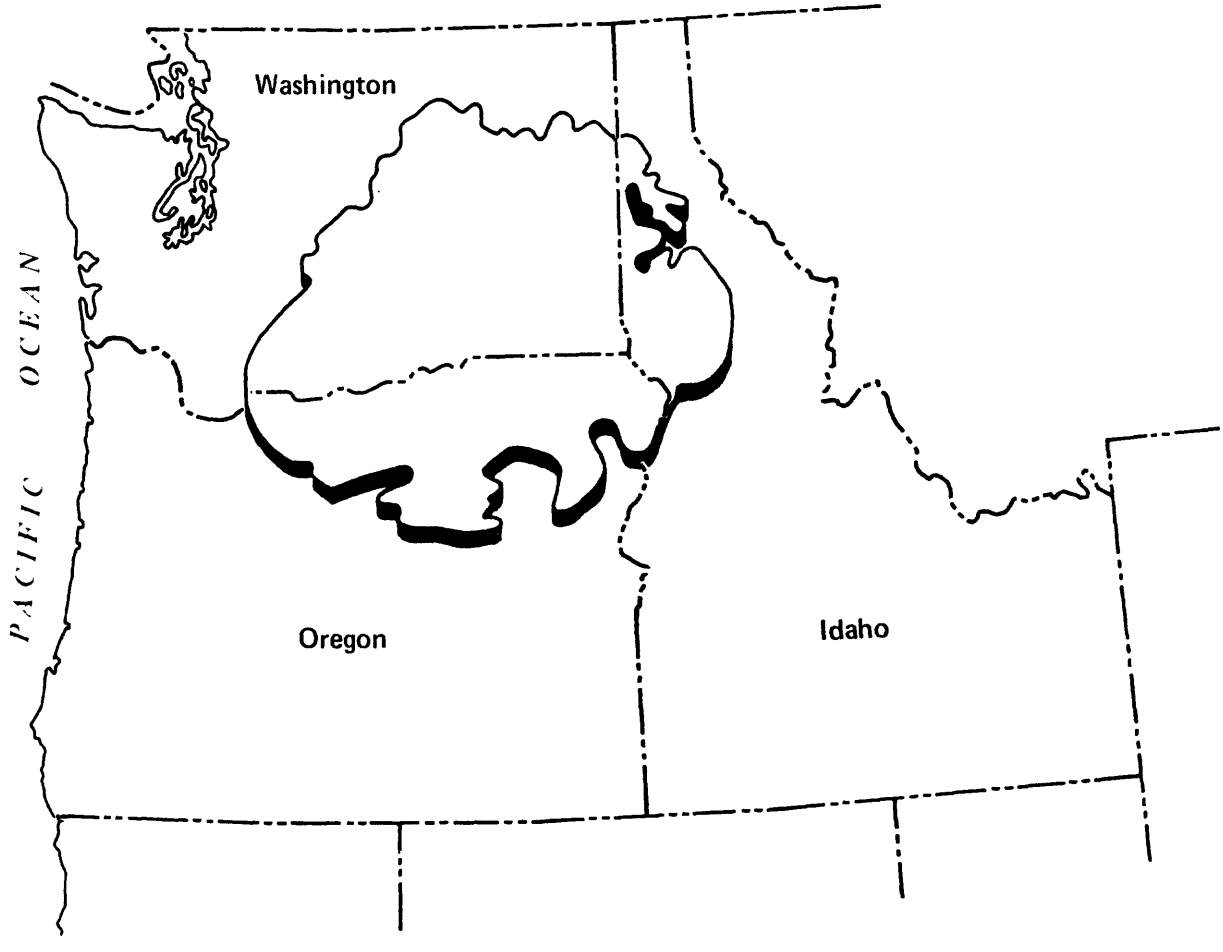
Archiving of Deep Percolation Models, Data Files, and Calculated Recharge Estimates for the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho

A contribution of the Regional Aquifer-System Analysis Program

U.S. GEOLOGICAL SURVEY
Open-File Report 88-186



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MANUEL LUJAN, JR., Secretary

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Dallas L. Peck, Director

For additional information
write to:

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ARCHIVING OF DEEP PERCOLATION MODELS, DATA FILES, AND CALCULATED RECHARGE ESTIMATES FOR THE COLUMBIA PLATEAU REGIONAL AQUIFER SYSTEM, WASHINGTON, OREGON, AND IDAHO

