Appendix 8

Water Budget Data Sheet

Aggregate Industries, Inc.

Dault Expansion - Chelsea Plant, Waterloo Township, Jackson County, Michigan

Precipitation Station	May and October 30 Year Mean Monthly Precipitation						1971-2000
	May	June	July	August	September	October	*subtotal*
Jackson, MI	2.90	3.26	3.27	3.48	3.44	2.29	*18.64*
						Total	***18.64***
						Average	***18.64***

MSU Agricultural Weather Office web site at www.agweather.geo.msu.edu.

From 1971 though 2000 thirty year record:

May-Oct = 184 days

Mean May-Oct Precip: 18.64 inches

Mean May-Oct. Daily Precip = 0.1013 inches

Mean May-Oct. Daily Evaporation = 25 inches per 184 period = 0.1359 inches per day

Change in storage = Precip - Evaporation = - 0.0346 inches per day (evaporation loss) = 0.0029 ft per day

May-Oct amount	Mean Values (inches)	
18.64	0.1013	**Daily Precip**
25	0.1359	**Daily Evap**
Change in Storage	-0.0346	(in/day)
	-0.0029	(ft/day)

Example evaporative loss Calculation: 19 acre lake x 43560 ft2 per acre = 827640 ft2 x 0.0029 ft per day evaporation = 2400.16 ft3 per day evaporative loss = 17953.17 gal per day or 12.47 gal/min

conversion factors:

1 cubic ft per day = 5.19×10^{-3} gal/min

7.48 gallons = 1 cubic foot

1440 minutes = 1 day

43560 ft^2 per acre

Projected Lake Size		Projected volume of Evaporative Loss		
Acres	Sq feet	Evaporative loss (ft^3/day)	gallon/day	gallon/minute
4	174240	505.30	3779.61	2.62
10	435600	1263.24	9449.04	6.56
14	609840	1768.54	13228.65	9.19
14.2	618552	1793.80	13417.63	9.32
19	827640	2400.16	17953.17	12.47
20	871200	2526.48	18898.07	13.12
28	1219680	3537.07	26457.30	18.37
30	1306800	3789.72	28347.11	19.69
40	1742400	5052.96	37796.14	26.25
60	2613600	7579.44	56694.21	39.37
70	3049200	8842.68	66143.25	45.93
80	3484800	10105.92	75592.28	52.49
90	3920400	11369.16	85041.32	59.06
100	4356000	12632.40	94490.35	65.62
120	5227200	15158.88	113388.42	78.74

Lake Water Residence Time				
Lake Area (Acres)	Lake Depth (ft)	Lake Volume (ft3)	Turn Over Time (days)	Lake Turn Over Time (Years)
4	35	6,098,400	508	1.4
28	35	42,688,800	3557	9.7

Calculation of Groundwater Flux and Lake Water Residence Time

Groundwater Flux

Q = K b w i

12000.00	**Q** = flow volume (ft^3/day)
40	**b** = aquifer thickness (ft)
800	**w** = aquifer width (ft) = max width of lake perpinducular to gw flow
0.0025	**i** = hydraulic gradient (ft/ft)
150	**K** = hydraulic conductivity (ft/day)
6000.00	**T** = Transmissivity = bK (ft2/day)

Q (gpm) = **62**

% volume lost to Evaporation

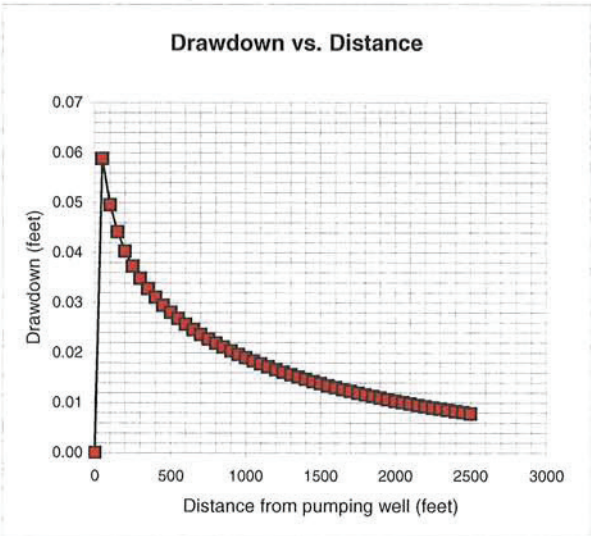
4.21% **4 acre lake**

Theis Analysis

Program to calculate drawdown at different distances from a pumping well using the method of Theis (1935).
The method assumes one-dimensional steady-state flow with no lateral boundaries or vertical leakage.
Drawdown is calculated at different distances from the pumping well.
A time value is input for these calculations.

