

APPENDIX C

TCEQ VERIFICATION CALCULATION

**HELP[®] MODEL CALCULATION FOR ESTIMATING
RAIN WATER LEACH RATE THROUGH THE WCS
BYPRODUCT FACILITY COVER SYSTEM**

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**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE          **
**          HELP MODEL VERSION 3.07 (1 NOVEMBER 1997)              **
**          DEVELOPED BY ENVIRONMENTAL LABORATORY                  **
**          USAE WATERWAYS EXPERIMENT STATION                     **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
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PRECIPITATION DATA FILE:   C:\HELP3\WCS\WEATHER5.D4
TEMPERATURE DATA FILE:    C:\HELP3\WCS\TEMP5.D7
SOLAR RADIATION DATA FILE: C:\HELP3\WCS\SOLAR5.D13
EVAPOTRANSPIRATION DATA:  C:\HELP3\WCS\EVAP5.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\WCS\SOIL5.D10
OUTPUT DATA FILE:         C:\HELP3\WCS\OUTPUT5.OUT

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TIME: 13:33 DATE: 7/25/2007

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TITLE:  WCS LEACHING OF RAIN WATER THROUGH COVER.
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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 1

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THICKNESS           =      1.00  INCHES
POROSITY            =      0.4170 VOL/VOL
FIELD CAPACITY      =      0.0450 VOL/VOL
WILTING POINT      =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0676 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.999999978000E-02 CM/SEC
NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 3.00
      FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	30.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1621	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0459	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	48.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0451	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 15

THICKNESS	=	96.00	INCHES
POROSITY	=	0.4750	VOL/VOL
FIELD CAPACITY	=	0.3780	VOL/VOL

WILTING POINT = 0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3780 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.170000003000E-04 CM/SEC

LAYER 6

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 2

THICKNESS = 24.00 INCHES
POROSITY = 0.4370 VOL/VOL
FIELD CAPACITY = 0.0620 VOL/VOL
WILTING POINT = 0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.0620 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.579999993000E-02 CM/SEC
SLOPE = 2.00 PERCENT
DRAINAGE LENGTH = 500.0 FEET

LAYER 7

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 16

THICKNESS = 36.00 INCHES
POROSITY = 0.4270 VOL/VOL
FIELD CAPACITY = 0.4180 VOL/VOL
WILTING POINT = 0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000001000E-06 CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 15

THICKNESS = 18.00 INCHES
POROSITY = 0.4750 VOL/VOL
FIELD CAPACITY = 0.3780 VOL/VOL
WILTING POINT = 0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3752 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.170000003000E-04 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
 SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
 POOR STAND OF GRASS, A SURFACE SLOPE OF 2. %
 AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	62.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	16.000	ACRES
EVAPORATIVE ZONE DEPTH	=	26.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.711	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	10.367	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.418	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	67.273	INCHES
TOTAL INITIAL WATER	=	67.273	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
 AMARILLO TEXAS

STATION LATITUDE	=	35.00	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	67	
END OF GROWING SEASON (JULIAN DATE)	=	317	
EVAPORATIVE ZONE DEPTH	=	26.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	6.90	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	52.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	50.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	55.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	58.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR AMARILLO TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.46	0.57	0.87	1.08	2.79	3.50
2.70	2.95	1.72	1.39	0.58	0.49

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR AMARILLO TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
35.40	39.60	46.40	56.50	65.50	74.90
78.60	77.00	69.70	59.20	45.40	38.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR AMARILLO TEXAS
 AND STATION LATITUDE = 35.23 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.75	856680.062	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	14.724	855175.875	99.82
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000388	22.509	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 8	0.441610	25648.689	2.99
CHANGE IN WATER STORAGE	-0.416	-24144.463	-2.82
SOIL WATER AT START OF YEAR	67.273	3907189.000	
SOIL WATER AT END OF YEAR	66.857	3883044.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.071	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	22.37	1299249.870	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	21.756	1263614.120	97.26
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.000805	46.741	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 8	0.168636	9794.350	0.75
CHANGE IN WATER STORAGE	0.445	25840.707	1.99
SOIL WATER AT START OF YEAR	66.857	3883044.500	
SOIL WATER AT END OF YEAR	67.302	3908885.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.712	0.00

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	17.07	991425.812	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	17.997	1045249.370	105.43
DRAINAGE COLLECTED FROM LAYER 6	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.002457	142.683	0.01
AVG. HEAD ON TOP OF LAYER 7	0.0000		
PERC./LEAKAGE THROUGH LAYER 8	0.093440	5427.008	0.55
CHANGE IN WATER STORAGE	-1.020	-59250.711	-5.98
SOIL WATER AT START OF YEAR	67.302	3908885.250	
SOIL WATER AT END OF YEAR	66.282	3849634.500	

CHANGE IN WATER STORAGE	1.407	81727.648	5.70
SOIL WATER AT START OF YEAR	68.488	3977789.250	
SOIL WATER AT END OF YEAR	70.269	4081204.250	
SNOW WATER AT START OF YEAR	0.394	22892.311	1.60
SNOW WATER AT END OF YEAR	0.021	1204.840	0.08
ANNUAL WATER BUDGET BALANCE	0.0000	-0.474	0.00