By J. J. Vaccaro and H. H. Bauer

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Tacoma, Washington
1990

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By J. J. Vaccaro and H. H. Bauer

ABSTRACT

The report documents the archiving of computer files used in a daily deep percolation model to calculate recharge estimates for the Columbia Plateau regional aquifer system in parts of Washington, Oregon, and Idaho. The files are obtainable on magnetic tape from the U.S. Geological Survey. There are 53 files containing source codes of the models used for 53 zones and one file containing the source code for an inverse Lambert projection. Basic input data and model output are each contained in 103 files, 53 files for pre-development and 50 files for current land-use conditions. Other files contain data for (1) model grid definition; (2) line printer output-map configurations; (3) soil types; (4) land uses; (5) annual irrigation application rates; (6) land-surface altitudes, slopes, and aspects; (7) annual average precipitation values; (8) daily stream discharges; (9) monthly estimates of baseflow to streams; (10) locations of precipitation weather stations; (11) locations and altitudes of temperature weather stations; (12) long-term average July minimum and maximum air temperatures at temperature weather stations; (13) mean daily precipitation data at 103 weather stations for 22 years; (14) mean daily maximum air temperatures at 89 weather sites for 22 years; and (15) mean daily minimum air temperatures at 89 sites for 22 years.

INTRODUCTION

A study of the Columbia Plateau regional aquifer system was begun in October 1982, as one of the 28 studies in the U.S. Geological Survey's Regional Aquifer-System Analyses Program (RASA). The Columbia Plateau aquifer system underlies the Columbia Plateau (fig. 1) in central and eastern Washington, north-central and eastern Oregon, and a small part of northwestern Idaho. The aquifer system is composed of the Columbia River Basalt Group, all of the intercalated sediments collectively assigned to the Ellensburg Formation, and the unconsolidated sediments overlying the basalts.

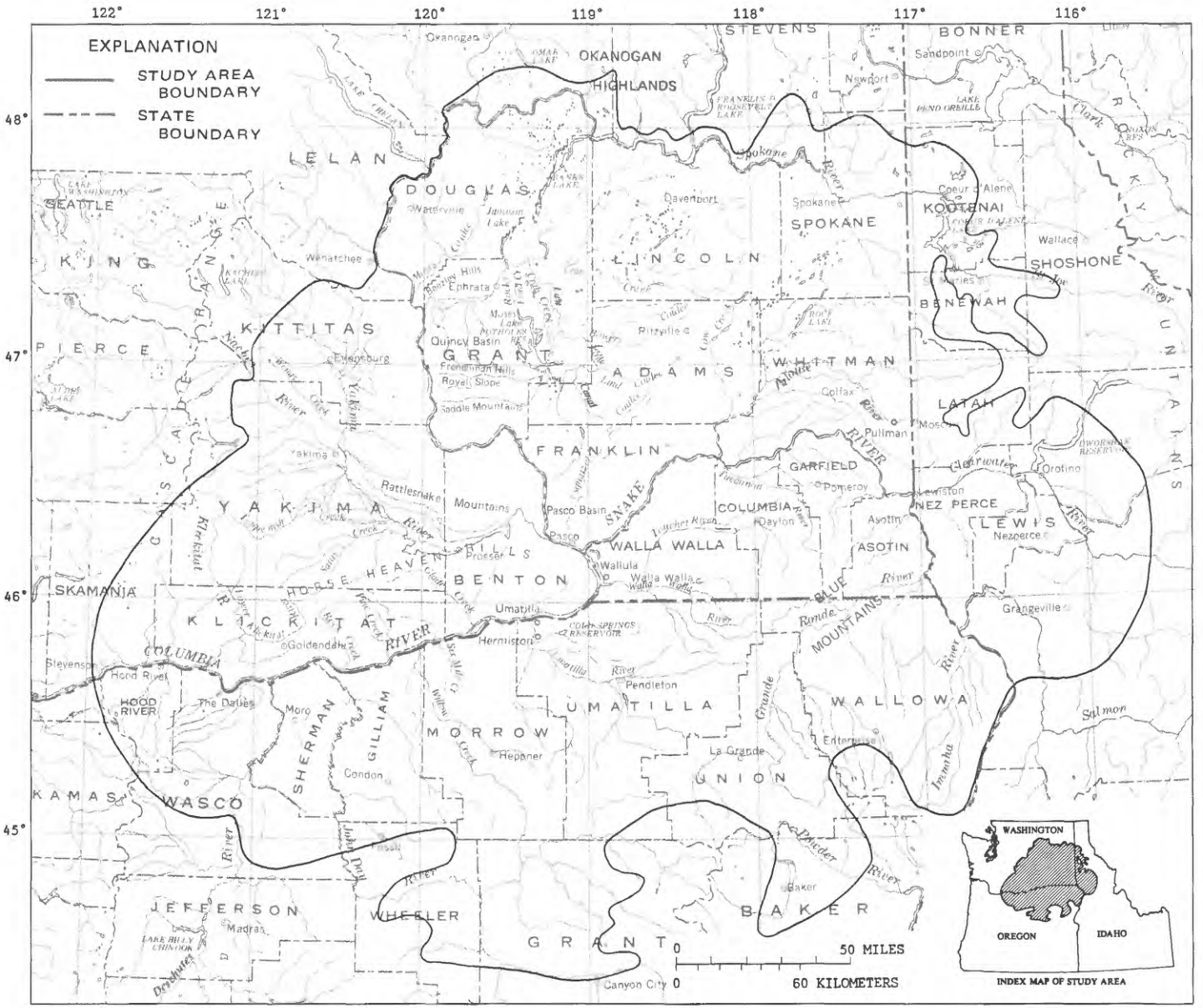
Recharge to the water table aquifer was estimated using a deep percolation model (DPM), documented by Bauer and Vaccaro (1987), for the part of the aquifer system within the boundaries of a ground-water flow model being constructed for the study (fig. 2). The model was used to estimate recharge for 53 basins and zones, herein called zones (fig. 2), for predevelopment land-use conditions and for 50 zones for current land-use conditions. Land-use conditions in three zones (4, 5, and 37) remained unchanged as of 1977. The application of the DPM to these zones, including tables of characteristics and results, is given by Bauer and Vaccaro (1990). Attributes, including naming conventions and characteristics, for the 53 zones modeled are given in table 1 of this report.

