertical Datum of 1929.
Remarks—No estimated daily discharges. Records good. Some regulation at low flow caused by mill above station. The city of Rocky Mount diverted an average of 24.1 ft^3/s for municipal water supply, most of which was returned as treated effluent below station. Minimum discharge for period of record and current water year, result of temporary regulation. Gage-height telemeter at station.

Discharge, cubic feet per second, water year October 1990 to September 1991 (mean daily values)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	79	222	843	823	821	1990	4371	915	267	87	419	192
2	102	201	700	1410	767	667	4810	1290	175	94	413	128
3	58	191	526	1290	686	359	3838	877	212	133	226	98
4	64	177	449	4111	634	1470	1310	612	168	109	205	98
5	68	168	392	924	688	2791	957	468	301	123	175	98
6	192	161	512	805	58	3358	847	463	247	118	103	119
7	139	148	616	960	898	1930	813	342	282	113	118	210
8	119	147	632	1870	669	1200	744	369	185	105	93	164
9	117	141	601	3230	801	992	674	347	142	90	105	133
10	118	345	581	4000	762	858	670	323	128	85	162	102
11	136	308	558	3180	681	749	576	3873	105	131	165	101
12	93	338	509	2850	613	679	550	291	96	89	137	89
13	108	446	437	4200	582	679	495	286	96	101	341	106
14	107	381	375	5200	573	836	584	257	91	107	259	119
15	96	297	224	5471	496	1091	544	288	141	115	889	117
16	123	249	329	4391	585	1380	308	362	137	104	847	118
17	131	228	384	1690	472	1050	745	134	93	109	672	117
18	146	211	366	1610	477	1060	727	156	102	103	429	105
19	144	200	370	1520	489	1440	565	330	96	84	240	97
20	133	183	370	1630	527	2310	889	599	155	92	196	118
21	124	215	532	1930	612	1790	775	805	149	71	154	116
22	121	156	879	2780	654	1180	744	860	141	77	132	82
23	231	194	1220	2120	684	961	754	715	107	82	130	67
24	344	190	1140	1340	563	952	793	509	95	80	109	102
25	1510	197	842	1120	526	897	653	406	89	75	89	107
26	1490	198	652	969	515	796	511	327	99	69	8	117
27	822	198	521	886	517	129	471	274	108	77	141	111
28	610	209	601	824	562	662	477	272	101	100	135	105
29	454	416	637	784	—	689	453	340	89	305	132	104
30	313	895	687	779	—	1390	625	314	90	545	156	102
31	258	—	723	833	—	3150	—	287	—	423	184	—
Total	8550	7500	18200	32577	16983	39115	31474	14141	4209	4004	7633	3442
Mean	276	253	587	2019	607	1262	1049	456	140	129	246	115
Max	1510	865	1220	5470	521	3358	4810	1290	301	545	889	210
Min	58	141	224	779	472	359	453	134	89	69	87	67
CFSM	.30	.27	.63	2.18	.66	1.36	1.13	.49	.15	.14	.27	.12
In.	.34	.30	.73	2.52	.68	1.57	1.27	.57	.17	.16	.31	.14
Mean	276	501	829	1531	1623	2065	1476	1022	683	396	409	211
Max	1079	1905	1720	3230	3260	4301	3447	2725	2238	1316	977	805
(WY)	1990	1980	1984	1978	1983	1989	1987	1989	1982	1984	1989	1979
Min	70.4	74.5	142	254	546	477	359	258	128	54.1	79.7	84.3
(WY)	1981	1981	1981	1981	1977	1981	1981	1986	1986	1986	1987	1980

Summary statistics	1990 calendar year		1991 water year		1977-1991 water years	
Annual total	353444		217908			
Annual mean	9678		597		922	
Highest annual mean				1500	1984	
Lowest annual mean				262	1981	
Highest daily mean	7160	Apr 1	5470	Jan 15	12100	May 1, 1978
Lowest daily mean	28	Sep 27	58	Oct 3	6.6	Oct 3, 1983
Annual 7-day minimum	60	Sep 27	76	Jul 21	40	Jul 3, 1986
Instantaneous peak flow			5480	Jan 15	12300	May 1, 1978
Instantaneous peak stage			14.43	Jan 15	23.66	May 1, 1978
Instantaneous low flow			7.2	Nov 1	5.7	Sep 23, 1988
Annual runoff (CFSM)	1.05		.68		1.00	
Annual runoff (inches)	14.21		8.76		13.54	
10 percentile	2290		1250		2280	
50 Percentile	601		344		430	
95 percentile	118		98		99	

650.1902 Runoff volumes

(a) Introduction

Four tools are presented that deal with runoff volumes. Three of them can be used to compute surface runoff volumes on a daily, monthly, seasonal, or annual basis. Selection of the tool depends upon the data available and the intended use of the results. These tools are used to

- Obtain runoff data from stream gage records.
- Run SPAW or other daily simulation model, such as SWRRBWQ.
- Manually compute daily runoff using rainfall gage data and seasonally adjusted runoff curve numbers.
- Determine the duration and frequency of surface flooding of depressional areas.

Each tool is presented separately in its respective section. The first three tools generally are used to provide data for the fourth tool.

(b) Tool to obtain runoff data from stream gage records

(1) Applicable situations for use

Runoff data from a stream gage are appropriate for use if stream gage data are available. Daily, monthly, seasonal, or annual runoff volumes can be used directly as inflow into potential wetlands. A frequency curve of runoff volumes is generally developed and used with physical characteristics of a potential wetland to determine the frequency and duration of flooding from surface sources.

(2) Data required

The drainage area of the stream gage should be in the same range of magnitude as the area for which runoff is needed. A maximum drainage area of the stream gage is 20 square miles. With significant differences in drainage areas, the chance is greater that base flow and total runoff volumes will differ.

Runoff varies significantly with differences in climate, land cover, and soils. The climate, land cover, and soils of the stream gage's drainage area should be similar to that of the area for which runoff is needed.

The data should be relatively long-term, current, complete, and error free. Generally, a minimum of 20 continuous years of data is considered to be long-term.

(3) Sources of data

Gages have been operated on many streams and lakes by various Federal, State, and local agencies. Stream and lake gage readings are available from the Corps of Engineers, TVA, USGS, NOAA, BOR, various highway departments, and State or local public works agencies.

The gage data published include mean daily discharge, peak stage and discharge for flood events, and mean daily lake level. The primary source of these data is the USGS Water Resources Data publications. Private vendors have loaded these data on compact disks for sale or lease. NRCS National Water and Climate Center has archived some stream gaged data.

(4) Limitations

Knowledge and experience required—A general knowledge of runoff is needed to use this tool.

Factors affecting the accuracy of results—The drainage area of the stream gage is assumed to be representative of the drainage area of concern. Any significant differences will reduce the accuracy of the results of this tool. This tool does not have the capability to determine the impact of land cover on runoff. An advantage of using this tool is that runoff data from one stream gage may be usable for several sites. Caution should be used when transferring stream gage data from one watershed to another. However, this tool will provide information about the general hydrology of a site. A water budget of the site will provide information regarding the frequency and duration of inundation.

(5) Methodology

Step 1—Obtain the long-term daily surface runoff volumes for representative gages. Long-term is defined as 20 years or more of data. The stream drainage area should be limited to approximately 20 square miles or less.

Step 2—Verify that the runoff data meet the limitations listed.

Step 3—If these data are not in inches of depth, perform the conversion. See National Engineering Handbook, Section 4 (NEH-4), Hydrology, chapter 22 for the appropriate conversion factor.

Step 4—If durations other than daily are required, sum the daily values for the period desired.

Step 5—Develop a frequency curve of runoff for the selected time period using the statistical techniques in chapter 18, NEH-4.

(c) Tool to run daily simulation model, such as SPAW

(1) Applicable situations for use

Runoff data from a daily simulation model are appropriate for use. Daily, monthly, seasonal, or annual runoff volumes can be used directly as inflow into potential wetlands. A frequency curve of runoff volumes is developed and used with physical characteristics of a potential wetland to determine the frequency and duration of flooding from surface sources.

(2) Data required

The data required to use this tool are:

- Daily precipitation and temperature data from a nearby climate station.
- Soil, plant, land cover, and slope data.
- Planting and harvesting dates.
- Other data required by the selected model.

(3) Sources of data

Data can be obtained from the NRCS National Water and Climate Center, Portland, Oregon.

Soil data can be obtained from the Soil Survey Report.

Plant, land cover, and slope data should be obtained during a visit to the site.

(4) Limitations

Knowledge and experience required—A general knowledge of use of the selected model is needed.

Climatic regions of applicability—This tool is applicable in all climatic regions.

Factors affecting the accuracy of results—The accuracy is a function of the input data and the selected model. Most daily simulation models adjust the runoff curve number daily based on land cover, plant growth, and soil moisture accounting. Thus the accuracy is dependent on the soil moisture accounting procedure. The SPAW soil moisture accounting procedure has been evaluated and found satisfactory.

(5) Methodology

Step 1—Obtain data required for selected model.

Step 2—Run the selected model.

Step 3—If the model results are not in inches of depth, perform the conversion. See NEH-4, chapter 22 for the appropriate conversion factor.

Step 4—If the model results are not summarized for the required durations, sum the daily values for the period desired.

Step 5—Develop a frequency curve of runoff for the selected time period using the statistical techniques in Chapter 18, National Engineering Handbook, Section 4, Hydrology.

(d) Tool to manually compute daily runoff using precipitation data and seasonally adjusted runoff curve numbers

(1) Applicable situations for use

Runoff data computed manually are appropriate for use if precipitation data are available. Daily, monthly, seasonal, or annual runoff volumes can be used as inflow into potential wetlands. A frequency curve of runoff volumes is generally developed and used with physical characteristics of a potential wetland to determine the frequency and duration of flooding from surface sources.

(2) Data required

The data required to use this tool are:

- Daily precipitation data (30 years or more) from a representative climate station within the same climate area as the potential wetland site.
- Soil, plant, and land cover data.
- Planting and harvesting dates.

(3) Sources of information

Data can be obtained from the NRCS National Water and Climate Center, Portland, Oregon, through the state climatic data liaison.

Soil data can be obtained from the Soil Survey Report.

Plant, land cover, and slope data should be obtained during a visit to the site.

(4) Limitations

Knowledge and experience required—A general knowledge of NRCS Runoff Curve Number (RCN) procedure is needed. Chapter 9, NEH-4, will provide insights to RCN procedure. This procedure does not apply in areas with significant snowmelt.

Factors affecting the accuracy of results—The accuracy is a function of the input data. The runoff curve number is adjusted seasonally among six values depending upon land cover, plant growth, and the antecedent precipitation. The antecedent precipitation is used as an indicator of soil moisture. See table 19–3 for a relationship between antecedent precipitation and soil moisture.

This procedure assumes that the recorded rainfall for each day is from a separate storm. Thus, when a storm spans 2 days in the station record, the runoff is underestimated because the rainfall for the second and succeeding days is reduced by the initial abstraction. The error is partly compensated by increasing the RCN. Because it is most significant in humid climate areas, it is recommended that significant multiple-day rainfall events be considered to be single events.

Duration, frequency, and areal extent can be obtained using a detailed water budget of the potential site.

(5) Methodology

Step 1—Obtain daily precipitation data (30 years or more) from a representative climate station within the same climate area as the potential wetland site.

Step 2—Compute the average RCN of the drainage area of the potential wetland site using the procedures in the EFH, Chapter 2.

Step 3—Compute the seasonally adjusted RCN's of the drainage area of the potential wetland site using the procedures in the NEH-4, chapter 10 for each major stage of plant growth.

- Use the fallow RCN (Engineering Field Handbook [EFH], chapter 2, table 2–3) for cultivated crops between initial tillage operations and planting and whenever two-thirds of the soil surface is exposed.
- Use the average RCN between planting and the time when only a third of the soil surface is exposed.
- Use the normal peak growth RCN between the time when only a third of the soil surface is exposed during plant growth and the time when more than a third of the soil surface is exposed after harvest. Use RCN normal peak growth as 2 (RCN average) – RCN fallow.
- For pasture, meadow, and range, estimate the seasonal RCN by adjusting the hydrologic condition based on the ground cover and grazing conditions (EFH table 2–3b and c).

Step 4—Obtain the RCN for dry, average, and wet antecedent runoff conditions from NEH–4, table 10.1 for average, fallow, and normal plant growth conditions.

Step 5—For each RCN obtained, obtain the rainfall required before runoff will occur. This can be found in the column titled, Curve starts where P =, of NEH-4, table 10.1.

Step 6—Actual soil moisture data usually are not available; therefore, use the antecedent precipitation as an indication of the antecedent runoff condition. The only relationship between antecedent precipitation and runoff condition known to exist is shown in table 19–3. Antecendent runoff condition ARC is a measure of the runoff potential of the watershed prior to an event.

Table 19–3 Seasonal rainfall limits for ARC's

ARC	- - Total 5-day antecedent rainfall - -	
	dormant season (inches)	growing season (inches)
Dry	< 0.5	< 1.4
Average	0.5 to 1.1	1.4 to 2.1
Wet	> 1.1	> 2.1

Step 7—Using the computed seasonally adjusted RCN's, compute the daily runoff for each day that the rainfall is great enough to produce runoff. (See step 5.)

(6) Sample documentation

(i) Procedures used to analyze runoff events—The conventions used to determine runoff into depressional areas are the seasonal RCN for a wheat/fallow rotation on B hydrologic group soils. The procedure used to determine the change in runoff curve number for full growth is in NEH–4, chapter 10.

Full growth RCN equation:
RCN full growth = 2 (RCN average) – (RCN fallow)

Hydrologic soil group B curve numbers:
- Fallow RCN = 84
- Small grain RCN = 73.

$$\begin{aligned} RCN_{fg} &= 2(73) - 84 \\ &= 146 - 82 \\ &= 62 \end{aligned}$$

The full growth equation yields a RCN_{fg} = 62 for wheat.

The full growth RCN was used after harvest until the first fallow tillage operation was done or a third of the soil was exposed. The first tillage operation in western Kansas is typically not done until May of the year following harvest. It is expected that a third of the soil will not be exposed until November following a June harvest. Average RCN conditions may be used during periods after a third of the soil is exposed until the first tillage operation, and following planting until full plant growth. Fallow RCN conditions are used after the first tillage operation, or two-thirds of the soil is exposed until planting time. Table 19–4 displays the RCN used by month for wheat and fallow and the composite RCN used to determine runoff.

Also considered was the soil moisture condition when the rainfall event happened as to whether runoff would occur. Table 19–5 shows the RCN for dry ARC I, field capacity ARC II, wet ARC III, and the precipitation needed before runoff will occur.

Table 19–3 shows the precipitation amounts needed for dormant and growing season ARC conditions. Generally, a 5- to 10-day period of precipitation and other factors preceding the event were used to determine the ARC conditions.

