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RE-EVALUATION OF THE EFFECTIVENESS OF THE CENTRAL A/M AREA RECOVERY WELL NETWORK (U)

by

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**Re-Evaluation of the Effectiveness of the
Central A/M Area Recovery Well Network (U)**

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June, 1991

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EXECUTIVE SUMMARY

A groundwater recovery well network has been operating in the central portion of the A/M Area of the Savannah River Site (SRS) since 1985 to retrieve chlorinated volatile organic solvents. In 1986, a groundwater modeling study was performed to evaluate the effectiveness of the recovery well network that included planned recovery wells (RWM 1 through 11) and process water wells (S. S. Papadopoulos, 1986). Since the original modeling study, use of some of the process wells has discontinued and some pumping rates at other wells have changed. Also, the understanding of the hydrologic system in the A/M Area has improved because additional monitoring wells have been installed in the area. As a result, an updated groundwater flow model (Beaudoin et al., 1991) for the area was used to evaluate the effectiveness of the existing recovery network. The results of this study indicate that the estimated effectiveness of the recovery well has not changed dramatically since the original groundwater modeling study. However, slight differences do exist between the original study and this study because the recent model more accurately reflects the A/M Area subsurface hydrologic system.

TABLE OF CONTENTS

INTRODUCTION	1
METHODOLOGY	1
RESULTS	2
ACKNOWLEDGEMENT	3
REFERENCES	4
TABLES	5
FIGURES	7
APPENDIX	A1

LIST OF TABLES

Table 1. Historical Pumping Rates for A/M Area Wells	5
Table 2. Recent Pumping Rates for A/M Area Wells	6

LIST OF FIGURES

Figure 1. Areal Discretization of Model Area	7
Figure 2. Zone of Capture for the Water Table (Total Recovery Well Pumping of 427 gpm)	8
Figure 3. Zone of Capture for the Upper Congaree (Total Recovery Well Pumping of 427 gpm)	9
Figure 4. Zone of Capture for the Lower Congaree (Total Recovery Well Pumping of 427 gpm)	10
Figure 5. Zone of Capture for the Water Table (Total Recovery Well Pumping of 508 gpm)	11
Figure 6. Zone of Capture for the Upper Congaree (Total Recovery Well Pumping of 508 gpm)	12
Figure 7. Zone of Capture for the Lower Congaree (Total Recovery Well Pumping of 508 gpm)	13

INTRODUCTION

A recovery well network has been operating in the central portion of the A/M Area of the Savannah River Site (SRS) since 1985 to remove trichloroethylene (TCE) and perchloroethylene (PCE) from groundwater. In 1986, a groundwater modeling study was performed to evaluate the effectiveness of the existing recovery and process water wells (S. S. Papadopoulos, 1986). Since the original modeling study, use of some process wells has discontinued and some pumping rates at other wells have changed. Also, the understanding of the hydrologic system in the A/M Area has improved. As a result, the groundwater flow model for the area was updated (Beaudoin et al., 1991). This revised model was used in conjunction with particle tracking to re-evaluate the effectiveness of the existing recovery network. The results of this particle tracking study are also reported in the Part B Post Closure Permit for the M-Area Hazardous Waste Management Facility (1990).

This report is a particle tracking and zone of capture study only. The reader who is interested or requires the details of the flow model that was used for the basis of this study is directed to Beaudoin et al., 1991.

METHODOLOGY

A calibrated steady-state groundwater flow model was used in conjunction with particle tracking to determine the effectiveness of the recovery network. Particle tracking is an effective method to evaluate the performance of a recovery well system without completing a more-costly contaminant transport simulation. Particle tracking is completed by simulating the backward paths of a distribution of particles emanating from the circumference of a well. The mathematical conceptualization of this approach is piece-wise time integration of the negative of the velocity field. The particle tracking method allows one to determine the hydrologic control of a plume and estimate the region of water that is recovered by the network during a specific time period. For this study, the particle tracking method incorporated advection only and did not account for mechanical dispersion or retardation. However, equilibrium-type retardation can be accounted for by increasing the zone of capture time directly proportional to the retardation coefficient. The effective porosity for this study was set equal to 30 percent, which is believed to be conservatively high.

The MODFLOW code was used to simulate the steady-state groundwater flow system for the area (McDonald and Harbaugh, 1984). The MODFLOW code is a quasi-three-dimensional groundwater flow computer code. That is, the vertical flow between aquifers is incorporated with a leakance coefficient, and the aquitards

are therefore not discretized. The modeled system consists of four water bearing units. From top to bottom, these units have been informally named the water table, the Upper Congaree, the Lower Congaree, and the Black Creek. The Ellenton was not discretized as an aquifer because it is mainly lenses of clay and does not have substantial water production capacity. It is recognized that these names do not adhere to the formal hydrostratigraphic nomenclature used for the SRS (Aadland and Bledsoe, 1991), but they were maintained to allow comparison to the previous modeling effort. Steady-state simulations of a coarse-grid model for the entire A/M Area were run to determine the hydrologic parameters for the system that adequately reproduced the observed average hydraulic heads (1Q89 to 1Q90) for the area (Beaudoin et al., 1991). The calibrated values of transmissivity, leakance coefficient, and recharge for the model domain are given in Appendix A. These parameters are within the range of those determined from aquifer tests and grain size analyses. This coarse-grid model was used for the basis of the particle tracking, but the grid was refined in the central region, so that wells could be placed at a node close to its true location, and to minimize numerical errors in the particle tracking used for the zone of capture analysis. The refined areal discretization varied from 125 to 1000 feet and is shown in Figure 1.