The purpose of this report is to describe the archiving of the computer files containing DPM source code for each recharge model, the input data files and output file for each model, and a source code for an inverse Lambert projection. There are 775 files stored on magnetic tape at the U.S. Geological Survey's Washington State office, Tacoma, Washington. A listing of these files and the reference number of the modeled zone (fig. 2 and table 1) are given in table 2, and the next section describes the attributes for the magnetic tape. Copies of the tape can be obtained from the State Office Chief, Water Resources Division, U.S. Geological Survey, Suite 600, 1201 Pacific Avenue, Tacoma, Washington, 98402.

MAGNETIC TAPE ATTRIBUTES

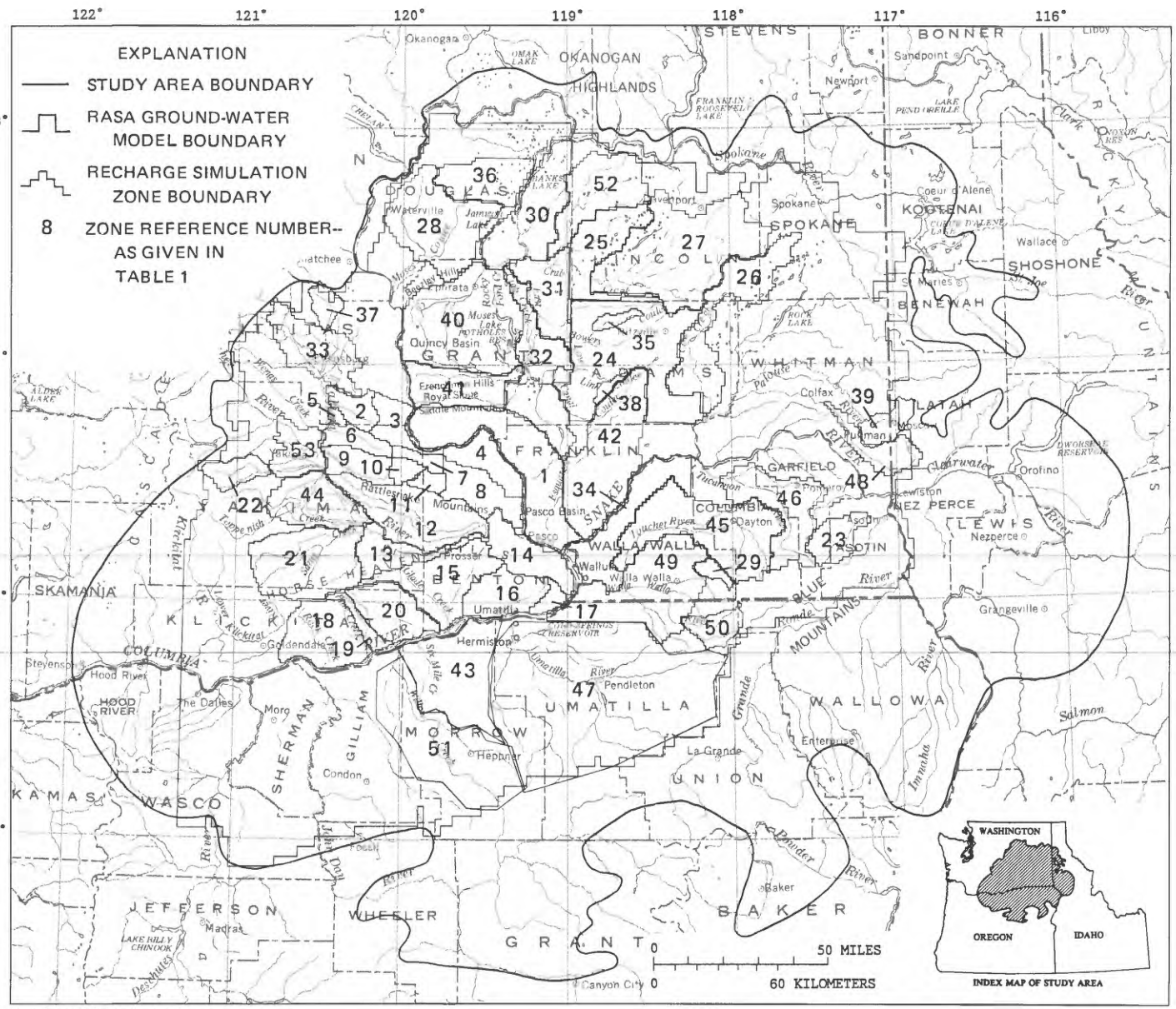
The attributes of the magnetic tape for archiving the files described in this report are:

Fixed Record Length:	Files 1 through 604,	80 bytes
	Files 605 through 626,	618 bytes
	Files 627 through 670,	712 bytes
	Files 671 through 774,	80 bytes
Block Size:	Files 1 through 604,	12,000 bytes
	Files 605 through 626,	11,742 bytes
	Files 627 through 670,	12,104 bytes
	File 671	1,360 bytes
	Files 672 through 774,	7,200 bytes



Base from U.S. Geological Survey
State base maps, 1:500 000

FIGURE 1.--Location of Columbia Plateau regional aquifer system study.



Base from U.S. Geological Survey
State base maps, 1:500 000

Figure 2.--Zones, with reference numbers, where recharge was estimated using the daily deep percolation model.