Table 19–4 Runoff curve number (RCN) for wheat and fallow (50/50 rotation)—western Kansas

Month	Wheat	Fallow	Composite
Jun	62 harvest	84	73
Jul	62	84	73
Aug	62	84	73
Sep	62	84 plant	73
Oct	62	73	68
Nov	62	73	68
Dec	assumed all precipitation was snow		
Jan	assumed all precipitation was snow		
Feb	73	73	73
Mar	73	73	73
Apr	73	62	68
May	73	62	68

Table 19–5 Precipitation needed to produce runoff

ARC group	RCN	Precipitation (inches)
Dry conditions		
I	54	2.0
I	48	2.5
Field capacity conditions		
II	73	0.9
II	68	1.1
Wet conditions		
III	87	0.5
III	84	0.5

Rainfall gage data were analyzed for runoff events at gage locations of Lakin, Kearny County, Kansas. The Lakin gage was analyzed using 51 years of records that covered a 52-year period (fig. 19–3). Table 19–6 shows the number of times that the maximum yearly event occurred in that month.

The records showed that 11 of the 51 years did not have any runoff events. Records were not available for 1950. Figure 19–3 gives the number of runoff events, maximum runoff event by month and amount, and the total runoff for each year.

A frequency analysis was made on the maximum yearly event (fig. 19–4) and the total yearly runoff (fig. 19–5). There is a fifty percent probability of having 0.21 inch of total runoff in any given year and 0.16 inch of runoff on any given year from the maximum yearly runoff event. This compares to 0.20 inches of average annual runoff from the USGS Average Annual Runoff Map of the United States for years 1951 through 1980.

Table 19–6 Runoff event table, Lakin, Kansas

Month	Events occurring by month
March	1
April	2
May	10
June	10
July	5
August	7
September	2
October	3
November	0
Total	**40**

Figure 19–3 Summary of runoff events, maximum runoff event, and total runoff for 52-year reporting period, Kearny County, Kansas

Year	No. of Events	Runoff (in) — Month: March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total runoff for year
1990	3			0.54							0.87
1989	3			1.58							1.7
1988	0										0
1987	2			0.16							0.24
1986	0										0
1985	2							0.75			0.85
1984	1					0.25					0.25
1983	2				0.01						0.02
1982	3					0.25					0.29
1981	3							0.08			0.1
1980	4						0.19				0.24
1979	2						0.13				0.17
1978	2			0.33							0.37
1977	4			0.13							0.36
1976	0										0
1975	3				0.17						0.23
1974	1				0.3						0.3
1973	2	0.17									0.22
1972	3						0.14				0.16
1971	1				0.04						0.04
1970	2						0.12				0.13
1969	7				0.32						0.81
1968	2					0.39					0.45
1967	2				0.08						0.12
1966	1					0.05					0.05
1965	4								0.27		0.4
1964	1			0.16							0.16
1963	1				0.28						0.28
1962	0										0
1961	0										0
1960	1			0.27							0.27
1959	1								0.43		0.43
1958	2					0.05					0.07
1957	1				0.28						0.28
1956	1			0.03							0.03
1955	1		0.21								0.28
1954	3										0
1953	0										0
1952	0										0
1951	4			0.65							0.78
1950						No	data				N/A
1949	3				3.85						4.61
1948	3				0.1						0.27
1947	0										0
1946	7								0.7		1.01
1945	2						0.33				0.35
1944	3			0.28							0.42
1943	0										0
1942	4		0.69								0.8
1941	3				0.15						0.37
1940	2						0.32				0.57
1939	0										0

Figure 19–4 Annual runoff event probability for Lakin Gage, Kearny County, Kansas (estimated 50% chance annual runoff is 0.21 inch)

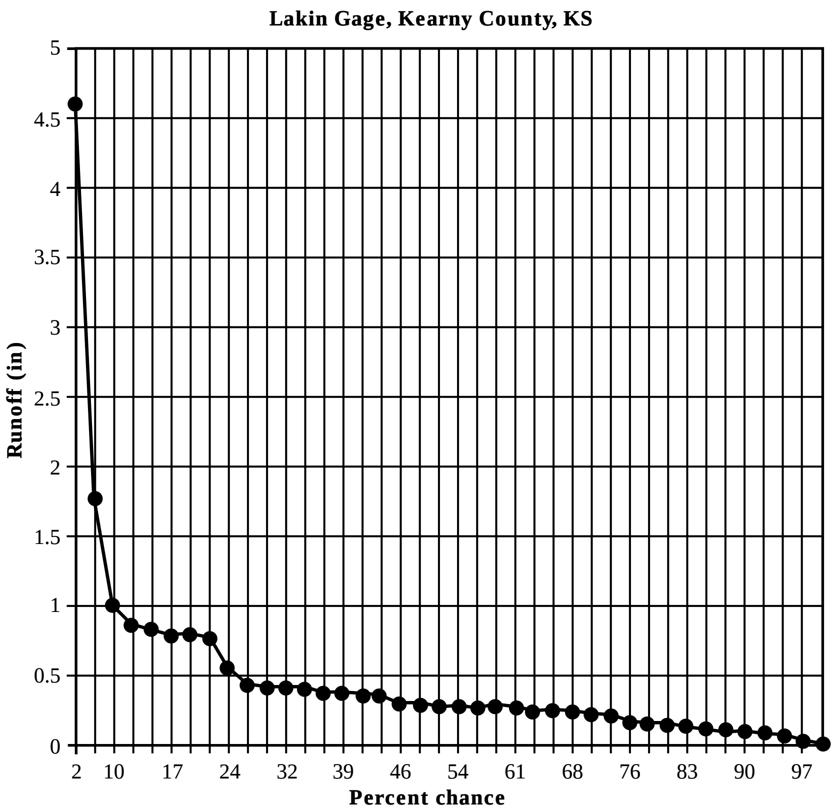
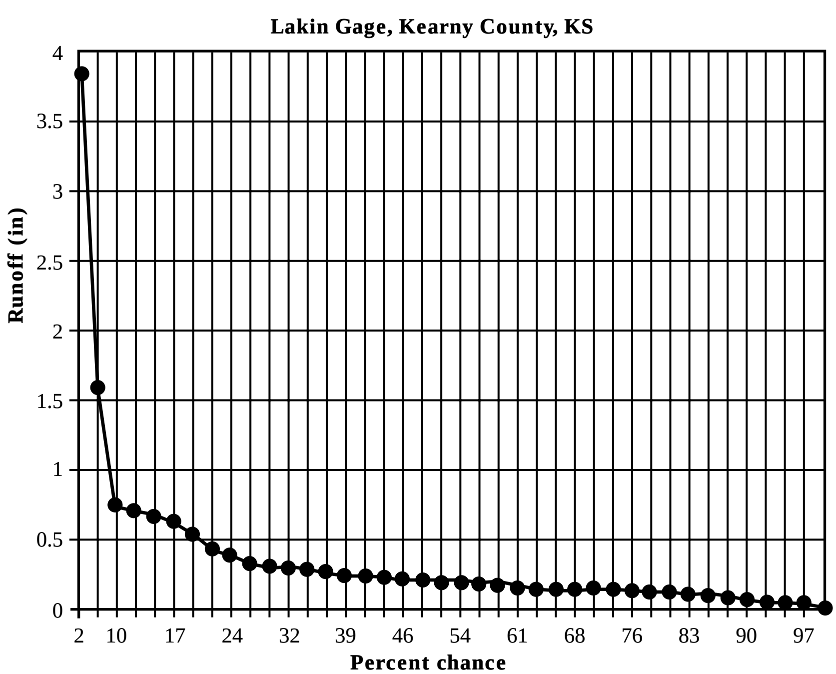


Figure 19–5 Monthly runoff probability for Lakin Gage, Kearny County, Kansas (estimated 50% chance maximum runoff is 0.16 inch)



(e) Tool to determine the duration and frequency of surface flooding of depressional areas

This tool can be used to determine the duration and frequency of surface flooding of depressional areas. It has two levels of application. The first level can be used to develop a relationship between a depressional area's drainage area and surface area. The second uses the relationship from the first level to determine if the depressional area clearly meets the wetland hydrology criteria or if additional study is needed.

(1) Applicable situations for use

Runoff data computed manually are appropriate for use if precipitation data are available. Daily, monthly, seasonal, or annual runoff volumes can be used directly as inflow into potential wetlands. A frequency curve of runoff volumes is generally developed and used with physical characteristics of a potential wetland to determine the frequency and duration of flooding from surface sources.

(2) Data required

The data required to use this tool are:

- Precipitation data (30 years or more) from a representative climate station within the same homogeneous climate area as the potential wetland site.
- Soil, plant, and land cover data.
- Planting and harvesting dates.

(3) Sources of information

Data can be obtained from the NRCS National Water and Climate Center, Portland, Oregon.

Soil data can be obtained from the Soil Survey Report. Plant, land cover, and slope data should be obtained during a visit to the site.

(4) Limitations

Knowledge and experience required—A general knowledge of the NRCS RCN procedure is needed.

Climatic regions of applicability—This tool is applicable in all climates.

Factors affecting the accuracy of results—The accuracy of results is dependent on the accuracy of the input data. The runoff curve number is adjusted seasonally among six values depending upon land cover, plant growth, and the antecedent precipitation. The antecedent precipitation is used as an indicator of soil moisture. See table 19-3 for a relationshop between antecendent precipitation and soil moisture.

(5) Methodology

Step 1—Sum the daily runoff values to obtain total annual runoff for each year.

Step 2—Tabulate the maximum daily runoff for each year.

Step 3—Using the appropriate statistical analysis (see NEH-4, chapter 18), compute the 50 percent chance value for the two sets of data from Steps 1 and 2.

Step 4—Compute the average total water losses in the depressional area for the period of time specified by the wetland hydrology criterion. To do this,

- Develop a water budget for the depression on a daily basis for the critical duration. The water budget for the depressional area is

$$\Delta S = I - L$$

where:

ΔS = change in water storage in the depressional area
I = inflow to the depressional area
L = losses from the depressional area

The formula for losses to the depressional area is

$$L = S_w + F + O + E_d$$

where:

L = total depressional water losses (in)
O = outflow from area (in)
S_w = soil-water holding capacity from 1/10 bar to 15 bar, or saturation to plant wilt (in) for a given depth (in) in soils
F = total infiltration for critical duration (in)
E_d = average evaporation from the depression for critical duration from growing season

The evaporation rates are from NOAA Technical Report NWS 34, December 1982. The soil infiltration rate and water holding capacity, at wilting point, are from soil survey data.

- Develop a relationship for the shape adjustment factor. This factor takes into account that the top area will always be greater than the base; thus, the base measurements are increased by the adjustment factor. The shape adjustment factor is explained further in section (6)(iii) on page 19–22.

- Solve the water budget equation for the 50 percent chance event.

  (50% chance runoff) $(\Delta_M) = (P_s)(P_a)(L)$

  where:
  P_s = playa storage adjustment fuction
  P_a = playa surface area
  L = playa loss
  Δ_M = minimum drainage area required to supply the runoff to satisfy duration criteria

  $\Delta_M = (P_s)(P_a)(L)$ / (50% chance runoff) or runoff from the drainage area needed to match the change in the storage in the depressional area.

- Develop a log-log inundation graph of drainage area (acres) needed versus playa size (acres).

Step 5—Determine the depressional area size and drainage area in acres. It is assumed that the critical duration of inundation for a pothole is 7 days.

Step 6—Place a dot on the inundation graph where the depressional area size and the drainage area needed intersect. If the dot is above the line, the depressional area is inundated for the time specified by the wetland criteria, and the depressional area meets the wetland hydrology criteria. If the dot is below the line, the depressional area is inundated for a shorter duration, and the depressional area does not meet the wetland hydrology criteria.

(6) Sample documentation

The following is an example of the second procedure used to determine the drainage area required to meet the duration criteria in a playa in Kearny County, Kansas.

(i) Procedure used to analyze playa lake losses—Water losses to the playa areas include evaporation by month, infiltration rate, and soil-water holding capacity. The total losses for the playa can be expressed by the following equation:

$$L = E_d + S_w + F + O$$

where:
L = total playa water losses (in)
E_d = average evaporation from the playa for 6.5 days for April through October (in)
O = outflow from area; playa outflow = zero
S_w = soil-water holding capacity from 1/10 bar to 15 bar or saturation to plant wilt (in) for a given depth (in) in Ness soils
F = total infiltration at an infiltration rate of 0.004 inches per hour for a 7-day period (in)

The evaporation rates used are from NOAA Technical Report NWS 34, December 1982. The soil infiltration rate and water holding capacity, at wilting point, were from soil survey data for Ness soil. Table 19–7 shows evaporation by month (E_m), 6.5-day evaporation (E_d), and water holding capacity at different depths (S_w). It is assumed that the critical duration for inundation of a pothole is 7 days.

Table 19–7 Evaporation, water holding capacity, by months

Month	E_m	E_d*	S_w 12-inch	S_w 18-inch	S_w 24-inch	S_w 36-inch
Mar	4.3	.9	1.1	1.9	2.9	4.7
Apr	6.7	1.5				
May	8.0	1.7				
Jun	9.6	2.1				
Jul	10.3	2.2				
Aug	8.3	1.7				
Sep	6.2	1.3				
Oct	5.1	1.1				
Nov	2.8	.6				

* $E_d = \frac{(6.5)}{30}(E_m)$

The average 6.5-day evaporation (E_d) for April through October is 1.7 inches. The 6.5-day period was used to remove the freestanding water, and the other half day was used to reduce the soil saturation. The monthly evaporation rates shown in table 19–7 are from studies made on shallow lakes and reservoirs. Shallow is defined as a depth of 6 to 8 feet.

The total soil-water holding capacity is a function of the depths shown in the table (S_w). In an average (50% chance) year, a percentage of the total soil-water holding capacity is available for storing surface runoff before ponding occurs. It was felt the total drying depth would approach 36 inches in an average year before an event occurred. For this analysis, a depth of 18 inches was selected to account for the precipitation falling on the playa area. This represents about 50 percent of the soil-water holding capacity.

The assumed total infiltration F is equal to the infiltration rate times the duration times depth.

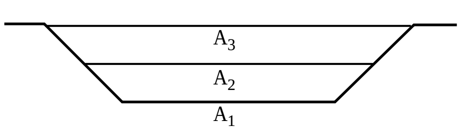
$$\begin{aligned} F &= (I)(\text{duration}) \\ &= (.004 \text{ in/hr})(24 \text{ hr/d})(7 \text{ days}) \\ &= .672 \text{ in, or } 0.7 \text{ in} \end{aligned}$$

***(ii) Total losses*—**Total losses are based on a depth in inches over 1 acre of playa area. To find total losses, use the following equation:

$$\begin{aligned} L &= E_d + S_{wl8} + F \\ &= 1.7 + 1.9 + .7 \\ &= 4.3 \text{ inches} \end{aligned}$$

***(iii) Adjustment factor*—**The playa shape factor takes into account that the top area is always greater than the base, thus, the base measurements are increased by 1.13 adjustment factor (P_s). The playa shape factor is developed for several playas in the general area. This factor is the ratio of the surface area for the playa ground surface area and the surface area for the next elevation.

$$P_s = \frac{\dfrac{A_2}{A_1} + \dfrac{A_3}{A_2} + \cdots \dfrac{A_n}{A_{n-1}}}{n}$$



***(iv) Procedure used to determine 7-day playa inundation*—**The following steps need to be followed to determine whether the playa area is inundated for a 7-day period:

- Determine playa size (P_a) in acres.
- Determine losses in acre-inches by multiplying P_a times losses in inches L then times the adjustment (P_s).
- Determine the contributing drainage area (Δ_m) necessary to satisfy losses, divide the total losses determined above by the 50 percent chance runoff.