ANNUAL TOTALS FOR YEAR 55

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.91	982133.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	17.695	1027724.940	104.64
DRAINAGE COLLECTED FROM LAYER 6	0.0000	1.563	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.164049	9527.960	0.97
AVG. HEAD ON TOP OF LAYER 7	0.0001		
PERC./LEAKAGE THROUGH LAYER 8	0.205425	11931.077	1.21
CHANGE IN WATER STORAGE	-0.990	-57524.785	-5.86
SOIL WATER AT START OF YEAR	70.269	4081204.250	
SOIL WATER AT END OF YEAR	69.299	4024884.250	
SNOW WATER AT START OF YEAR	0.021	1204.840	0.12
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.241	0.00

ANNUAL TOTALS FOR YEAR 56

RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	21.841	1268513.000	99.91
DRAINAGE COLLECTED FROM LAYER 6	0.0038	219.901	0.02
PERC./LEAKAGE THROUGH LAYER 7	0.388464	22562.018	1.78
AVG. HEAD ON TOP OF LAYER 7	0.0079		
PERC./LEAKAGE THROUGH LAYER 8	0.771741	44822.738	3.53
CHANGE IN WATER STORAGE	-0.756	-43926.457	-3.46
SOIL WATER AT START OF YEAR	69.102	4013446.750	
SOIL WATER AT END OF YEAR	68.346	3969520.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

ANNUAL TOTALS FOR YEAR 100

	INCHES	CU. FEET	PERCENT
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PRECIPITATION	24.06	1397404.870	100.00
RUNOFF	0.009	527.974	0.04
EVAPOTRANSPIRATION	20.429	1186507.370	84.91
DRAINAGE COLLECTED FROM LAYER 6	0.0000	1.551	0.00
PERC./LEAKAGE THROUGH LAYER 7	0.192858	11201.181	0.80
AVG. HEAD ON TOP OF LAYER 7	0.0002		
PERC./LEAKAGE THROUGH LAYER 8	0.306690	17812.535	1.27
CHANGE IN WATER STORAGE	3.315	192554.844	13.78
SOIL WATER AT START OF YEAR	68.346	3969520.250	
SOIL WATER AT END OF YEAR	71.661	4162075.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.585	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
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PRECIPITATION						

TOTALS	0.45	0.60	0.86	1.04	2.89	3.36
	2.69	2.90	1.71	1.61	0.60	0.48
STD. DEVIATIONS	0.39	0.44	0.62	0.78	1.59	1.65
	1.37	1.79	1.15	1.38	0.61	0.48
RUNOFF						

TOTALS	0.000	0.000	0.000	0.000	0.000	0.001
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.001	0.000	0.000	0.000	0.002	0.010
	0.000	0.002	0.000	0.000	0.000	0.003
EVAPOTRANSPIRATION						

TOTALS	0.579	0.704	0.932	1.098	2.619	3.395
	2.964	2.576	1.749	1.005	0.649	0.575
STD. DEVIATIONS	0.335	0.368	0.546	0.690	1.176	1.330
	1.386	1.470	0.983	0.594	0.362	0.339
LATERAL DRAINAGE COLLECTED FROM LAYER 6						

TOTALS	0.0029	0.0025	0.0026	0.0024	0.0027	0.0029
	0.0031	0.0032	0.0032	0.0033	0.0031	0.0030
STD. DEVIATIONS	0.0148	0.0131	0.0138	0.0128	0.0120	0.0114
	0.0124	0.0132	0.0135	0.0145	0.0143	0.0149
PERCOLATION/LEAKAGE THROUGH LAYER 7						

TOTALS	0.0207	0.0190	0.0209	0.0205	0.0219	0.0224
	0.0240	0.0243	0.0231	0.0221	0.0207	0.0208
STD. DEVIATIONS	0.0268	0.0239	0.0265	0.0268	0.0290	0.0293
	0.0307	0.0305	0.0285	0.0287	0.0276	0.0273

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0223	0.0200	0.0204	0.0202	0.0223	0.0217
	0.0227	0.0224	0.0226	0.0238	0.0228	0.0231
STD. DEVIATIONS	0.0287	0.0256	0.0252	0.0235	0.0252	0.0248
	0.0268	0.0274	0.0269	0.0279	0.0263	0.0284