TABLE 1.--Attributes for the zones which were modeled

Reference number	Name[1]	Average latitude	Area, in square miles	Years[2] of simulation	Runoff[3] record	Altitude[4] data	Nodes	Cells	Cell size,[5] in square miles	Dry land[6] cells	Irrigated cells
1	BWIP1	46.5	737	1956-77	N	Y	3,151	2,949	0.25	169	1,191
2	BWIP2	46.8	115	56-76	P	Y	365	310	.375	0	3
3	BWIP3	46.8	146	56-77	N	Y	469	395	.375	0	5
4	BWIP4	46.6	190	56-77	N	Y	581	507	.375	0	0
5	BWIP5	46.8	20	56-77	N	Y	73	54	.375	0	0
6	BWIP6	46.7	112	56-73	P	Y	357	303	.375	0	5
7	BWIP7	46.7	59	67-78	P	Y	193	156	.375	11	0
8	BWIP8	46.5	234	56-77	N	Y	718	632	.375	7	12
9	BWIP9	46.6	161	63-76	P	Y	492	436	.375	30	90
10	BWIP10	46.6	56	56-77	N	Y	181	149	.375	38	0
11	BWIP11	46.5	52	56-77	N	Y	173	138	.375	22	0
12	BWIP12	46.3	548	56-76	P	Y	1,579	1.462	.375	214	733
13	BWIP13	46.2	211	56-77	N	Y	671	571	.375	60	141
14	BWIP14	46.2	260	56-73	P	Y	790	701	.375	239	123
15	BWIP15	46.1	431	63-68	S	Y	1,266	1,149	.375	854	102
16	BWIP16	46.0	260	56-77	N	Y	760	692	.375	215	94
17	BWIP17	46.0	52	56-77	N	Y	176	139	.375	68	26
18	BWIP18	46.8	391	63-68	D	Y	1,665	1,565	.25	179	14
19	BWIP19	45.8	70	64-68	S	Y	352	278	.25	40	0
20	BWIP20	45.9	281	63-68	D	Y	1,218	1,124	.25	257	58
21	BWIP21	46.2	576	63-72	D	Y	1,532	1,537	.375	1	4
22	Ahtanum	46.5	122	61-67	D	Y	552	487	.25	2	17
23	Asotin	46.23	157	60-77	D	Y	204	167	1.0	30	0
24	Bowers Coulee	47.0	1,020	56-76	S	N	1,134	1,020	1.0	758	150
25	Canniwai	47.5	347	56-77	N	N	442	347	1.0	117	67
26	Cow Creek	47.2	546	62-69	D	N	657	546	1.0	161	35
27	Crab Creek	47.45	1,019	56-77	D	N	1,126	1,019	1.0	612	31
28	Douglas Creek	46.6	601	56-77	D	Y	672	601	1.0	406	15
29	Dry Creek	46.15	57	56-66	D	Y	226	182	.25	125	0
30	East Banks	47.5	482	56-77	N	N	550	482	1.0	222	41
31	East High Canal	47.3	293	56-77	N	N	346	293	1.0	69	105
32	Eastlow Canal	47.00	504	56-77	N	N	599	504	1.0	18	266
33	Ellensburg	47.0	362	56-77	N	N	425	362	1.0	3	193
34	Eureka Flat	46.35	501	56-77	N	N	501	409	1.0	240	68
35	Farrier Coulee	47.15	43	62-73	D	N	217	172	.25	148	16
36	Jameson Lake	47.7	293	56-77	N	N	338	293	1.0	179	0
37	Naneum Creek	47.2	85	57-77	S	Y	390	338	.25	0	0
38	Providence Coulee	46.9	31	56-76	D	N	162	122	.25	73	36
39	Pullman-Moscow	46.7	106	60-77	D	Y	592	525	.25	430	0
40	Quincy	47.1	872	56-77	N	Y	945	872	1.0	69	314
41	Royal Slope	46.9	321	56-77	N	Y	1,396	1,285	.25	134	470
42	Rye Grass Flat	46.65	711	56-77	N	N	787	711	1.0	496	47
43	Six Mile Creek	45.6	624	56-77	N	N	35	24	V	0	3
44	Toppenish	46.4	346	56-77	N	N	397	346	1.0	40	213

TABLE 1.--Attributes for the zones which were modeled--continued

Reference number	Name[1]	Average latitude	Area, in square miles	Years[2] of simulation	Runoff[3] record	Altitude[4] data	Nodes	Cells	Cell size,[5] in square miles	Dry land[6] cells	Irrigated cells
45	Touchet River	46.30	734	56-77	D	Y	835	734	1.0	543	9
46	Toucannon River	46.40	433	59-77	D	Y	515	433	1.0	197	0
47	Umatilla River	45.55	2,392	56-77	S	Y	143	120	V	39	22
48	Union Flat Creek	46.6	185	56-70	D	N	239	185	1.0	113	0
49	Walla Walla	46.0	726	56-77	N	N	814	726	1.0	508	115
50	South-North Fork Walla Walla River	45.85	128	56-77	D,S	Y	581	513	.25	8	6
51	Willow Creek	45.4	856	56-77	N	Y	85	64	V	0	11
52	Wilson Creek	47.7	427	56-72	D	Y	494	427	1.0	288	21
53	Yakima	46.6	203	56-77	N	N	246	203	1.0	10	110

[1]Name refers to location of zone or feature within area and BWIP refers to zones in the Basalt Waste Isolation Project study area discussed in Bauer and Vaccaro (1987).

[2]Years is the calendar years for which the model was operated.

[3]Runoff record shows the type of streamflow data used in the model, where: N=assumed no surface runoff, D=observed daily values, S=synthesized record using standard techniques, and P=daily values synthesized from peak value data.