The equation becomes:

$$\Delta_M = \frac{(P_s)\times(P_a)\times(L)}{(50\% \text{ chance runoff})}$$

$$= \frac{1.13\times P_a \times 4.3}{0.16} = 30.5P_a$$

where:

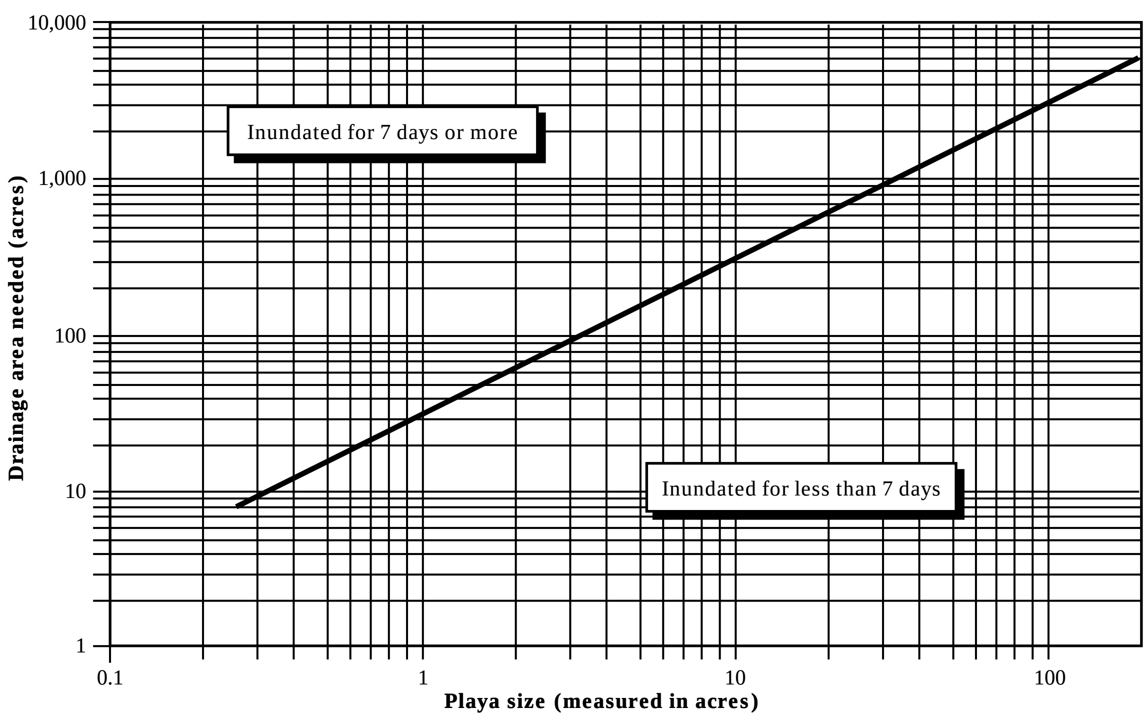
Δ_M = minimum drainage area required to supply the required runoff to satisfy duration criteria
P_s = playa storage adjustment factor (normally 1.15)
L = playa loss (inches)
P_a = playa surface area acres

When the actual drainage acres are less than required to satisfy the losses, it would be assumed not to be inundated for a 7-day period from a hydrologic standpoint. When the actual drainage acres are larger than needed to satisfy the losses, it would be assumed to be inundated for a 7-day period.

Figure 19–6 shows the 7-day inundation graph for Kearny County, Kansas. The drainage area needed to satisfy the playa losses can be determined using this graph by knowing the playa acres, moving up to the diagonal line, and then moving left horizontally to read drainage area in acres. If the drainage area is above the line, it is inundated for 7 days or more; and if it is below the line, it is inundated for less than 7 days. The graph is based on an 18-inch soil depth, a 50 percent chance maximum runoff event, evaporation, and soil-water holding capacity. A graph is needed for each playa type, soil, and county or climatic zone. Figure 19–6 is the graph of runoff events versus graph of playa size.

Thus for a 1-acre playa area wetland, 30 acres of drainage area would be required to provide sufficient water to meet assumed wetland criteria. If 15 acres of drainage area were uncontrolled, 0.5 acres of playa wetland would meet the assumed criteria.

Figure 19–6 7-Day inundation graph, Kearny County, Kansas



650.1903 Supplemental data for remote sensing

(a) Applicable situations for use

Remote sensing provides procedures to help document the wetland hydrology associated with mapping conventions. This documentation also helps to determine which years of aerial photograph signatures can be correlated with hydrology of natural wetlands and thus provides independent validation of the wetland hydrology. The procedures are:

Procedure 1 Use of precipitation data to help select the years that signatures indicating wet conditions might be seen on aerial photos.

Procedure 2 Use of precipitation data to document the frequency of signature in humid climates.

Procedure 3 Use of runoff volumes to document wetland hydrology in semiarid areas, such as western Kansas.

(b) Data required

The data required are:

- Daily or monthly precipitation from a long-term, nearby climatic station is needed for procedures 1 and 2.
- Long-term daily or monthly runoff volume is needed for procedure 3.

(c) Limitations

(1) Knowledge and experience required
General knowledge of climate, wetland signatures, and how to interpret rain and runoff data is required. Knowledge of the local agricultural practices improves the quality of photo interpretation.

(2) Climatic regions of applicability
Procedures 1 and 2 are applicable to all climate regions. Procedure 3 is applicable in semiarid regions only.

(3) Factors affecting the accuracy of results
The accuracy of the meteorological data has a significant impact on the results. Saturation and/or inundation has to be observed for a specified duration and frequency during the growing season to establish that the wetland hydrology criterion has been met. An aerial photograph only represents conditions at that point in time. An aerial photograph used alone does not provide sufficient information to establish that the wetland hydrology criterion has been met.

The hydrological conditions need to be established for proper interpretation of wetland signatures on aerial photographs. Precipitation data are widely available for long periods of time and may be used to determine the antecedent moisture conditions.

(d) Sources of information

Precipitation data can be obtained from the NRCS National Water and Climate Center, Portland, Oregon.

Various stream gage data are published. They include mean daily discharge, mean daily stage, peak stage and discharge for flood events, and mean daily lake level. The primary sources for these data are the USGS Water Resources Data publications for each state. Stream and lake gage readings are also available from Corps of Engineers, TVA, USGS, NOAA, BOR, various highway departments, and state or local public works agencies.

Various computer models can also be used to determine the daily runoff volumes. This approach is discussed in the previous section.

(e) Methodology

(1) Rainfall data for procedures 1 and 2
Determine the climate station nearest to the site that has sufficient records to have had statistical information calculated for it. Obtain precipitation data for the site. For procedure 1, annual data are sought. For procedure 2, monthly rainfall totals during the growing season are the desired data. Both procedures require use of the WETS table available on the Internet. The internet address for WETS table and associated documentation is www.wcc.nrcs.usda.gov. The WETS table

is on the National Water and Climate Center's home page of NRCS. This table identifies the boundary where 3 in 10 of the precipitation amounts are wetter than normal value and the boundary where 3 in 10 values are drier than normal. Normal is considered to be values that fall between these two boundaries.

(2) Procedure 1

Precipitation data are used to help select years that signatures might be seen on aerial slides.

***Step 1*—**Determine what aerial photographs are available. Plan to use at least 5 years for the analysis so 5 to 10 years will be examined, depending on how many normal years are anticipated.

***Step 2*—**Compare the annual rainfall total for each year to the annual boundaries for wet and dry as mentioned above in the rainfall data section.

***Step 3*—**Select years where normal precipitation was experienced for the year. These years will be key in determining whether wetland hydrology is present or not on a site. If less than 5 normal years are available, use an equal number of wet and dry years after discarding years where the rainfall was extremely high or low. Review the signatures in all the available years of flights, but concentrate on the normal years. Note slides where further records may need to be checked in case an extreme event occurred that was within normal for the year, but may have been extreme as a single event for a single month.

***Step 4*—**If state mapping conventions are to be developed from the years selected in this process, study data from several sites before determining which years are to be used for the valuation. If a wet signature appears for a site only in wet years, a good probability exists that wetland hydrology is not present under normal circumstances. If a wet signature is seen in both dry and wet years, the site may well meet wetland hydrology criteria. Where the signatures appear in wet and normal years, further study is needed to determine whether wetland hydrology exists on the site.

(3) Procedure 2

Precipitation data are used to document the frequency of wet signatures in humid climates.

***Step 1*—**Complete the general information on figure 19–7 for the year to be evaluated. Determine the date the photograph was taken or estimate it based on information available. Decide which three months will be used to represent the climatic conditions that existed prior to the time the photograph was taken. For example, if a photo was taken July 1, April, May, and June would be the most likely choices for the three prior months. However, if the photo was taken July 22, May, June, and July would be logical choices, provided no extreme events occurred in late July that would alter the wetness condition for that month. Enter the chosen months in the first column in figure 19–7.

***Step 2*—**Enter the monthly rainfall totals in column 5. Enter the wet and dry boundaries and the monthly normal from the WETS table in columns 4, 2, and 3 respectively.

***Step 3*—**Compare the actual rainfall in column 5 to the boundary values in columns 2 and 4 and determine if the actual rainfall was more than the upper boundary (thereby wet), less than the lower boundary (thereby dry), or between the two boundary values (thereby normal). Enter this condition in column 6.

***Step 4*—**Using the small table of condition values in figure 19–7, enter the correct number (1, 2, or 3) in column 7 to correspond to the condition in column 6.

***Step 5*—**Multiply the condition value in column 7 by the monthly weight value in column 8 and place the result in column 9. Sum the three values in column 9 and place the total below the three boxes.

***Step 6*—**Compare this total to the sums in the small table in figure 19–7 to determine whether the evaluation for that year's slide is wet, normal, or dry.

Figure 19–7 Rainfall documentation worksheet

Rainfall Documentation
(use with photographs)

Date: _____________

Weather station: ______________________ Landowner: _____________________________ Tract no.: ___________

County: ______________________ State:___________________

Soil name: ___________________ Growing season: _______________________

Photo date: ______________

		Long-term rainfall records							
	Month	3 yrs. in 10 less than	Normal	3 yrs. in 10 more than	Rain fall	Condition dry, wet, normal	Condition value	Month weight value	Product of previous two columns
1st prior month*								3	
2nd prior month*								2	
3rd prior month*								1	
								Sum	

* Compared to photo date

Note: If sum is
- 6 - 9 then prior period has been drier than normal
- 10 - 14 then prior period has been normal
- 15 - 18 then prior period has been wetter than normal

Condition value:
- Dry =1
- Normal =2
- Wet =3

Conclusions:

Using the worksheet, Wetland Hydrology Determination, Summary and Conclusion (fig. 19–8), summarize the years of information recorded on each Rainfall Documentation worksheet. This will help document the process for concluding if wetland hydrology exists. The following steps should be used to complete the summary worksheet:

Step 1—Complete general information.

Step 2—Complete the first five columns using information from the Rainfall Documentation worksheet. After entering the weighted sum in column 2, place an **X** in columns 3, 4, or 5, as appropriate being certain to mark only one box. View appropriate photo and indicate in column 6 if wetland hydrology signature was observed. Comments should be entered in column 7.

Step 3—Complete the three narrative paragraphs using the data in the summary table. Circle either **does** or **does not** in the fourth narrative paragraph. Correlate mapping conventions (signature) with the precipitation data. If the signature occurred in both wet and dry years, the area is wet. If the signature only occurred in wet years, additional review of the signature is needed. If the signature occurred in wet and normal years, the area needs additional study.

(4) Procedure 3

The methodology for procedure 3 follows. This procedure should be used in those areas where the growing season precipitation is random and limited. A good example is western Kansas.

Step 1—Generate the long-term monthly surface runoff volumes using one of the runoff volume tools described in the previous section. Sum the monthly runoff volumes for the growing season for each year.

Step 2—Develop a frequency curve of growing season surface runoff volumes using statistical techniques. The statistical techniques are outlined in chapter 18, NEH-4.

Step 3—Obtain the available FSA aerial photographs and note the flight dates. Use only one photograph per year. The selected photograph should represent the growing season, if possible.

Step 4—Determine the percent chance of occurrence for the seasonal surface runoff for each selected year.

Step 5—Determine surface runoff for the period of concern before the date of photograph using the procedures in step 2.

Step 6—Determine the percent chance of occurrence for the period from the frequency curves developed in step 2.

Step 7—Develop a table for the selected events using a format similar to that shown in table 19–8.

Step 8—A wet runoff season exists if the percent chance of occurrence is smaller than 50 percent. Record a mark in the Hit column if a positive hit can be identified for the year. A positive hit on the FSA slide indicates ponding, saturation, or flooding.

Step 9—If there are more hits than wet years, the wetland may be caused by imported water or supported by groundwater. If the number of hits is less than the number of wet years, the wetland is being starved or drained, or the drainage area may not be large enough to support a wetland.

Table 19–8 Selected runoff events

Year	Surface runoff occurrence (%)	Wet year	Hits
1990	10	X	H
1989	5	X	H
1988	75		
1987	65		
1986	30	X	H
Number		**3**	**3**

Figure 19–8 Wetland hydrology determination worksheet

Wetland Hydrology Determination
Summary & Conclusion

Date: ______________________________ Prepared by: ____________________________

County: ____________________________ Landowner: _____________________________

State: ______________________________ Tract no.: ______________________________

Summary

Year (1)	Weighted sum (2)	Rainfall condition Dry (3)	Normal (4)	Wet (5)	Photo record wetness (6)	Comments (7)

The above is a tabulation of __________ years of record. There were _______ years of normal rainfall conditions and wetness was observed in ________ of those normal years.

There were ________ years with drier than normal condition, and wetness was observed in ___________ of those dry years.

There were ________ years with wetter than normal condition, and wetness was observed in __________ of those wet years.

It is my determination that the area (*does* or *does not*) meet wetland hydrology frequency requirements.

The duration of flooding or ponding is estimated to be ___________ days.

Comments:

(f) Sample documentation

(1) Sample 1

Sample 1 is documentation for procedure 1. In Nelson County, several years of aerial photographs with wetland signatures need correlation with hydrology. The normal annual precipitation for Nelsonville in Nelson County is 23.6 inches for 1961 to 1990 (table 19–9). The 3 year in 10 year precipitation is 17.7 and 29.5 inches, respectively.

In sample 1, 1984, 1985, 1988, 1989, and 1990 were selected to correlate signature with precipitation. This would be the minimum number of flights to use. The correlation of the signatures with the information would be improved by using all the available flights. The sample years selected for analysis encompass normal, wet, and dry condition.