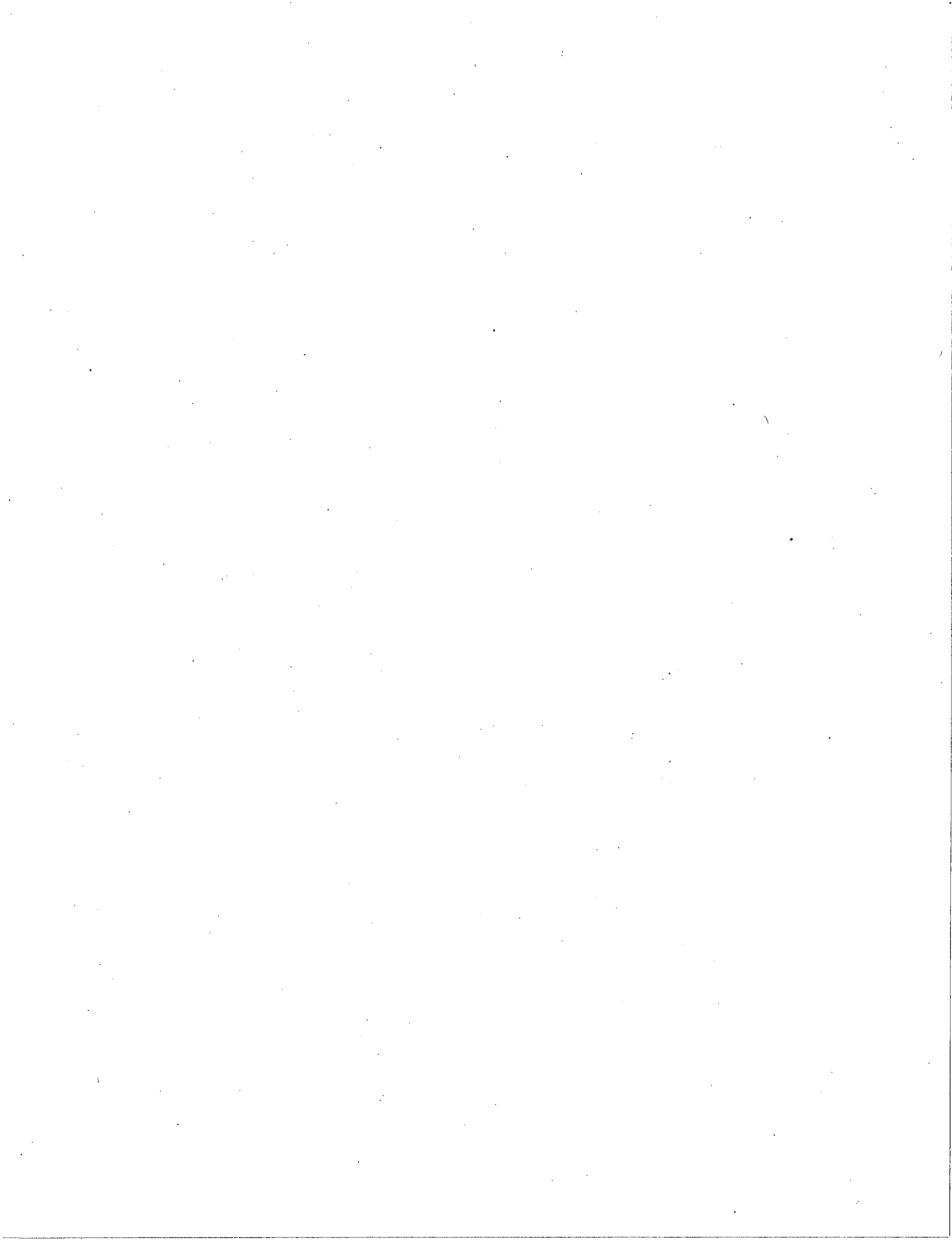
AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0707	0.0667	0.0642	0.0621	0.0661	0.0738
	0.0768	0.0787	0.0803	0.0808	0.0781	0.0741
STD. DEVIATIONS	0.3622	0.3512	0.3398	0.3239	0.2943	0.2889
	0.3034	0.3240	0.3414	0.3548	0.3629	0.3652

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	19.19	(3.698)	1114578.5	100.00
RUNOFF	0.002	(0.0110)	127.34	0.011
EVAPOTRANSPIRATION	18.845	(3.3019)	1094524.50	98.201
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.03491	(0.13349)	2027.309	0.18189
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.26044	(0.30414)	15126.493	1.35715
AVERAGE HEAD ON TOP OF LAYER 7	0.073	(0.278)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.26430	(0.28535)	15350.405	1.37724
CHANGE IN WATER STORAGE	0.044	(1.3412)	2548.86	0.229



PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	4.02	233481.594
RUNOFF	0.101	5839.2324
DRAINAGE COLLECTED FROM LAYER 6	0.00341	197.90884
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.003646	211.78358
AVERAGE HEAD ON TOP OF LAYER 7	2.592	
MAXIMUM HEAD ON TOP OF LAYER 7	4.665	
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	49.8 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.006766	392.96970
SNOW WATER	1.05	61002.2969
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.3103
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1315

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

FINAL WATER STORAGE AT END OF YEAR 100

<u>LAYER</u>	<u>(INCHES)</u>	<u>(VOL/VOL)</u>
1	0.0483	0.0483
2	6.8416	0.2281
3	0.6488	0.1081
4	4.2334	0.0882
5	36.2880	0.3780
6	1.8611	0.0775
7	15.3720	0.4270
8	6.3679	0.3538
SNOW WATER	0.000	