[4]Y=all cells for zone that had altitude, slope, and aspect data; N=none of the cells had such data.

[5]Size of cells that zones were subdivided into, and V=variable size blocks.

[6]Number of cells in a zone that had dryland agriculture assumed to be winter wheat on 2-year cycle.

TABLE 2.--List of files stored on magnetic tape

File Numbers	Contents
1-53[1]	Source code for DPM models
54-106[1] 107-156[2]	Main data stream input
157-209[1]	Grid definition files x,y values in feet
210-262[1]	Line printer output-map data
263-315[1]	Soil type data
316-368[1]	Land-use classification data for predevelopment land-use conditions

TABLE 2.--List of files stored on magnetic tape--continued

File Numbers	Contents
369-418[2]	Land-use classification data for current land-use conditions
419-458[3]	Annual irrigation application rates (in inches) for current land-use models
459-493[3]	Land surface altitude, slope, and aspect
494-546[1]	Annual average precipitation for all cells in all models
547-574[3]	Daily discharge data, period of record listed in table 1
575-602[3]	Mean monthly estimates of ground-water baseflow for each year simulated. Years simulated listed in table 2 and same as period of record listed above
603	Longitude and latitude location of 103 precipitation weather sites
	Then follows the longitude, latitude, and altitude (in feet) of 89 air temperature weather sites
604	Long-term average July minimum and maximum air temperatures at 89 weather sites
605-626	ANSI standard direct access files for mean daily precipitation at 103 weather sites, each file is one calendar year starting in 1956.
627-648	ANSI standard direct access files for mean daily maximum air temperatures at 89 weather sites
649-670	ANSI standard direct access files for mean daily minimum air temperatures at 89 weather sites
671	Source code for an inverse Lambert projection, converts feet to decimal degrees
672-724[1]	Results of operating the models for predevelopment land-use conditions (model output)
725-774[2]	Results of operating the models for current land-use conditions (model output)

[1]Files in same order as reference numbers in table 1.

[2]Files in same order as reference numbers in table 1 except zones 4, 5, and 37 not included, because not modeled for current land-use conditions.

[3]Order of files listed in table 3.

SOURCE CODE FILES FOR DEEP PERCOLATION MODEL

The FORTRAN 77 source code for each of the 53 DPMs is stored on magnetic tape as an ASCII file, and the file numbers are listed on tables 2 and 3. Each file consists of the MAIN program and the subroutines. The dimensions in the common blocks are unique for each model and, in fact, are the only change in the source code for each model.

TABLE 3.--Model reference numbers for the magnetic tape files for a specific model zone

Model reference number	Source codes	Main data stream p	Main data stream c	Grid definition	Line printer output-map	Soil type	Land use p	Land use c	Annual irrigation rates	Land-surface data	Annual average precipitation	Daily discharge	Monthly groundwater baseflow
1	1	54	107	157	210	263	316	369	419	459	494	---	---
2	2	55	108	158	211	264	317	370	420	460	495	547	575
3	3	56	109	159	212	265	318	371	421	461	496	---	---
4	4	57	---	160	213	266	319	---	---	462	497	---	---
5	5	58	---	161	214	267	320	---	---	463	498	---	---
6	6	59	110	162	215	268	321	372	422	464	499	548	576
7	7	60	111	163	216	269	322	373	---	465	500	549	577
8	8	61	112	164	217	270	323	374	423	466	501	---	---
9	9	62	113	165	218	271	324	375	424	467	502	550	578
10	10	63	114	166	219	272	325	376	---	468	503	---	---
11	11	64	115	167	220	273	326	377	---	469	504	---	---
12	12	65	116	168	221	274	327	378	425	470	505	551	579
13	13	66	117	169	222	275	328	379	426	471	506	---	---
14	14	67	118	170	223	276	329	380	427	472	507	552	580
15	15	68	119	171	224	277	330	381	428	473	508	553	581
16	16	69	120	172	225	278	331	382	429	474	509	---	---
17	17	70	121	173	226	279	332	383	430	475	510	---	---
18	18	71	122	174	227	280	333	384	431	476	511	554	582
19	19	72	123	175	228	281	334	385	---	477	512	555	583
20	20	73	124	176	229	282	335	386	432	478	513	556	584
21	21	74	125	177	230	283	336	387	433	479	514	557	585
22	22	75	126	178	231	284	337	388	434	480	515	558	586
23	23	76	127	179	232	285	338	389	---	481	516	559	587
24	24	77	128	180	233	286	339	390	435	---	517	560	588
25	25	78	129	181	234	287	340	391	436	---	518	---	---
26	26	79	130	182	235	288	341	392	437	---	519	561	589
27	27	80	131	183	236	289	342	393	438	---	520	562	590
28	28	81	132	184	237	290	343	394	439	482	521	563	591
29	29	82	133	185	238	291	344	395	---	483	522	564	592
30	30	83	134	186	239	292	345	396	440	---	523	---	---
31	31	84	135	187	240	293	346	397	441	---	524	---	---
32	32	85	136	188	241	294	347	398	442	---	525	---	---
33	33	86	137	189	242	295	348	399	443	---	526	---	---
34	34	87	138	190	243	296	349	400	444	---	527	---	---
35	35	88	139	191	244	297	350	401	445	---	528	565	593
36	36	89	140	192	245	298	351	402	---	---	529	---	---
37	37	90	---	193	246	299	352	---	---	484	530	566	594