(2) Sample 2

Sample 2 is the documentation for procedure 2. D. Wood selected the available photo during the growing season for a farm in Washington County, Oregon. Five years of flights were available for the D. Wood farm (fig. 19–9 and 19–10).

Table 19–9 Precipitation in Nelsonville, Nelson County, 1982 to 1990

Year	Total precipi-tation (inches)	3 in 10 year condition D = dry N = normal W = wet	Photos N = no Y = yes
1982	25.4	N	
1983	22.1	N	
1984	17.5	D	Y
1985	16.2	D	Y
1986	24.8	N	Y
1987	23.8	N	Y
1988	29.6	W	Y
1989	23.1	N	Y
1990	31.3	W	Y
Normal	**23.6**		

Figure 19–9 Completed rainfall documentation worksheet

Rainfall Documentation
(use with photographs)

Date: 5-31-93

Weather station: Hillsboro

Landowner: D. Wood

Tract no.: ___________

County: Washington

State: OR

Soil name: ___________________

Growing season: 3/7 - 11/15

Photo date: 6/86

	Month	Long-term rainfall records: 3 yrs. in 10 less than	Normal	3 yrs. in 10 more than	Rain fall	Condition dry, wet, normal	Condition value	Month weight value	Product of previous two columns
1st prior month*	May	1.06	1.62	1.94	2.04	W	3	3	9
2nd prior month*	Apr.	1.50	2.15	2.56	1.47	D	1	2	2
3rd prior month*	Mar.	2.67	4.02	4.81	3.47	N	2	1	2
								Sum	13

* Compared to photo date

Note: If sum is
- 6 - 9 then prior period has been drier than normal
- 10 - 14 then prior period has been normal
- 15 - 18 then prior period has been wetter than normal

Condition value:
- Dry =1
- Normal =2
- Wet =3

Conclusions: This year represents normal conditions.

Similar sheets were completed for the other years shown on the next page.

Figure 19–10 Completed wetland hydrology documentation worksheet

Wetland Hydrology Determination
Summary & Conclusion

Date: 5-31-93

Prepared by: DEW

County: Washington

Landowner: D. Wood

State: OR

Tract no.:

Summary

Year (1)	Weighted sum (2)	Rainfall condition Dry (3)	Normal (4)	Wet (5)	Photo record wetness (6)	Comments (7)
1986	13		x		yes	
1987	11		x		yes	
1988	16			x	yes	
1989	11		x		yes	
1991	17			x	yes	

The above is a tabulation of 5 years of record. There were 3 years of normal rainfall conditions and wetness was observed in 2 of those normal years.

There were 0 years with drier than normal condition, and wetness was observed in 0 of those dry years.

There were 2 years with wetter than normal condition, and wetness was observed in 2 of those wet years.

It is my determination that the area (*does* or *does not*) meet wetland hydrology frequency requirements.

Comments:

650.1904 DRAINMOD

(a) Applicable situations for use

DRAINMOD (version 4.6) was developed for describing the water balance between parallel drainage ditches or drain tubes. Thus, it is reliable for wetland analysis only for those lands that have parallel drainage systems.

DRAINMOD was developed by Dr. R.W. Skaggs to simulate the performance of water table management systems. It was first used as a research tool to investigate the performance of drainage and subirrigation systems and their effects on water use and crop response. DRAINMOD has been modified to facilitate its use for wetland analysis.

Version 4.6 incorporates a counting procedure that determines how many days the area is wet and the number of occurrences in a given year. This information helps document the frequency and duration of saturated field condition.

Technology used in DRAINMOD—The equations used in DRAINMOD were developed by Hooghoudt, Cuthin, Kirkham, and Ernst to calculate drainage rates. Infiltration rates are predicted by the Green and Ampt equation. Surface drainage is characterized by the average depth of depressional storage. Kirkham's equation is used for developing the effects of ponded water.

(b) Data required

The data required to successfully run DRAINMOD are:
- Hourly precipitation data.
- Daily minimum and maximum temperatures or potential evapotranspiration data.
- Drainage parameters:
  - — depth from the soil surface to the drain
  - — drain spacing
  - — effective radius of the drains
  - — distance from the drain to the restrictive layer
  - — drainage coefficient
  - — storage in local depressions
  - — maximum surface storage
- Soil parameters:
  - — lateral saturated hydraulic conductivity by soil layers
  - — soil water characteristic by soil layers
  - — volume of water free to drain by soil layers
  - — upward flux
  - — Green and Ampt parameters
  - — water content at permanent wilting point
- Growing season information:
  - — threshold water table depth
  - — required duration of high water
  - — beginning and ending dates for growing season

(c) Sources of information

Climatic data are available from the National Water and Climate Center in Portland, Oregon. The climatic data liaison in each NRCS state office can access the data in the proper format for the program.

The soils information necessary to run DRAINMOD is available on disk from the National Soil Survey Laboratory, Lincoln, Nebraska. A soil preparation program, DMSOIL, is needed to convert the data from the Soil Interpretation Records into format for DRAINMOD.

Information about DRAINMOD software and training can be obtained at http://www.bae.ncsu.edu/research/soil-water/www/watmngmnt/drainmod.

(d) Limitations

(1) Knowledge and experience required

Knowledge of the input requirement and output of the computer program and its limitations and applications is required. Normally this involves at least 1 week of training.

(2) Climatic regions of applicability

DRAINMOD is applicable to humid and subhumid regions.

(3) Factors affecting the accuracy of results

The reliability of the model predictions is verified in extensive field experiments. Tests in North Carolina indicate that daily water table depths can be predicted within 0.1 meter of the actual depth on the average. However, DRAINMOD cannot be directly applied to lands that receive runoff from adjacent areas, such as potholes or large depressions.

(e) Methodology

Appendix F to the DRAINMOD user guide sets forth the modifications made to produce version 4.6, which can be used for wetland analysis. Full details on the use of DRAINMOD are set forth in the user guide. Appendix F is reproduced here for your use.

Appendix F DRAINMOD 4.6, Hydrologic Analysis of Wetlands

DRAINMOD describes the soil-water balance for shallow water table soils. Water table depth is predicted on a day-by-day basis. Thus, it can be used to characterize the hydrology of certain types of wetlands. Further, DRAINMOD simulations can be used to determine if the hydrology of a particular site has been modified so that wetland hydrology is no longer satisfied.

This appendix presents a brief description of modifications made to DRAINMOD to facilitate its use for wetland analysis.

Note: DRAINMOD was developed for describing the water balance between parallel drainage ditches or drain tubes. Thus, it will be reliable for WETLAND analysis only for those lands that have parallel drainage systems. With careful attention to the inputs, it is possible to analyze some lands that have very poor natural drainage. However, DRAINMOD cannot be directly applied to lands that receive runoff from adjacent areas, such as potholes or large depressions.

Inputs

Inputs for wetlands analysis are needed on four data screens that are accessed through DMSHELL. Two of the screens are the General Information screens that have been modified to include information necessary for wetland analysis. Screen 1 (fig. 19–11) allows a constant monthly potential evapotranspiration (PET) value to be read in as a weather data option. Screen 2 (fig. 19–12) provides a choice for making hydrologic analyses for wetlands. If yes (Y) is chosen for the hydrologic analysis for wet soil conditions, a third screen requests information required for the analysis (fig. 19–13).

Wetland hydrologic criteria are entered in the following general form.

A site has wetland hydrology if the water table is less than a given depth (WTDWET) for a certain number of consecutive days (DAYSWET) during the growing season under average conditions. Average conditions are generally interpreted to mean that the criteria are met in at least 50 percent of the years (10 out of 20, 15 out of 30, etc.)

The inputs required in DRAINMOD are given in figure 19–12. They are:

- The first day of the growing season, IWST (Julian Day)
- The last day of the growing season, IWEND (Julian Day)
- The threshold water table depth, WTDWET (cm)
- The number of consecutive days required, DAYSWET

The other modification allows daily average PET values to be read in for each month (fig. 19–14). These values are read as centimeters. ***Note:*** A temperature file is still required, but the PET values read in will be used in the calculations.

Outputs

All outputs available for the general DRAINMOD program are also available for this application. In addition an output with the extension WET is printed in the output file. An example is given in figure 19–15. The summary includes a year-by-year list of the number of periods meeting the criteria and the longest period in each year that satisfies the water table depth criterion. In the example given in figure 19–15, the water table is at the soil surface 11 out of 20 years.

Appendix F DRAINMOD 4.6, Hydrologic Analysis of Wetlands—Continued

Figure 19–11 General inputs screen 1

```
File:      c:\dm46\inputs\wetintro.gen
Screen:    General Information - 1 of 2


Title to Identify Run:


Printing Options (Y/N):

           (N)  Rankings Only
           (N)  Yearly and Rankings
           (Y)  Monthly, Yearly and Rankings
           (N)  Daily, Monthly, Yearly and Rankings
           (N)  Mrank Version of Rankings (Adv. Option)

(N) Output for each year for daily water table graphs (Y/N)

Weather Data Options (Y/N):
           (Y)  Temperature File";
           (N)  Potential Evapotranspiration File ";
           (N)  Constant Monthly PET ";

F1     F2     F3   F4   F5    F6     F7     F8      F9       F10
HELP   RESET                  EXIT   ABORT  CLEAR   LASTSCR  NEXTSCR
```

Figure 19–12 General inputs screen 2

```
File:      c:\dm46\inputs\wetintro.gen
Screen:    General Information - 2 of 2"


Subsurface Water Management Options:


           (Y)  Conventional Drainage        Move cursor to select option
           (N)  Controlled Drainage          and press <Y>
           (N)  Subirrigation
           (N)  Combo: Drainage-Controlled Drainage-Subirrigation
                  NOTE: COMBO Must be on in Config.dm (Advanced Option)


Surface Water Management Option (Y/N)    :

           (N)  Waste Water Irrigation Application

           (Y)  Hydrologic Analysis for Wet Soil Conditions (Advance Option)

F1     F2     F3   F4   F5    F6     F7     F8      F9       F10
HELP   RESET                  EXIT   ABORT  CLEAR   LASTSCR  NEXTSCR
```

Appendix F DRAINMOD 4.6, Hydrologic Analysis of Wetlands—Continued

Figure 19–13 Inputs required for wetland analysis

```
File:     c:\dm46\inputs\wetintro.gen
Screen:   Hydrology Analysis for Wet Conditions 1 of 1

          Name    Value      Description


Starting and Ending days for Checking:
          IWST    66         Starting Day of the Year
          IWEND   332        Ending Day of the Year

Maximum Allowable Water Table Depth and Lenth of Period:

          WTDWET             30        Water Table Depth in cm
          DAYSWET            14        Length of period to count in days


*****************************************************************************
***WARNING===> This is an experimental release. Tests and                ***
*** evaluations of this version of DRAINMOD are being done               ***
*****************************************************************************


F1     F2     F3   F4   F5    F6    F7     F8      F9       F10
HELP   RESET                  EXIT  ABORT  CLEAR   LASTSCR  NEXTSCR
```

Figure 19–14 Average daily PET values may be read in for each month

```
File:     c:\dm46\inputs\wetintro.gen
Screen:   Weather Inputs (Monthly PET Option) - 2 of 2


          Average Daily PET (cm)

           January          0.08
           February         0.15
           March            0.23     **********************************************
           April            0.31     *NOTE:  VALID TEMPERATURE FILES  *
           May              0.38     *       ARE REQUIRED.  THIS      *
           June             0.43     *       SCREEN PROVIDES THE      *
           July             0.40     *       ACTUAL PET VALUES USED   *
           August           0.36     *       BY DRAINMOD              *
           September        0.31     **********************************************
           October          0.18
           November         0.13
           December         0.08


F1     F2     F3   F4   F5    F6    F7     F8      F9       F10
HELP   RESET                  EXIT  ABORT  CLEAR   LASTSCR  NEXTSCR
```

Appendix F DRAINMOD 4.6, Hydrologic Analysis of Wetlands—Continued

Figure 19–15 Sample output for wetland analysis

```
            ------------------------------------------------------------------
            *              DRAINMOD version 4.60a                            *
            *              Copyright 1990-91 North Carolina State University *
            ------------------------------------------------------------------

  ANALYSIS OF WETLAND HYDROLOGIC CRITERIA FOR portswet SOIL AT WILMINGTON N.C. for
  FOREST:100m D/SPACING, STMAX=4.0cm, thwtd=3ocm/14days, Ksat=6
  ***************************************************************************************************


  ------------RUN STATISTICS-------------                 time: 10/ 6/1991  @ 22:46
  input file:                            c:\DM46\INPUT45\P10S4D4.LIS
  parameters:     free drainage                           and yields not calculat
              drain spacing= 10000. cm                    drain depth= 120.0 cm
  ---------------------------------------------------------------------------------------------------


                             D R A I N M O D --- HYDROLOGY EVALUATION
                            ******** INTERIM EXPERIMENTAL RELEASE*****

                      Number of periods with water table closer than 30.00 cm
                           for at least 14 days.  Counting starts on day
                                68 and ends on day 332 of each year


   YEAR            Number of Periods              Longest Consecutive
                     of 14 days or                  Period in Days
                     more with WTD
                       <30.00 cm

   1968                    0.                           0.
   1969                    2.                          26.
   1970                    2.                          37.
   1971                    1.                          16.
   1972                    0.                           0.
   1973                    2.                          21.
   1974                    2.                          28.
   1975                    0.                           7.
   1976                    0.                          12.
   1977                    0.                          11.
   1978                    0.                           8.
   1979                    2.                          34.
   1980                    1.                          26.
   1981                    0.                          13.
   1982                    0.                          13.
   1983                    1.                          28.
   1984                    2.                          25.
   1985                    0.                           0.
   1986                    1.                          14.
   1987                    1.                          14.

   Number of Years with at least one period =          11.
```

650.1905 Scope and effect equations

(a) Applicable situations for use

Numerous water table drawdown equations are available. These equations will not help to determine the extent of natural wetlands, but can be used to determine whether existing drainage systems are sufficient to remove wetland hydrology from a site.

The impact or effectiveness of a surface drainage system can be evaluated using the procedures outlined in Drainage of Agricultural Lands, National Engineering Handbook, section 16 (NEH 16).

The ellipse equation may be used where wetland hydrology is the result of a high water table with a restrictive soil layer and the hydrology has been altered with drains. If lowering of the water table for specified duration is all that is required to define wetland hydrology, then the ellipse equation is satisfactory to approximate this situation.

(b) Data required

The following parameters for the ellipse equation are required:

- average saturated hydraulic conductivity K
- parallel drain or ditch spacing
- depth of barrier or impervious layer
- drainage rate
- depth to drain
- vertical distance, after drawdown, of water table above the drain and at midpoint between drains

(c) Limitations

(1) Knowledge and experience required

General knowledge of the ellipse equation and its application is required.

(2) Climatic regions of applicability

The ellipse equation is applicable to humid climates.

(3) Factors affecting the accuracy of results

This equation assumes no inflow to the wetland from surface flow. It is also assumed the outlet is adequate and has been maintained. Significant surface inflow reduces the accuracy of the answer.