Dault property
4-acre lake

Transmissivity (ft^2/day)	6000.000	(K=150ft/day)
Storativity	**1.500E-01**	
Well pumping rate (gpm)	**2.620**	
Time (days)	184.000	
Distance to calculate drawdown (feet)	6000.000	
Increment to calculate drawdown (feet)	50.000	



Distance (feet)	u	W(u)	Drawdown (feet)	Drawdown (inches)
0				
50	8.5E-05	8.80	0.06	0.71
100	3.4E-04	7.41	0.05	0.59
150	7.6E-04	6.60	0.04	0.53
200	1.4E-03	6.03	0.04	0.48
250	2.1E-03	5.58	0.04	0.45
300	3.1E-03	5.22	0.03	0.42
350	4.2E-03	4.91	0.03	0.39
400	5.4E-03	4.64	0.03	0.37
450	6.9E-03	4.41	0.03	0.35
500	8.5E-03	4.20	0.03	0.34
550	1.0E-02	4.01	0.03	0.32
600	1.2E-02	3.84	0.03	0.31
650	1.4E-02	3.68	0.02	0.30
700	1.7E-02	3.54	0.02	0.28
750	1.9E-02	3.40	0.02	0.27
800	2.2E-02	3.27	0.02	0.26
850	2.5E-02	3.15	0.02	0.25
900	2.8E-02	3.04	0.02	0.24
950	3.1E-02	2.94	0.02	0.24
1000	3.4E-02	2.84	0.02	0.23
1050	3.7E-02	2.74	0.02	0.22
1100	4.1E-02	2.66	0.02	0.21
1150	4.5E-02	2.57	0.02	0.21
1200	4.9E-02	2.49	0.02	0.20
1250	5.3E-02	2.41	0.02	0.19
1300	5.7E-02	2.34	0.02	0.19
1350	6.2E-02	2.27	0.02	0.18
1400	6.7E-02	2.20	0.01	0.18
1450	7.1E-02	2.13	0.01	0.17
1500	7.6E-02	2.07	0.01	0.17
1550	8.2E-02	2.01	0.01	0.16
1600	8.7E-02	1.95	0.01	0.16
1650	9.2E-02	1.89	0.01	0.15
1700	9.8E-02	1.84	0.01	0.15
1750	1.0E-01	1.79	0.01	0.14
1800	1.1E-01	1.74	0.01	0.14
1850	1.2E-01	1.69	0.01	0.14
1900	1.2E-01	1.64	0.01	0.13
1950	1.3E-01	1.59	0.01	0.13
2000	1.4E-01	1.55	0.01	0.12
2050	1.4E-01	1.51	0.01	0.12
2100	1.5E-01	1.47	0.01	0.12
2150	1.6E-01	1.43	0.01	0.11
2200	1.6E-01	1.39	0.01	0.11
2250	1.7E-01	1.35	0.01	0.11
2300	1.8E-01	1.31	0.01	0.11
2350	1.9E-01	1.28	0.01	0.10
2400	2.0E-01	1.24	0.01	0.10
2450	2.0E-01	1.21	0.01	0.10
2500	2.1E-01	1.17	0.01	0.09
2550	2.2E-01	1.14	0.01	0.09
2600	2.3E-01	1.11	0.01	0.09
2650	2.4E-01	1.08	0.01	0.09
2700	2.5E-01	1.05	0.01	0.08
2750	2.6E-01	1.02	0.01	0.08
2800	2.7E-01	1.00	0.01	0.08
2850	2.8E-01	0.97	0.01	0.08
2900	2.9E-01	0.94	0.01	0.08

Distance (feet)	u	W(u)	Drawdown (feet)	Drawdown (inches)
2950	3.0E-01	0.92	0.01	0.07
3000	3.1E-01	0.89	0.01	0.07
3050	3.2E-01	0.87	0.01	0.07
3100	3.3E-01	0.84	0.01	0.07
3150	3.4E-01	0.82	0.01	0.07
3200	3.5E-01	0.80	0.01	0.06
3250	3.6E-01	0.78	0.01	0.06
3300	3.7E-01	0.76	0.01	0.06
3350	3.8E-01	0.73	0.00	0.06
3400	3.9E-01	0.71	0.00	0.06
3450	4.0E-01	0.70	0.00	0.06
3500	4.2E-01	0.68	0.00	0.05
3550	4.3E-01	0.66	0.00	0.05
3600	4.4E-01	0.64	0.00	0.05
3650	4.5E-01	0.62	0.00	0.05
3700	4.7E-01	0.60	0.00	0.05
3750	4.8E-01	0.59	0.00	0.05
3800	4.9E-01	0.57	0.00	0.05
3850	5.0E-01	0.56	0.00	0.04
3900	5.2E-01	0.54	0.00	0.04
3950	5.3E-01	0.52	0.00	0.04
4000	5.4E-01	0.51	0.00	0.04
4050	5.6E-01	0.50	0.00	0.04
4100	5.7E-01	0.48	0.00	0.04
4150	5.9E-01	0.47	0.00	0.04
4200	6.0E-01	0.46	0.00	0.04
4250	6.1E-01	0.44	0.00	0.04
4300	6.3E-01	0.43	0.00	0.03
4350	6.4E-01	0.42	0.00	0.03
4400	6.6E-01	0.41	0.00	0.03
4450	6.7E-01	0.39	0.00	0.03
4500	6.9E-01	0.38	0.00	0.03