TABLE 3.--Model reference numbers for the magnetic tape files for a specific model zone--continued

Model reference number	Source codes	Main data stream p	Main data stream c	Grid definition	Line printer output map	Soil type	Land use p	Land use c	Annual irrigation rates	Land-surface data	Annual average precipitation	Daily discharge	Monthly groundwater baseflow
38	38	91	141	194	247	300	353	403	446	---	531	567	595
39	39	92	142	195	248	301	354	404	---	485	532	568	596
40	40	93	143	196	249	302	355	405	447	486	533	---	---
41	41	94	144	197	250	303	356	406	448	487	534	---	---
42	42	95	145	198	251	304	357	407	449	---	535	---	---
43	43	96	146	199	252	305	358	408	450	---	536	---	---
44	44	97	147	200	253	306	359	409	451	---	537	---	---
45	45	98	148	201	254	307	360	410	452	488	538	569	597
46	46	99	149	202	255	308	361	411	---	489	539	570	598
47	47	100	150	203	256	309	362	412	453	490	540	571	599
48	48	101	151	204	257	310	363	413	---	---	541	572	600
49	49	102	152	205	258	311	364	414	454	---	542	---	---
50	50	103	153	206	259	312	365	415	455	491	543	573	601
51	51	104	154	207	260	313	366	416	456	492	544	---	---
52	52	105	155	208	261	314	367	417	457	493	545	574	602
53	53	106	156	209	262	315	368	418	458	---	546	---	---

[1] p = Files are for predevelopment land-use conditions; c = files are for current land-use conditions.

DATA FILES

The data needed for input to each DPM are stored on 618 magnetic tape files and have been grouped into 15 categories. The data categories and pertinent information for each category are described in the subsections that follow. Many of the data in the files are for discrete rectangular areas called cells; the cells are the divisions of a modeled area for which the recharge calculations are made. A description and FORTRAN format for the data files used in each model are given by Bauer and Vaccaro (1987), and all file numbers and associated information are given in table 2. The input data files are set up to be used for either predevelopment or current land-use conditions (table 3). Generally, when a model that has been set up to operate under predevelopment land-use conditions is changed to operate under current land-use conditions, only the main data stream and the land-use file would change. Furthermore, a simulation for current land-use conditions might require annual average irrigation application rates. All longitude and latitude values are in decimal degrees.

Main Data Stream Input

Files 54 through 156 contain the general information on the model setup that includes such items as years of simulation, FORTRAN input and output device numbers, simulation options, and output options. These basic input data are currently set up to be read from FORTRAN unit number 5, defined as IN1 in the subroutine DATAIN. There are 103 data files representing 53 predevelopment-condition models and 50 current-condition models.

Model Grid Definition Data

Files 157 through 209 are the model grid definition files. The model grid data in these files establishes the cells for a modeled zone. The x,y locations in each file are in Lambert feet. File 672, which is the source code for the inverse of the Lambert projection, can be used to convert the x,y coordinates in Lambert feet to longitude and latitude (decimal degrees).

Line Printer Output-Map Data

Files 210 through 262 are the data that define how the estimates of recharge and actual evapotranspiration, stored in one-dimensional arrays, will be printed in two dimensions for a modeled area. These files are integer data relating array sequence to row-column position.