After the water table starts to drop, rainfall can occur any time between the first and last day of the evaluation period. The ellipse equation as developed considered the volume of water removed as equivalent to the rainfall volume during the removal period. In its application here, the volume of water removed in lowering of the water table during the removal period is substituted for rainfall volume. Rainfall during this period decreases the accuracy of the answer.

When rainfall occurs, a certain amount infiltrates into the soil; a certain amount leaves the wetland area as surface runoff, and a certain amount accumulates in depressions, remaining available for infiltration at some later time. Major factors affecting these various components are rainfall amount and intensity, surface roughness, initial soil moisture, and vertical hydraulic conductivity. The spacing or impact of the drains may be approximate because infiltration was not considered.

The ellipse equation does not consider the effect of evaporation on the water table. During the height of the growing season, the influence of evapotranspiration (ET) on the water table drawdown is equal to or greater than that caused by drainage. ET is not usually significant early in the growing season when many of the wetter periods may occur.

Assumptions made in the development of the ellipse equation make it important to use this equation under the following conditions:

- Where ground water flow is known to be largely in the horizontal direction.
- Where the barrier to flow lies at twice the depth of the drain or less to restrict natural flow and flow water to move horizontally toward the drain.
- Where open ditches or drains with sand and gravel filters are used so that restrictions to flow into drains are managed.

(d) Sources of data

The depth to the impermeable layer below the drain is estimated from local soil information or, in the field, it is generally determined by boring holes. The holes generally are dug to a depth approximately one and one-half times the actual depth of the drain. The textural changes that occur between horizons are observed. The changes in texture may be determined by feeling the soil. The layer considered impermeable is high in clay content, continuous over a major portion of the site, and of such thickness as to provide a positive deterrent to the downward flow of water.

A commonly used rule of thumb is that the estimated hydraulic conductivity of the barrier must be less than 10 percent of the overlying layer. Other potential sources for determining the depth to the barrier are available; however, professional judgment must be exercised when using these sources if they are not adjacent to the site in question. Other sources include:

- Observation well logs
- Logs from geological investigations
- Road and channel cuts

Hydraulic conductivity is the saturated horizontal hydraulic conductivity, as the flow to the drains is generally horizontal. In soils that have strata of differing textures and structures, the difference between horizontal and vertical hydraulic saturated conductivities can be significant. The horizontal K generally is larger than the vertical K. For layered soils, equivalent K may be computed using the following equation:

$$\text{Equivalent K} = \frac{K1T1 + K2T2 + K3T3}{T1 + T2 + T3}$$

where:
K = the hydraulic conductivity
T = thickness of each layer

Specific measurements of K should be made where possible. Numerous methods have been developed to measure saturated K in the field. The method most commonly used is the auger hole method described in NEH-16, chapter 2.

In the absence of onsite measurements, the hydraulic conductivity may be calculated using the computer program DMSOILS.

The volume of water drained at various water table depths can be measured directly from large soil cores. However, it is not usually practical to collect large soil cores in many sites, so the drainage volume is derived from the soil moisture retention data. The DMSOILS computer program can provide an estimate of this parameter, which can also be estimated using the soil drainage porosity. Soil information in the DMSOILS computer program can be obained from the local NRCS office.

(e) Methodology

(1) Ellipse equation

The equation was originally developed to approximate economical spacings and depths of agricultural drain tubing and ditches for agricultural crops. It is also used to determine if the hydrology of the wetland has been modified by existing drainage measures for optimal crop production. The usual requirement is to lower the water table below the root zone in 24 to 48 hours after saturation. The ellipse equation is:

$$S = \sqrt{(4K)\frac{\left(m^2 + 2am\right)}{q}}$$

where:
S = parallel drain spacing (ft) (see fig. 19–16)
K = weighted hydraulic conductivity above the restrictive layer (in/hr)
m = vertical distance (d – c), after drawdown, of water table above drain and at midpoint between drains (ft)
  where:
  d = depth to drain from the surface (ft)
  c = depth to the water table drawdown after the evaluation period (ft)
a = depth of barrier (impermeable layer) below drains (ft)
q = drainage rate (in/hr)

This equation was developed for parallel drains. The drainable rate q as used for this application is the volume of water that will drain from a known volume of saturated soil through the forces of gravity (g) divided by the duration of saturation (t).

$$q = \frac{v}{t}$$

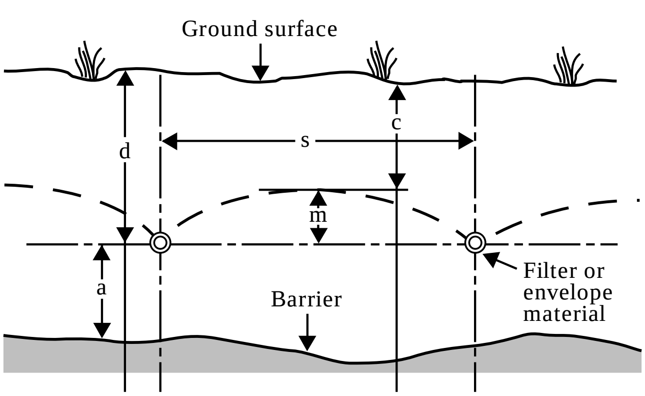
A more accurate analysis of the scope and effect of drainage systems on wetland hydrology can be obtained by using the ellipse equation with drainage coefficients developed from field trials combined with mathematical modeling, such as DRAINMOD.

(f) Sample documentation

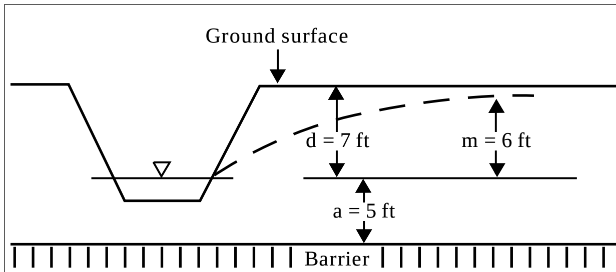
Example 19–4 shows the steps to determine the effects of a drain on the hydrology of the wetland. For this example, assume the duration of drawdown is 14 days, the drainage porosity (F) is 0.05 foot per foot, and the depth (c) of drawdown at the midpoint is 1 foot.

With the given values of the parameter, the water table midway between the drains would be lowered by 1 foot from the soil surface during a 14-day period if the drains were spaced at 494 feet apart. If the drains were spaced at or closer than 494 feet, the entire strip of land between the drains is effectively drained and will not have wetland hydrology. On the other hand, if the drains were spaced farther apart, there would be a strip between the drains bounded by a line 247 feet from each drain that would still have wetland hydrology. If only one drain exists, areas outside a line 247 feet from the drain would still have wetland hydrology.

Figure 19–16 Parallel drain spacing



Example 19–4 Steps to determine effects of a drain on hydrology of wetland



Step 1 $m = d - c = 7 - 1 = 6$ ft

Step 2 $K = 1.14$ in/hr (24 hr/d) = 27.36 in/d

Step 3 v = (F)(c) or v may be obtained from the soil properties

q = (0.05 ft/ft)(1 ft) = 0.05 ft

Converted to inches:

q = (0.05 ft)(12 in/ft/ft) = 0.6 inch

Step 4 $$q = \frac{v}{t} = \frac{0.6 \text{ in}}{14 \text{ d}} = 0.043 \text{ in / d}$$

Step 5 $$S = \sqrt{(4K)\frac{\left(m^2 + 2am\right)}{q}}$$

Step 6 $$S = \sqrt{4(27.36 \text{ in / d})\frac{\left[(6)^2 + 2(5 \text{ ft})(6 \text{ ft})\right]}{0.043 \text{ in / d}}}$$

$S = 494$ ft

(2) Other equations

***Hooghoudt equation*—**This equation is similar to the ellipse equation except the parameter **a**, depth to the impermeable layer from the free water surface in the drain, is replaced by $\mathbf{d_e}$, or the effective depth. Many researchers agree that this substitution makes the equation more accurate and widely applicable. This equation is meant to be applied with no standing water above the tile line(s).

***van Schilfgaarde equation*—**While the ellipse equation uses steady state assumptions, the van Schilfgaarde equation was developed for nonsteady state. It includes a parameter for time so that different lengths of time for the duration of saturation can be examined. It is most easily applied using a spreadsheet, as a two-step iteration process is recommended to use the effective depth in place of actual depth, such as was described for the Hooghoudt equation. The van Schilfgaarde equation is meant to be applied with no standing water above the tile line(s).

***Kirkham's equation*—**Kirkham's equation simulates the gradual lowering of the water ponded above a tile line or system. It is often combined with the Hooghoudt or van Schilfgaarde equation to describe the total removal of the water. Kirkham's equation calculates the time to remove the ponded water, and the other drainage equation determines the time to remove the saturation to the specified depth. Kirkham's equation is meant to be applied where the tile line(s) lies directly under the wetland, but the site has no surface intake and water ponds.

650.1906 NRCS drainage guides

(a) Applicable situations for use

NRCS state drainage guides, developed by a committee composed of soil scientists, engineers, technicians, and agronomists, contain information that can help in the determination of wetlands. Drainage guides help define and interpret some of the soil-water characteristics. Drainage guides are in NRCS field offices in each county where drainage measures have been installed. If the tile or ditch spacing is equal to or less than suggested spacing in the guide, it can be assumed on a screening basis that the wetland hydrology has been removed.

(b) Data required

The data required to use NRCS drainage guides include:

- Soil name and the depth and spacing of drainage measures.
- The adequacy of the outlet conditions.

(c) Limitations

(1) Knowledge and experience required

An understanding of the guide and its use is required.

(2) Climatic regions of applicability

The NRCS drainage guides are applicable to all climate regions for which they were developed.

(3) Factors affecting the accuracy of results

Drainage guides can be an effective screening tool to help to establish the presence or absence of hydrology in a potential wetland. The drainage guide should be up-to-date. Where the drainage system is properly maintained with an adequate outlet, drainage guides can be used by the field office to help determine if the wetland hydrology has been removed.

Soils listed in the guides generally are grouped according to the soil characteristics that are most relevant to natural and manmade drainage. The information in drainage guides is based on field tests and experience of managing conservation cropping systems on each soil listed.

The two soil characteristics described are the rate at which water will move through the soil (saturated hydraulic conductivity) and the degree of wetness before any drainage practices are applied. Another characteristic described that also is important to define wetland areas is general soil depth.

(d) Sources of information

Section 2 of the Field Office Technical Guide gives up-to-date drainage guide information.

(e) Methodology

This procedure involves the following steps:

Step 1—Determine the soil series for the wetland.

Step 2—Determine the drainage measure spacing.

Step 3—Determine the adequacy of the outlet.

Step 4—Determine if the actual spacing is greater or less than the spacing proposed in the guide. If the actual spacing is less than that proposed and the outlet conditions are adequate, the system has the potential to remove the wetland hydrology. If the actual spacing is greater than that proposed, then only the portion of the wetland within the zone of influence may be affected.

The information gathered in following these steps can be used in conjunction with the conservation plan files to determine if the installed drainage is adequate. If a drainage system is in a poor state of repair, calculations may show the system has the potential to remove the wetland hydrology, but aerial slides may show wet signatures in normal years.

650.1907 Observation wells

(a) Applicable situation for use

An observation well in a potential wetland area indicates ground water depths over time. Thus, durations of saturation (ground water levels) above or below a specific elevation can be determined.

Water level records provide an index of the duration and frequency of saturation of the area. These records are obtained on either a continuous or a fixed time interval basis.

(b) Data required

The following data are required:

- Location of the observation well
- Ground level and the reference elevation of the measurements
- Depth from the reference elevation to the water surface in the observation on a continuous or regular basis during the growing season

(c) Limitations

(1) Knowledge and experience required
General knowledge of statistical procedures and specific knowledge of soil, hydrology, and observation well installation are required.

(2) Climatic regions of applicability
This hydrology tool is applicable to all climate regions.

(3) Factors affecting the accuracy of results
Wells that have been properly installed and maintained provide the best data.

Artesian or flowing wells provide information about a confined aquifer and may not represent the shallow water table under a wetland. Water levels in nonartesian or nonflowing wells may not represent the local shallow water table, depending on intake screen location and seal. Piezometers are not to be used to measure water table levels.

Water levels that have been obtained on a continuous basis are the best data. Continuous records indicate both the duration and frequency of saturation. The information on a fixed time interval provides an index of the frequency and duration if the sampling interval is equal to or shorter than the minimum duration of wetland saturation.

If there are 10 or more years of continuous data, then a statistical analysis can be made. The statistical analysis determines how often the wetland has been saturated in the past. It can be assumed that the same frequency of saturation will happen in the future if no alterations occur.

If the record length is between 5 and 10 years, the number of years of saturation of the wetland is used. It would then be necessary to determine if these years are representative of the average conditions.

If the record length is less than 3 years, additional analysis must be made to support the conclusions.

(d) Sources of information

Observation well data may be available from local and state agencies responsible for regulating well drilling. State agencies include geologic survey, water right, or water resource agencies. Local agencies may also have copies of the water levels. The state geologist can provide assistance in obtaining the record of water levels. The data should be used with great care because most water level data were established for another purpose.

(e) Methodology

The following steps are involved in the analysis of the observation well data:

Step 1—Determine the growing season.

Step 2—Obtain the observation well data or water levels for the growing season.

Step 3—Determine the maximum water level for the critical duration for each year.

Step 4—Determine if the critical duration was met 50 percent of the time for the period of record.

- If the record length is 10 years or more, statistical inferences about the mean conditions can be made.
- If the record length is between 5 and 10 years, determine the number of years the criteria were met, for example, 4 out of the 10 years.
- If the record length is less than 5 years, determine if the record can be correlated with other corroborating data.
- If no other well data are available, correlate the well observations with precipitation to determine if the precipitation for the recharge period was wet, average, or dry. If the recharge period precipitation is less than the lower 3 out of 10 year value, the period is dry. If it is greater than the higher 3 out of 10 year value, the period is wet. If the water level elevation met the criteria during a dry period, the area is most likely a wetland. If the water level elevation met the criteria during a wet period, additional analysis is needed.

(f) Establishing an observation well

An observation well can be established in a wetland to verify the wetland mapping convention or initial identification. The well needs to be observed for 10 years to establish the average conditions. The observations should be on a continuous basis during the growing season.

The state geologist or hydraulic engineer should be consulted before an observation well is established in a wetland. The state geologist has specifications and information on how to install, case, and seal the well and how to take and record the measurements. Sprecher (1993) provides guidelines on installation of wetland observation wells.

(g) Sample documentation

(1) 14 years of records

This analysis is of the well records from a state agency data base. The records indicate 14 years of records and that the water levels were obtained on a continuous basis. The values are feet below the ground level. Thus a value of zero indicates the water in the well is at ground level. This well is in the wetland. It was installed for observation purposes, and no pumping has occurred. The soil is not sandy, so the criteria indicate if the water level is within 1 foot of the surface for the specified duration, the area meets the wetland hydrology criteria for saturation. For this example, duration criterion is assumed to be 15 days.