Soil Type Data

Files 263 through 315 are integer arrays of soil number codes assigned to each cell of a model. Each number refers to a particular combination of soil properties defined in the main data input stream (files 54 through 156).

Land-Use Data

Files 316 through 418 are integer arrays of land-use number codes for predevelopment and current conditions. Each integer represents the prevailing land use for a model cell that corresponds to one of the land uses described by Bauer and Vaccaro (1987).

Annual Irrigation Application Rates

The first record in each of files 419 through 458 contains an integer number equal to the total number of cells in a zone with irrigation. The following records (equal to number of cells with irrigation) have cell number and annual application rate (in inches per year). There are 40 zones that have irrigated cells. The reference number of the model zone associated with the file number is given in table 3.

Land-Surface Altitude, Slope, and Aspect

Each record in files 459 through 493 contains a cell number and the altitude, slope, and aspect for that cell. Table 3 defines which of the 35 model zones with land-surface information is associated with the file number.

These data, excluding cell numbers, were read as unformatted data off of a FORTRAN unit number different than IN1=5 (see beginning of this section). The data have been prefixed with a cell number, formatted, and then put into the tape files in order to make them machine readable. Thus, either these data files will need to be processed into unformatted files or the main data stream will have to be changed in order to operate the models (see Bauer and Vaccaro, 1987).

Annual Average Precipitation

Files 494 through 546 contain the long-term 22-year annual average precipitation data for each cell in a model. The precipitation data are in inches per year.

Daily Discharge Data

Files 547 through 574 contain daily stream discharge data for 28 of the model zones. The first record of each file contains the drainage area to the stream gage (square miles) and response time (days). Each record, thereafter, has one value of average daily streamflow (cubic feet per second). Table 3 gives the reference number of the model zone associated with the file number.

Monthly Ground-Water Baseflow

Files 575 through 602 contain estimates of mean monthly ground-water baseflow contribution to stream discharge, for each year simulated by a model. The 20 files are stored on tape in the same order as the discharge data discussed above (table 3). The estimates are in cubic feet per second, 12 values per record, one record per year.

Location of Precipitation Weather Sites

The longitude and latitude of the 103 precipitation weather sites used for the study are listed in File 603.

Location and Altitude of Air Temperature Weather Sites

The longitude, latitude, and altitude (in feet) of the 89 temperature sites used in the study are contained in File 604.

Long-term Average July Air Temperatures

The 22-year long-term average July minimum and maximum air temperatures (in degrees Fahrenheit) for 89 weather sites are contained in File 552. These values are used in the calculation of potential evapotranspiration.

Mean Daily Precipitation

Files 606 through 627 contain ANSI standard direct access files for mean daily precipitation (integer values in inches times 100) for 103 weather sites. The files start with calendar year 1956 and end in calendar year 1977. Each record in a file has a record length of 309, which corresponds to 103 daily values for a particular day.

Mean Daily Maximum Air Temperature

Files 628 through 649 contain ANSI standard direct access files for mean daily maximum air temperature (in degrees Fahrenheit) for 89 weather sites, one file per calendar year starting with year 1956. Each record in a file has a record length of 356, corresponding to 89 daily values for a day.

Mean Daily Minimum Air Temperature

Files 650 through 671 contain ANSI standard direct access files for mean daily minimum air temperature (in degrees Fahrenheit) for 89 weather sites, one file per calendar year starting with year 1956. Each record in a file has a record length of 356, corresponding to 89 daily values for a day.

INVERSE LAMBERT PROJECTION SOURCE CODE

File 672 contains the source code for a program to convert the x,y-location data (in Lambert feet) in files 157 through 209 to decimal degrees.

MODEL OUTPUT

Files 673 through 775 contain the DPM output from operating the 53 models (table 3). The first 53 files (673 through 725) are the output for predevelopment land-use conditions, and the last 50 files (726 through 775) are the DPM output for simulating deep percolation under current land-use conditions.

REFERENCES

Bauer, H. H., and Vaccaro, J. J., 1987, Documentation of a deep percolation model for estimating ground-water recharge: U.S. Geological Survey Open-File Report 86-536, 140 p.

Bauer, H. H., and Vaccaro, J. J., 1990, Estimates of ground-water recharge to the Columbia Plateau regional aquifer system, Washington, Oregon, and Idaho, for predevelopment and current land-use conditions: U.S. Geological Survey, Water-Resources Investigations Report 88-4108, 37 p.

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