The record has been analyzed, and the water level of 1 foot or less for a continuous 15-day period during the growing season (March 1 through October 15) has been determined. The tabulated values (table 19–10) represent the highest water level or the smallest reading in that 15-day period. For example, in 1975 the 15-day consecutive values were 0.9, 1.0, 0.9, 0.95, 0.9, 1.0, 1.0, 0.9, 0.9, 0.9, 0.9, 0.9, 0.9, 0.9, and 0.9, thus the value used in the analysis is 0.9. It should be remembered that the highest water level in the well would be the smallest depth to water from the ground surface.

If the yearly values are arrayed from the largest to the smallest the median value is 1 foot below the ground surface. The median or the value in the middle of the array is a good representative of the average conditions. This well indicated that on the average, or 11 out of the 14 years, the water in the well would be within 1 foot of the ground surface. The wetland hydrology indicator is met for this situation.

(2) 5-year records where water level taken every 5 days

This analysis is of the observation well records from state data base. A search of the data base indicates that there are 5 years of records (tables 19–11 to 19–15) and that the water levels were obtained every 5 days on a regular basis. The values are in feet below ground level. This means that a value of zero indicates the water in the well is at ground level. This well is located at the edge of a potential wetland. The record is for water years 1980 through 1984. For this example the wetland criteria are water level at the surface and the duration of 15 consecutive days. The growing season is from March 15 to September 15.

Analysis of the data indicates the following:

Water Year 1980—The water level in the well is at ground level during one period 16 to 24 consecutive days in length and three periods 6 to 14 consecutive days in length.

Water Year 1981—The water level in the well is at ground level for one period of 6 to 14 consecutive days in length and two periods of 1 to 9 days.

Water Year 1982—The water is at the soil surface for one period of 6 to 14 consecutive days in length, and two periods of 1 to 9 consecutive days in length.

Water Year 1983—The water does not reach the soil surface.

Water Year 1984—The water does not reach the soil surface.

This analysis indicates that water level has been at the ground surface for 3 out of the 5 years of record. In water year 1980, the water was at ground level for longer than the minimum of 15 days.

Table 19–10 Observation well records for 1970 to 1983

Year	Highest level during 15 days	Array from largest to smallest
1970	1.0	1.3
1971	1.1	1.2
1972	0.9	1.1
1973	0.9	1.0
1974	1.0	1.0
1975	1.0	1.0
1976	1.3	1.0
1977	0.9	1.0
1978	1.0	1.0
1979	0.9	0.9
1980	1.0	0.9
1981	0.9	0.9
1982	1.0	0.9
1983	1.2	0.9

This analysis also illustrates the problem of making conclusions if the observations are not taken every day; i.e., no conclusions can be made regarding the duration of the water table during the noted periods.

For example, in 1982 the record shows:

May 20	0.10
May 25	0.00
May 31	0.00
June 5	0.20

The shortest period is May 25 to 31, 7 days, and the maximum is May 21 to June 4, 15 days.

Table 19–11 Water level, in feet below land-surface datum, for October 1979 to September 1980

Pittsburg County

350422095341901. local Number, 07W-16E-24 B&B 1
Location—Lat 35 4’22" Long 95 34’19", Hydrologic unit 11090204
Owner:
Aquifer—Local aquifer
Well characteristics—Observation well
Datum—Altitude of land-surface is unavailable

Water level, in feet below land-surface datum, for October 1979 to September 1980

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Oct 5	2.00	Jan 5	0.55	Apr 5	0.10	Jul 5	0.05
Oct 10	1.90	Jan 10	0.40	Apr 10	0.05	Jul 10	0.00
Oct 15	1.80	Jan 15	0.30	Apr 15	0.00	Jul 15	0.10
Oct 20	1.75	Jan 20	0.20	Apr 20	0.00	Jul 20	0.20
Oct 25	1.70	Jan 25	0.10	Apr 25	0.05	Jul 25	0.30
Oct 31	1.65	Jan 31	0.00	Apr 30	0.10	Jul 31	0.50
Nov 5	1.60	Feb 5	0.00	May 5	0.05	Aug 5	0.80
Nov 10	1.55	Feb 10	0.05	May 10	0.00	Aug 10	1.00
Nov 15	1.54	Feb 15	0.00	May 15	0.00	Aug 15	1.20
Nov 20	1.50	Feb 20	0.05	May 20	0.00	Aug 20	1.40
Nov 25	1.45	Mar 5	0.00	May 25	0.00	Aug 25	1.60
Nov 30	1.40	Mar 10	0.00	May 31	0.10	Aug 30	1.80
Dec 5	1.35	Mar 15	0.05	Jun 5	0.20	Sep 5	1.85
Dec 10	1.30	Mar 20	0.00	Jun 10	0.15	Sep 10	1.90
Dec 15	1.25	Mar 25	0.00	Jun 15	0.10	Sep 15	2.00
Dec 20	1.00	Mar 30	0.05	Jun 20	0.05	Sep 20	2.05
Dec 25	0.90			Jun 25	0.00	Sep 25	2.00
Dec 31	0.80			Jun 30	0.00	Sep 30	2.10

Table 19–12 Water level, in feet below land-surface datum, for October 1980 to September 1981

Pittsburg County

350422095341901. local Number, 07W-16E-24 B&B 1
Location—Lat 35 4’22" Long 95 34’19", Hydrologic unit 11090204
Owner:
Aquifer—Local aquifer
Well characteristics—Observation well
Datum—Altitude of land-surface is unavailable

Water level, in feet below land-surface datum, for October 1980 to September 1981

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Oct 5	2.00	Jan 5	0.80	Apr 5	0.10	Jul 5	0.05
Oct 10	2.00	Jan 10	0.70	Apr 10	0.05	Jul 10	0.20
Oct 15	1.90	Jan 15	0.60	Apr 15	0.05	Jul 15	0.10
Oct 20	1.75	Jan 20	0.50	Apr 20	0.05	Jul 20	0.20
Oct 25	1.70	Jan 25	0.40	Apr 25	0.05	Jul 25	0.30
Oct 31	1.60	Jan 31	0.30	Apr 30	0.10	Jul 31	0.50
Nov 5	1.60	Feb 5	0.20	May 5	0.05	Aug 5	0.90
Nov 10	1.50	Feb 10	0.10	May 10	0.00	Aug 10	1.10
Nov 15	1.50	Feb 15	0.20	May 15	0.05	Aug 15	1.20
Nov 20	1.50	Feb 20	0.15	May 20	0.05	Aug 20	1.40
Nov 25	1.40	Mar 5	0.10	May 25	0.00	Aug 25	1.60
Nov 30	1.40	Mar 10	0.00	May 31	0.15	Aug 30	1.80
Dec 5	1.30	Mar 15	0.05	Jun 5	0.25	Sep 5	1.85
Dec 10	1.30	Mar 20	0.00	Jun 10	0.25	Sep 10	1.90
Dec 15	1.25	Mar 25	0.00	Jun 15	0.20	Sep 15	2.10
Dec 20	1.00	Mar 30	0.05	Jun 20	0.15	Sep 20	2.25
Dec 25	0.95			Jun 25	0.10	Sep 25	2.20
Dec 31	0.80			Jun 30	0.10	Sep 30	2.20

Table 19–13 Water level, in feet below land-surface datum, for October 1981 to September 1982

Pittsburg County

350422095341901. local Number, 07W-16E-24 B&B 1
Location—Lat 35 4’22" Long 95 34’19", Hydrologic unit 11090204
Owner:
Aquifer—Local aquifer
Well characteristics—Observation well
Datum—Altitude of land-surface is unavailable

Water level, in feet below land-surface datum, for October 1981 to September 1982

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Oct 5	2.20	Jan 5	1.85	Apr 5	0.20	Jul 5	0.05
Oct 10	2.30	Jan 10	1.70	Apr 10	0.15	Jul 10	0.00
Oct 15	2.25	Jan 15	1.60	Apr 15	0.10	Jul 15	0.10
Oct 20	2.15	Jan 20	1.50	Apr 20	0.05	Jul 20	0.20
Oct 25	2.00	Jan 25	1.30	Apr 25	0.05	Jul 25	0.30
Oct 31	2.15	Jan 31	1.10	Apr 30	0.10	Jul 31	0.50
Nov 5	2.20	Feb 5	1.00	May 5	0.05	Aug 5	0.60
Nov 10	2.35	Feb 10	0.85	May 10	0.05	Aug 10	0.70
Nov 15	2.30	Feb 15	0.80	May 15	0.05	Aug 15	0.80
Nov 20	2.20	Feb 20	0.75	May 20	0.10	Aug 20	0.90
Nov 25	2.15	Mar 5	0.60	May 25	0.00	Aug 25	1.00
Nov 30	2.10	Mar 10	0.50	May 31	0.00	Aug 30	1.10
Dec 5	2.05	Mar 15	0.45	Jun 5	0.20	Sep 5	1.25
Dec 10	2.30	Mar 20	0.40	Jun 10	0.15	Sep 10	1.40
Dec 15	2.20	Mar 25	0.30	Jun 15	0.10	Sep 15	1.60
Dec 20	2.00	Mar 30	0.25	Jun 20	0.05	Sep 20	1.75
Dec 25	1.90			Jun 25	0.00	Sep 25	1.80
Dec 31	0.80			Jun 30	0.10	Sep 30	1.90

Table 19–14 Water level, in feet below land-surface datum, for October 1982 to September 1983

Pittsburg County

350422095341901. local Number, 07W-16E-24 B&B 1
Location—Lat 35 4'22" Long 95 34'19", Hydrologic unit 11090204
Owner:
Aquifer—Local aquifer
Well characteristics—Observation well
Datum—Altitude of land-surface is unavailable

Water level, in feet below land-surface datum, for October 1982 to September 1983

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Oct 5	2.00	Jan 5	2.30	Apr 5	0.80	Jul 5	0.45
Oct 10	2.00	Jan 10	2.40	Apr 10	0.65	Jul 10	0.40
Oct 15	2.10	Jan 15	2.30	Apr 15	0.50	Jul 15	0.30
Oct 20	2.25	Jan 20	2.20	Apr 20	0.40	Jul 20	0.20
Oct 25	2.30	Jan 25	2.10	Apr 25	0.45	Jul 25	0.30
Oct 31	2.45	Jan 31	2.00	Apr 30	0.40	Jul 31	0.40
Nov 5	2.60	Feb 5	1.90	May 5	0.45	Aug 5	0.60
Nov 10	2.55	Feb 10	1.80	May 10	0.50	Aug 10	0.80
Nov 15	2.45	Feb 15	1.70	May 15	0.60	Aug 15	0.90
Nov 20	2.30	Feb 20	1.60	May 20	0.70	Aug 20	1.00
Nov 25	2.20	Mar 5	1.50	May 25	0.60	Aug 25	1.00
Nov 30	2.10	Mar 10	1.40	May 31	0.50	Aug 30	1.00
Dec 5	2.00	Mar 15	1.30	Jun 5	0.30	Sep 5	1.00
Dec 10	2.10	Mar 20	1.10	Jun 10	0.45	Sep 10	1.10
Dec 15	2.20	Mar 25	1.00	Jun 15	0.40	Sep 15	1.00
Dec 20	2.30	Mar 30	0.90	Jun 20	0.45	Sep 20	1.00
Dec 25	2.40			Jun 25	0.40	Sep 25	1.50
Dec 31	2.30			Jun 30	0.40	Sep 30	1.80

Table 19–15 Water level, in feet below land-surface datum, for October 1983 to September 1984

Pittsburg County

350422095341901. local Number, 07W-16E-24 B&B 1
Location—Lat 35 4’22" Long 95 34’19", Hydrologic unit 11090204
Owner:
Aquifer—Local aquifer
Well characteristics—Observation well
Datum—Altitude of land-surface is unavailable

Water level, in feet below land-surface datum, for October 1983 to September 1984

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Oct 5	1.90	Jan 5	2.30	Apr 5	0.80	Jul 5	0.45
Oct 10	2.00	Jan 10	2.40	Apr 10	0.65	Jul 10	0.40
Oct 15	2.10	Jan 15	2.30	Apr 15	0.50	Jul 15	0.30
Oct 20	2.25	Jan 20	2.20	Apr 20	0.40	Jul 20	0.20
Oct 25	2.30	Jan 25	2.10	Apr 25	0.45	Jul 25	0.30
Oct 31	2.45	Jan 31	2.00	Apr 30	0.40	Jul 31	0.40
Nov 5	2.60	Feb 5	1.90	May 5	0.45	Aug 5	0.60
Nov 10	2.55	Feb 10	1.80	May 10	0.50	Aug 10	0.80
Nov 15	2.45	Feb 15	1.70	May 15	0.60	Aug 15	0.90
Nov 20	2.30	Feb 20	1.60	May 20	0.70	Aug 20	1.00
Nov 25	2.20	Mar 5	1.50	May 25	0.60	Aug 25	1.00
Nov 30	2.10	Mar 10	1.40	May 31	0.50	Aug 30	1.00
Dec 5	2.00	Mar 15	1.30	Jun 5	0.30	Sep 5	1.00
Dec 10	2.10	Mar 20	1.10	Jun 10	0.45	Sep 10	1.10
Dec 15	2.20	Mar 25	1.00	Jun 15	0.40	Sep 15	1.00
Dec 20	2.30	Mar 30	0.90	Jun 20	0.45	Sep 20	1.00
Dec 25	2.40			Jun 25	0.40	Sep 25	1.50
Dec 31	2.30			Jun 30	0.40	Sep 30	1.80

(3) 5-year records where water level taken daily

This analysis is of the well records from a state data base. A search of the data base indicates that there are 5 years of records (tables 19–16 to 19–20) and that the water levels were obtained every day. Only the data for March through October are shown in the example. For this example, it is assumed that the growing season is March 15 through September 15. The values are feet below ground level. This means that a value of zero indicates the water in the well is at ground level. This well is located at the edge of a potential wetland. The record is for water years 1980 though 1984. Two assumptions for this example are that the wetland criterion is 10-day duration for saturation and water must be at the surface for the entire duration.

Analysis of the data indicates the following:

Water Year 1980—The water level in the well is at ground level during two periods 10 days in length.

Water Year 1981—The water level in the well is at ground level during three periods, two periods of 5 days and one of 20 days.

Water Year 1982—The water is at the soil surface during two periods. One period is 10 days, and the other is 5 days.

Water Year 1983—The water reaches the soil surface for one period of 10 days.

Water Year 1984—The water does not reach the soil surface.

This analysis indicates that for this potential wetland, the water surface has been at the ground level for 4 out of the 5 years of record. Water is at the ground surface for a period of at least 10 days in 1980, 1981, 1982, and 1983. It would be helpful to correlate the 5 years of well data with climate data to make sure the well data represents normal conditions.

Table 19–16 Water level, in feet below land-surface datum, for October 1979 to September 1980

Washington County
350422095341901. local number, 08W-15E-254
Location—Lat 45 4'22" Long 122 34' 19"
Well characteristics—Observation well
Datum—Altitude of land-surface is unavailable

Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
Mar 1	0.50	Apr 1	0.04	May 1	0.10	Jun 1	0.18	Jul 1	0.10	Aug 1	0.41	Sep 1	0.60	Oct 1	0.85
Mar 2	0.50	Apr 2	0.05	May 2	0.11	Jun 2	0.19	Jul 2	0.15	Aug 2	0.42	Sep 2	0.61	Oct 2	0.86
Mar 3	0.49	Apr 3	0.06	May 3	0.12	Jun 3	0.20	Jul 3	0.20	Aug 3	0.42	Sep 3	0.62	Oct 3	0.86
Mar 4	0.48	Apr 4	0.05	May 4	0.13	Jun 4	0.20	Jul 4	0.22	Aug 4	0.44	Sep 4	0.63	Oct 4	0.86
Mar 5	0.47	Apr 5	0.05	May 5	0.15	Jun 5	0.21	Jul 5	0.25	Aug 5	0.45	Sep 5	0.61	Oct 5	0.87
Mar 6	0.47	Apr 6	0.10	May 6	0.18	Jun 6	0.22	Jul 6	0.26	Aug 6	0.45	Sep 6	0.60	Oct 6	0.89
Mar 7	0.44	Apr 7	0.10	May 7	0.29	Jun 7	0.20	Jul 7	0.27	Aug 7	0.46	Sep 7	0.61	Oct 7	0.90
Mar 8	0.43	Apr 8	0.10	May 8	0.25	Jun 8	0.19	Jul 8	0.30	Aug 8	0.47	Sep 8	0.62	Oct 8	0.91
Mar 9	0.42	Apr 9	0.05	May 9	0.28	Jun 9	0.18	Jul 9	0.35	Aug 9	0.48	Sep 9	0.63	Oct 9	0.93
Mar 10	0.40	Apr 10	0.03	May 10	0.25	Jun 10	0.16	Jul 10	0.33	Aug 10	0.49	Sep 10	0.65	Oct 10	0.94
Mar 11	0.38	Apr 11	0.05	May 11	0.28	Jun 11	0.14	Jul 11	0.35	Aug 11	0.48	Sep 11	0.66	Oct 11	0.95
Mar 12	0.37	Apr 12	0.03	May 12	0.37	Jun 12	0.13	Jul 12	0.37	Aug 12	0.48	Sep 12	0.65	Oct 12	0.97
Mar 13	0.35	Apr 13	0.05	May 13	0.33	Jun 13	0.12	Jul 13	0.38	Aug 13	0.49	Sep 13	0.67	Oct 13	0.95
Mar 14	0.32	Apr 14	0.06	May 14	0.35	Jun 14	0.11	Jul 14	0.37	Aug 14	0.45	Sep 14	0.65	Oct 14	0.96
Mar 15	0.33	Apr 15	0.05	May 15	0.33	Jun 15	0.10	Jul 15	0.40	Aug 15	0.44	Sep 15	0.67	Oct 15	0.97
Mar 16	0.31	Apr 16	0.06	May 16	0.34	Jun 16	0.08	Jul 16	0.41	Aug 16	0.46	Sep 16	0.68	Oct 16	0.98
Mar 17	0.30	Apr 17	0.07	May 17	0.31	Jun 17	0.06	Jul 17	0.42	Aug 17	0.47	Sep 17	0.69	Oct 17	0.99
Mar 18	0.28	Apr 18	0.05	May 18	0.32	Jun 18	0.05	Jul 18	0.43	Aug 18	0.48	Sep 18	0.70	Oct 18	1.00
Mar 19	0.26	Apr 19	0.03	May 19	0.32	Jun 19	0.03	Jul 19	0.45	Aug 19	0.49	Sep 19	0.71	Oct 19	1.01
Mar 20	0.24	Apr 20	0.01	May 20	0.33	Jun 20	0.02	Jul 20	0.45	Aug 20	0.50	Sep 20	0.73	Oct 20	1.00
Mar 21	0.22	Apr 21	0.00	May 21	0.35	Jun 21	0.00	Jul 21	0.47	Aug 21	0.50	Sep 21	0.75	Oct 21	0.99
Mar 22	0.20	Apr 22	0.00	May 22	0.33	Jun 22	0.00	Jul 22	0.43	Aug 22	0.51	Sep 22	0.76	Oct 22	1.00
Mar 23	0.15	Apr 23	0.00	May 23	0.31	Jun 23	0.00	Jul 23	0.45	Aug 23	0.52	Sep 23	0.77	Oct 23	1.01
Mar 24	0.13	Apr 24	0.00	May 24	0.30	Jun 24	0.00	Jul 24	0.47	Aug 24	0.53	Sep 24	0.78	Oct 24	1.02
Mar 25	0.11	Apr 25	0.00	May 25	0.28	Jun 25	0.00	Jul 25	0.45	Aug 25	0.52	Sep 25	0.79	Oct 25	1.03
Mar 26	0.10	Apr 26	0.00	May 26	0.26	Jun 26	0.00	Jul 26	0.43	Aug 26	0.53	Sep 26	0.80	Oct 26	1.04
Mar 27	0.05	Apr 27	0.00	May 27	0.28	Jun 27	0.00	Jul 27	0.42	Aug 27	0.54	Sep 27	0.81	Oct 27	1.03
Mar 28	0.03	Apr 28	0.00	May 28	0.25	Jun 28	0.00	Jul 28	0.43	Aug 28	0.55	Sep 28	0.82	Oct 28	1.04
Mar 29	0.01	Apr 29	0.00	May 29	0.20	Jun 29	0.00	Jul 29	0.42	Aug 29	0.56	Sep 29	0.81	Oct 29	1.05
Mar 30	0.02	Apr 30	0.00	May 30	0.18	Jun 30	0.00	Jul 30	0.42	Aug 30	0.55	Sep 30	0.81	Oct 30	1.10
Mar 31	0.03			May 31	0.16			Jul 31	0.40	Aug 31	0.58			Oct 31	1.10

Table 19–17 Water level, in feet below land-surface datum, for October 1980 to September 1981

Washington County
350422095341901. local number, 08W-15E-254
Location—Lat 45 4'22" Long 122 34' 19"
Well characteristics—Observation well
Datum—Altitude of land-surface is unavailable

Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
Mar 1	0.50	Apr 1	0.00	May 1	0.10	Jun 1	0.18	Jul 1	0.10	Aug 1	0.41	Sep 1	0.60	Oct 1	0.85
Mar 2	0.50	Apr 2	0.00	May 2	0.11	Jun 2	0.19	Jul 2	0.15	Aug 2	0.42	Sep 2	0.61	Oct 2	0.86
Mar 3	0.49	Apr 3	0.00	May 3	0.12	Jun 3	0.20	Jul 3	0.20	Aug 3	0.42	Sep 3	0.62	Oct 3	0.86
Mar 4	0.48	Apr 4	0.05	May 4	0.13	Jun 4	0.20	Jul 4	0.22	Aug 4	0.44	Sep 4	0.63	Oct 4	0.86
Mar 5	0.47	Apr 5	0.05	May 5	0.15	Jun 5	0.21	Jul 5	0.25	Aug 5	0.45	Sep 5	0.61	Oct 5	0.87
Mar 6	0.47	Apr 6	0.10	May 6	0.18	Jun 6	0.22	Jul 6	0.26	Aug 6	0.45	Sep 6	0.60	Oct 6	0.89
Mar 7	0.44	Apr 7	0.10	May 7	0.29	Jun 7	0.20	Jul 7	0.27	Aug 7	0.46	Sep 7	0.61	Oct 7	0.90
Mar 8	0.43	Apr 8	0.10	May 8	0.25	Jun 8	0.19	Jul 8	0.30	Aug 8	0.47	Sep 8	0.62	Oct 8	0.91
Mar 9	0.42	Apr 9	0.05	May 9	0.28	Jun 9	0.18	Jul 9	0.35	Aug 9	0.48	Sep 9	0.63	Oct 9	0.93
Mar 10	0.40	Apr 10	0.03	May 10	0.25	Jun 10	0.16	Jul 10	0.33	Aug 10	0.49	Sep 10	0.65	Oct 10	0.94
Mar 11	0.38	Apr 11	0.00	May 11	0.28	Jun 11	0.14	Jul 11	0.35	Aug 11	0.48	Sep 11	0.66	Oct 11	0.95
Mar 12	0.37	Apr 12	0.00	May 12	0.37	Jun 12	0.13	Jul 12	0.37	Aug 12	0.48	Sep 12	0.65	Oct 12	0.97
Mar 13	0.35	Apr 13	0.00	May 13	0.33	Jun 13	0.12	Jul 13	0.38	Aug 13	0.49	Sep 13	0.67	Oct 13	0.95
Mar 14	0.32	Apr 14	0.00	May 14	0.35	Jun 14	0.11	Jul 14	0.37	Aug 14	0.45	Sep 14	0.65	Oct 14	0.96
Mar 15	0.33	Apr 15	0.00	May 15	0.33	Jun 15	0.10	Jul 15	0.40	Aug 15	0.44	Sep 15	0.67	Oct 15	0.97
Mar 16	0.31	Apr 16	0.00	May 16	0.34	Jun 16	0.08	Jul 16	0.41	Aug 16	0.46	Sep 16	0.68	Oct 16	0.98
Mar 17	0.30	Apr 17	0.00	May 17	0.31	Jun 17	0.06	Jul 17	0.42	Aug 17	0.47	Sep 17	0.69	Oct 17	0.99
Mar 18	0.28	Apr 18	0.00	May 18	0.32	Jun 18	0.05	Jul 18	0.43	Aug 18	0.48	Sep 18	0.70	Oct 18	1.00
Mar 19	0.26	Apr 19	0.00	May 19	0.32	Jun 19	0.03	Jul 19	0.45	Aug 19	0.49	Sep 19	0.71	Oct 19	1.01
Mar 20	0.24	Apr 20	0.00	May 20	0.33	Jun 20	0.02	Jul 20	0.45	Aug 20	0.50	Sep 20	0.73	Oct 20	1.00
Mar 21	0.22	Apr 21	0.00	May 21	0.35	Jun 21	0.00	Jul 21	0.47	Aug 21	0.50	Sep 21	0.75	Oct 21	0.99
Mar 22	0.20	Apr 22	0.00	May 22	0.33	Jun 22	0.00	Jul 22	0.43	Aug 22	0.51	Sep 22	0.76	Oct 22	1.00
Mar 23	0.15	Apr 23	0.00	May 23	0.31	Jun 23	0.00	Jul 23	0.45	Aug 23	0.52	Sep 23	0.77	Oct 23	1.01
Mar 24	0.13	Apr 24	0.00	May 24	0.30	Jun 24	0.00	Jul 24	0.47	Aug 24	0.53	Sep 24	0.78	Oct 24	1.02
Mar 25	0.11	Apr 25	0.00	May 25	0.28	Jun 25	0.00	Jul 25	0.45	Aug 25	0.52	Sep 25	0.79	Oct 25	1.03
Mar 26	0.10	Apr 26	0.00	May 26	0.26	Jun 26	0.01	Jul 26	0.43	Aug 26	0.53	Sep 26	0.80	Oct 26	1.04
Mar 27	0.05	Apr 27	0.00	May 27	0.28	Jun 27	0.02	Jul 27	0.42	Aug 27	0.54	Sep 27	0.81	Oct 27	1.03
Mar 28	0.03	Apr 28	0.00	May 28	0.25	Jun 28	0.03	Jul 28	0.43	Aug 28	0.55	Sep 28	0.82	Oct 28	1.04
Mar 29	0.01	Apr 29	0.00	May 29	0.20	Jun 29	0.05	Jul 29	0.42	Aug 29	0.56	Sep 29	0.81	Oct 29	1.05
Mar 30	0.00	Apr 30	0.00	May 30	0.18	Jun 30	0.07	Jul 30	0.42	Aug 30	0.55	Sep 30	0.81	Oct 30	1.10
Mar 31	0.00			May 31	0.16			Jul 31	0.40	Aug 31	0.58			Oct 31	1.10

Table 19–18 Water level, in feet below land-surface datum, for October 1981 to September 1982

Washington County
350422095341901. local number, 08W-15E-254
Location—Lat 45 4’22" Long 122 34' 19"
Well characteristics—Observation well
Datum—Altitude of land-surface is unavailable

Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
Mar 1	0.50	Apr 1	0.04	May 1	0.10	Jun 1	0.18	Jul 1	0.10	Aug 1	0.41	Sep 1	0.60	Oct 1	0.85
Mar 2	0.50	Apr 2	0.05	May 2	0.11	Jun 2	0.19	Jul 2	0.15	Aug 2	0.42	Sep 2	0.61	Oct 2	0.86
Mar 3	0.49	Apr 3	0.06	May 3	0.12	Jun 3	0.20	Jul 3	0.20	Aug 3	0.42	Sep 3	0.62	Oct 3	0.86
Mar 4	0.48	Apr 4	0.05	May 4	0.13	Jun 4	0.20	Jul 4	0.22	Aug 4	0.44	Sep 4	0.63	Oct 4	0.86
Mar 5	0.47	Apr 5	0.05	May 5	0.15	Jun 5	0.21	Jul 5	0.25	Aug 5	0.45	Sep 5	0.61	Oct 5	0.87
Mar 6	0.47	Apr 6	0.10	May 6	0.18	Jun 6	0.22	Jul 6	0.26	Aug 6	0.45	Sep 6	0.60	Oct 6	0.89
Mar 7	0.44	Apr 7	0.10	May 7	0.29	Jun 7	0.20	Jul 7	0.27	Aug 7	0.46	Sep 7	0.61	Oct 7	0.90
Mar 8	0.43	Apr 8	0.10	May 8	0.25	Jun 8	0.19	Jul 8	0.30	Aug 8	0.47	Sep 8	0.62	Oct 8	0.91
Mar 9	0.42	Apr 9	0.05	May 9	0.28	Jun 9	0.18	Jul 9	0.35	Aug 9	0.48	Sep 9	0.63	Oct 9	0.93
Mar 10	0.40	Apr 10	0.03	May 10	0.25	Jun 10	0.16	Jul 10	0.33	Aug 10	0.49	Sep 10	0.65	Oct 10	0.94
Mar 11	0.38	Apr 11	0.05	May 11	0.28	Jun 11	0.14	Jul 11	0.35	Aug 11	0.48	Sep 11	0.66	Oct 11	0.95
Mar 12	0.37	Apr 12	0.03	May 12	0.37	Jun 12	0.13	Jul 12	0.37	Aug 12	0.48	Sep 12	0.65	Oct 12	0.97
Mar 13	0.35	Apr 13	0.05	May 13	0.33	Jun 13	0.12	Jul 13	0.38	Aug 13	0.49	Sep 13	0.67	Oct 13	0.95
Mar 14	0.32	Apr 14	0.06	May 14	0.35	Jun 14	0.11	Jul 14	0.37	Aug 14	0.45	Sep 14	0.65	Oct 14	0.96
Mar 15	0.33	Apr 15	0.05	May 15	0.33	Jun 15	0.10	Jul 15	0.40	Aug 15	0.44	Sep 15	0.67	Oct 15	0.97
Mar 16	0.31	Apr 16	0.06	May 16	0.34	Jun 16	0.08	Jul 16	0.41	Aug 16	0.46	Sep 16	0.68	Oct 16	0.98
Mar 17	0.30	Apr 17	0.07	May 17	0.31	Jun 17	0.06	Jul 17	0.42	Aug 17	0.47	Sep 17	0.69	Oct 17	0.99
Mar 18	0.28	Apr 18	0.05	May 18	0.32	Jun 18	0.05	Jul 18	0.43	Aug 18	0.48	Sep 18	0.70	Oct 18	1.00
Mar 19	0.26	Apr 19	0.03	May 19	0.32	Jun 19	0.03	Jul 19	0.45	Aug 19	0.49	Sep 19	0.71	Oct 19	1.01
Mar 20	0.24	Apr 20	0.01	May 20	0.33	Jun 20	0.02	Jul 20	0.45	Aug 20	0.50	Sep 20	0.73	Oct 20	1.00
Mar 21	0.22	Apr 21	0.00	May 21	0.35	Jun 21	0.00	Jul 21	0.47	Aug 21	0.50	Sep 21	0.75	Oct 21	0.99
Mar 22	0.20	Apr 22	0.00	May 22	0.33	Jun 22	0.00	Jul 22	0.43	Aug 22	0.51	Sep 22	0.76	Oct 22	1.00
Mar 23	0.15	Apr 23	0.00	May 23	0.31	Jun 23	0.00	Jul 23	0.45	Aug 23	0.52	Sep 23	0.77	Oct 23	1.01
Mar 24	0.13	Apr 24	0.00	May 24	0.30	Jun 24	0.00	Jul 24	0.47	Aug 24	0.53	Sep 24	0.78	Oct 24	1.02
Mar 25	0.11	Apr 25	0.00	May 25	0.28	Jun 25	0.00	Jul 25	0.45	Aug 25	0.52	Sep 25	0.79	Oct 25	1.03
Mar 26	0.10	Apr 26	0.01	May 26	0.26	Jun 26	0.00	Jul 26	0.43	Aug 26	0.53	Sep 26	0.80	Oct 26	1.04
Mar 27	0.05	Apr 27	0.02	May 27	0.28	Jun 27	0.00	Jul 27	0.42	Aug 27	0.54	Sep 27	0.81	Oct 27	1.03
Mar 28	0.03	Apr 28	0.03	May 28	0.25	Jun 28	0.00	Jul 28	0.43	Aug 28	0.55	Sep 28	0.82	Oct 28	1.04
Mar 29	0.01	Apr 29	0.05	May 29	0.20	Jun 29	0.00	Jul 29	0.42	Aug 29	0.56	Sep 29	0.81	Oct 29	1.05
Mar 30	0.02	Apr 30	0.06	May 30	0.18	Jun 30	0.00	Jul 30	0.42	Aug 30	0.55	Sep 30	0.81	Oct 30	1.10
Mar 31	0.03			May 31	0.16			Jul 31	0.40	Aug 31	0.58			Oct 31	1.10

Table 19–19 Water level, in feet below land-surface datum, for October 1982 to September 1983

Washington County
350422095341901. local number, 08W-15E-254
Location—Lat 45 4'22" Long 122 34' 19"
Well characteristics—Observation well
Datum—Altitude of land-surface is unavailable

Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
Mar 1	0.50	Apr 1	0.04	May 1	0.10	Jun 1	0.18	Jul 1	0.10	Aug 1	0.41	Sep 1	0.60	Oct 1	0.85
Mar 2	0.50	Apr 2	0.05	May 2	0.11	Jun 2	0.19	Jul 2	0.15	Aug 2	0.42	Sep 2	0.61	Oct 2	0.86
Mar 3	0.49	Apr 3	0.06	May 3	0.12	Jun 3	0.20	Jul 3	0.20	Aug 3	0.42	Sep 3	0.62	Oct 3	0.86
Mar 4	0.48	Apr 4	0.05	May 4	0.13	Jun 4	0.20	Jul 4	0.22	Aug 4	0.44	Sep 4	0.63	Oct 4	0.86
Mar 5	0.47	Apr 5	0.05	May 5	0.15	Jun 5	0.21	Jul 5	0.25	Aug 5	0.45	Sep 5	0.61	Oct 5	0.87
Mar 6	0.47	Apr 6	0.10	May 6	0.18	Jun 6	0.22	Jul 6	0.26	Aug 6	0.45	Sep 6	0.60	Oct 6	0.89
Mar 7	0.44	Apr 7	0.10	May 7	0.29	Jun 7	0.20	Jul 7	0.27	Aug 7	0.46	Sep 7	0.61	Oct 7	0.90
Mar 8	0.43	Apr 8	0.10	May 8	0.25	Jun 8	0.19	Jul 8	0.30	Aug 8	0.47	Sep 8	0.62	Oct 8	0.91
Mar 9	0.42	Apr 9	0.05	May 9	0.28	Jun 9	0.18	Jul 9	0.35	Aug 9	0.48	Sep 9	0.63	Oct 9	0.93
Mar 10	0.40	Apr 10	0.03	May 10	0.25	Jun 10	0.16	Jul 10	0.33	Aug 10	0.49	Sep 10	0.65	Oct 10	0.94
Mar 11	0.38	Apr 11	0.05	May 11	0.28	Jun 11	0.14	Jul 11	0.35	Aug 11	0.48	Sep 11	0.66	Oct 11	0.95
Mar 12	0.37	Apr 12	0.03	May 12	0.37	Jun 12	0.13	Jul 12	0.37	Aug 12	0.48	Sep 12	0.65	Oct 12	0.97
Mar 13	0.35	Apr 13	0.05	May 13	0.33	Jun 13	0.12	Jul 13	0.38	Aug 13	0.49	Sep 13	0.67	Oct 13	0.95
Mar 14	0.32	Apr 14	0.06	May 14	0.35	Jun 14	0.11	Jul 14	0.37	Aug 14	0.45	Sep 14	0.65	Oct 14	0.96
Mar 15	0.33	Apr 15	0.05	May 15	0.33	Jun 15	0.10	Jul 15	0.40	Aug 15	0.44	Sep 15	0.67	Oct 15	0.97
Mar 16	0.31	Apr 16	0.06	May 16	0.34	Jun 16	0.08	Jul 16	0.41	Aug 16	0.46	Sep 16	0.68	Oct 16	0.98
Mar 17	0.30	Apr 17	0.07	May 17	0.31	Jun 17	0.06	Jul 17	0.42	Aug 17	0.47	Sep 17	0.69	Oct 17	0.99
Mar 18	0.28	Apr 18	0.05	May 18	0.32	Jun 18	0.05	Jul 18	0.43	Aug 18	0.48	Sep 18	0.70	Oct 18	1.00
Mar 19	0.26	Apr 19	0.03	May 19	0.32	Jun 19	0.03	Jul 19	0.45	Aug 19	0.49	Sep 19	0.71	Oct 19	1.01
Mar 20	0.24	Apr 20	0.01	May 20	0.33	Jun 20	0.02	Jul 20	0.45	Aug 20	0.50	Sep 20	0.73	Oct 20	1.00
Mar 21	0.22	Apr 21	0.01	May 21	0.35	Jun 21	0.00	Jul 21	0.47	Aug 21	0.50	Sep 21	0.75	Oct 21	0.99
Mar 22	0.20	Apr 22	0.03	May 22	0.33	Jun 22	0.00	Jul 22	0.43	Aug 22	0.51	Sep 22	0.76	Oct 22	1.00
Mar 23	0.15	Apr 23	0.05	May 23	0.31	Jun 23	0.00	Jul 23	0.45	Aug 23	0.52	Sep 23	0.77	Oct 23	1.01
Mar 24	0.13	Apr 24	0.07	May 24	0.30	Jun 24	0.00	Jul 24	0.47	Aug 24	0.53	Sep 24	0.78	Oct 24	1.02
Mar 25	0.11	Apr 25	0.05	May 25	0.28	Jun 25	0.00	Jul 25	0.45	Aug 25	0.52	Sep 25	0.79	Oct 25	1.03
Mar 26	0.10	Apr 26	0.06	May 26	0.26	Jun 26	0.00	Jul 26	0.43	Aug 26	0.53	Sep 26	0.80	Oct 26	1.04
Mar 27	0.05	Apr 27	0.07	May 27	0.28	Jun 27	0.00	Jul 27	0.42	Aug 27	0.54	Sep 27	0.81	Oct 27	1.03
Mar 28	0.03	Apr 28	0.08	May 28	0.25	Jun 28	0.00	Jul 28	0.43	Aug 28	0.55	Sep 28	0.82	Oct 28	1.04
Mar 29	0.01	Apr 29	0.08	May 29	0.20	Jun 29	0.00	Jul 29	0.42	Aug 29	0.56	Sep 29	0.81	Oct 29	1.05
Mar 30	0.02	Apr 30	0.09	May 30	0.18	Jun 30	0.00	Jul 30	0.42	Aug 30	0.55	Sep 30	0.81	Oct 30	1.10
Mar 31	0.03			May 31	0.16			Jul 31	0.40	Aug 31	0.58			Oct 31	1.10

Table 19–20 Water level, in feet below land-surface datum, for October 1983 to September 1984

Washington County
3504295341901. local number, 08W-15E-254
Location—Lat 45 4'22" Long 122 34' 19"
Well characteristics—Observation well
Datum—Altitude of land-surface is unavailable

Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
Mar 1	0.45	Apr 1	0.14	May 1	0.20	Jun 1	0.28	Jul 1	0.20	Aug 1	0.41	Sep 1	0.60	Oct 1	0.85
Mar 2	0.40	Apr 2	0.15	May 2	0.21	Jun 2	0.19	Jul 2	0.25	Aug 2	0.42	Sep 2	0.61	Oct 2	0.86
Mar 3	0.45	Apr 3	0.16	May 3	0.22	Jun 3	0.20	Jul 3	0.20	Aug 3	0.42	Sep 3	0.62	Oct 3	0.86
Mar 4	0.45	Apr 4	0.15	May 4	0.23	Jun 4	0.20	Jul 4	0.22	Aug 4	0.44	Sep 4	0.63	Oct 4	0.86
Mar 5	0.45	Apr 5	0.15	May 5	0.25	Jun 5	0.21	Jul 5	0.25	Aug 5	0.45	Sep 5	0.61	Oct 5	0.87
Mar 6	0.43	Apr 6	0.20	May 6	0.28	Jun 6	0.25	Jul 6	0.26	Aug 6	0.45	Sep 6	0.60	Oct 6	0.89
Mar 7	0.43	Apr 7	0.20	May 7	0.19	Jun 7	0.25	Jul 7	0.27	Aug 7	0.46	Sep 7	0.61	Oct 7	0.90
Mar 8	0.42	Apr 8	0.20	May 8	0.15	Jun 8	0.29	Jul 8	0.30	Aug 8	0.47	Sep 8	0.62	Oct 8	0.91
Mar 9	0.42	Apr 9	0.15	May 9	0.18	Jun 9	0.38	Jul 9	0.35	Aug 9	0.48	Sep 9	0.63	Oct 9	0.93
Mar 10	0.41	Apr 10	0.23	May 10	0.15	Jun 10	0.26	Jul 10	0.33	Aug 10	0.49	Sep 10	0.65	Oct 10	0.94
Mar 11	0.35	Apr 11	0.25	May 11	0.18	Jun 11	0.24	Jul 11	0.35	Aug 11	0.48	Sep 11	0.66	Oct 11	0.95
Mar 12	0.33	Apr 12	0.13	May 12	0.27	Jun 12	0.23	Jul 12	0.37	Aug 12	0.48	Sep 12	0.65	Oct 12	0.97
Mar 13	0.33	Apr 13	0.15	May 13	0.23	Jun 13	0.22	Jul 13	0.38	Aug 13	0.49	Sep 13	0.67	Oct 13	0.95
Mar 14	0.31	Apr 14	0.16	May 14	0.25	Jun 14	0.21	Jul 14	0.37	Aug 14	0.45	Sep 14	0.65	Oct 14	0.96
Mar 15	0.33	Apr 15	0.15	May 15	0.23	Jun 15	0.25	Jul 15	0.40	Aug 15	0.44	Sep 15	0.67	Oct 15	0.97
Mar 16	0.34	Apr 16	0.16	May 16	0.34	Jun 16	0.28	Jul 16	0.41	Aug 16	0.46	Sep 16	0.68	Oct 16	0.98
Mar 17	0.32	Apr 17	0.17	May 17	0.33	Jun 17	0.26	Jul 17	0.42	Aug 17	0.47	Sep 17	0.69	Oct 17	0.99
Mar 18	0.28	Apr 18	0.15	May 18	0.33	Jun 18	0.25	Jul 18	0.43	Aug 18	0.48	Sep 18	0.70	Oct 18	1.00
Mar 19	0.28	Apr 19	0.13	May 19	0.33	Jun 19	0.23	Jul 19	0.45	Aug 19	0.49	Sep 19	0.71	Oct 19	1.01
Mar 20	0.26	Apr 20	0.11	May 20	0.35	Jun 20	0.22	Jul 20	0.45	Aug 20	0.50	Sep 20	0.73	Oct 20	1.00
Mar 21	0.21	Apr 21	0.11	May 21	0.35	Jun 21	0.20	Jul 21	0.47	Aug 21	0.50	Sep 21	0.75	Oct 21	0.99
Mar 22	0.22	Apr 22	0.13	May 22	0.35	Jun 22	0.20	Jul 22	0.43	Aug 22	0.51	Sep 22	0.76	Oct 22	1.00
Mar 23	0.18	Apr 23	0.15	May 23	0.32	Jun 23	0.20	Jul 23	0.45	Aug 23	0.52	Sep 23	0.77	Oct 23	1.01
Mar 24	0.16	Apr 24	0.17	May 24	0.36	Jun 24	0.20	Jul 24	0.47	Aug 24	0.53	Sep 24	0.78	Oct 24	1.02
Mar 25	0.16	Apr 25	0.15	May 25	0.38	Jun 25	0.20	Jul 25	0.45	Aug 25	0.52	Sep 25	0.79	Oct 25	1.03
Mar 26	0.11	Apr 26	0.16	May 26	0.36	Jun 26	0.20	Jul 26	0.43	Aug 26	0.53	Sep 26	0.80	Oct 26	1.04
Mar 27	0.11	Apr 27	0.17	May 27	0.38	Jun 27	0.20	Jul 27	0.42	Aug 27	0.54	Sep 27	0.81	Oct 27	1.03
Mar 28	0.13	Apr 28	0.18	May 28	0.35	Jun 28	0.20	Jul 28	0.43	Aug 28	0.55	Sep 28	0.82	Oct 28	1.04
Mar 29	0.11	Apr 29	0.11	May 29	0.30	Jun 29	0.20	Jul 29	0.42	Aug 29	0.56	Sep 29	0.81	Oct 29	1.05
Mar 30	0.12	Apr 30	0.19	May 30	0.28	Jun 30	0.20	Jul 30	0.42	Aug 30	0.55	Sep 30	0.81	Oct 30	1.10
Mar 31	0.13			May 31	0.28			Jul 31	0.41	Aug 31	0.58			Oct 31	1.10

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