The pumping rates for the wells within the model domain are given in Tables 1 and 2. Two simulations were completed; one for pumping rates totaling 425 gpm for the eleven dedicated recovery wells (RWM 1 through RWM 11), and one totaling 507 gpm for the eleven recovery wells. The former total pumping rate represents an average withdrawal that has been used over the past few years, while the latter pumping rate represents the recent increase in total pumping rate for the dedicated recovery wells.

RESULTS

The results of the zone of capture analysis for the recovery wells RWM 1 through RWM 11 pumping at a total of 425 gpm are shown in Figures 2, 3, and 4 for the water table, Upper Congaree and Lower Congaree, respectively. There is a slight difference between these figures compared to those of Papadopoulous (1986) for the Upper Congaree and water table for two reasons (Appendix B). The first reason for the difference is that some process wells are not operating any longer (PW-98, PW-99) and some of the flow rates at the recovery wells have changed. The second reason is that the Papadopoulous (1986) groundwater flow model used no-flow boundaries at all exterior edges of the model. Because there is no way for water to flow into the system other than through recharge with this type of boundary, Papadopoulous (1986) replaced the water removed through pumping with an artificially high recharge to the surface of the water table within the zone

of influence of the wells. Papadopoulos was forced to add recharge in this manner so that the simulated hydrologic system did not become dry. The result of this modeling assumption is that more water is moving vertically through the area of pumping than is realistically occurring.

The difference for the Lower Congaree zone of capture for this study and Papadopoulos is more pronounced. This is because the difference in the pumping rate for the production wells which was "pulling" groundwater down and preventing it from being captured by the recovery wells screened in the Lower Congaree.

The results of the zone of capture analysis for the recovery wells RWM 1 through RWM 11 pumping at a total of 507 gpm are shown in Figures 5, 6, and 7 for the water table, Upper Congaree and Lower Congaree, respectively. The distribution of the pumping to the recovery wells is shown in Table 2. This greater pumping rate reflects the recent increase in the pumping rates of the recovery wells. As can be seen by comparing Figures 2 through 4 with Figures 5 through 7, the simulated zone of capture is only slightly improved by the increased pumping, because the pumping increase as distributed over three hydrologic units is not significantly greater and the recovery well system relies on the direction of natural flow in the system, which is not significantly affected by the pumping of the wells.

However, the system as currently operating is controlling and recovering the central portion of the A/M Area plume. Additional modeling has been performed for a SRL recovery well network, and more is planned for the "southern sector." After the southern sector modeling is performed, an integrated zone of capture model will be completed to evaluate the integrated recovery system for the entire A/M Area.

ACKNOWLEDGEMENT

Mark Schwartz of Schreuder & Davis Inc. completed the drafting of the figures for the zone of capture analyses for this report.

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McDonald, M.G. and A. W. Harbaugh, 1984. A Modular Three-dimensional Finite-Difference Ground-Water Flow Model, United States Geological Survey, Reston, Virginia.

S. S. Papadopoulos, 1986. Evaluation of the Effectiveness of the M-Area Extraction System, Report prepared for the Savannah River Site, Aiken, SC.

	SRS	SRS	RATE						
Well	North	East	(GPM)	Layer 1	Layer 2	Layer 3	Layer 4*		
rwm-1	102608	48581	27	1.7	16.8	8.5	0		
rwm-2	104434	49206	24	1.5	15.0	7.5	0		
rwm-3	104730	49680	57	3.5	35.6	17.9	0		
rwm-4	103719	48948	42	2.6	26.2	13.2	0		
rwm-5	103502	49628	5	0.3	3.1	1.6	0		
rwm-6	102002	50107	50	3.1	31.2	15.7	0		
rwm-7	101905	49450	29	1.8	18.1	9.1	0		
rwm-8	101948	47353	34	2.1	21.2	10.7	0		
rwm-9	104100	50400	34	2.1	21.2	10.7	0		
rwm-10	102001	48244	60	3.7	37.4	18.8	0		
rwm-11	104875	50400	65	4.0	40.6	20.4	0		
905-20a	104000	50615	350	0	0	0	350		
905-53a	105011	50757	350	0	0	0	350		
905-68a	106266	50266	30	0	0	0	30		
905-82A	103330	51100	900	0	0	0	900		
905-67B	86693	42622	75	0	0	0	75		
* Layer 4 is Aquifer IB, but well screens across entire Aquifer I so the model input pumping is multiplied by 0.33 to reflect transmissivity									

TABLE 1. HISTORICAL PUMPING RATES FOR A/M AREA WELLS

DATA FOR MODFLOW WELLS												
SRS	SRS	PUMPAGE										
North	East	(GPM)	Layer 1	Layer 2	Layer 3	Layer 4*						
rwm-1	102608	48581	28	1.7	17.5	8.8	0					
rwm-2	104434	49206	23	1.4	14.4	7.2	0					
rwm-3	104730	49680	58	3.6	36.2	18.2	0					
rwm-4	103719	48948	46	2.9	28.7	14.4	0					
rwm-5	103502	49628	43	2.7	26.8	13.5	0					
rwm-6	102002	50107	57	3.5	35.6	17.9	0					
rwm-7	101905	49450	40	2.5	25.0	12.6	0					
rwm-8	101948	47353	43	2.7	26.8	13.5	0					
rwm-9	104100	50400	45	2.8	28.1	14.1	0					
rwm-10	102001	48244	60	3.7	37.4	18.8	0					
rwm-11	104875	50400	65	4.0	40.6	20.4	0					
905-20a	104000	50615	350	0	0	0	350					
905-53a	105011	50757	350	0	0	0	350					
905-68a	106266	50266	30	0	0	0	30					
905-82A	103330	51100	900	0	0	0	900					
905-67B	86693	42622	75	0	0	0	75					
* Layer 4 is Aquifer IB, but well screens across entire Aquifer I												
so the model input pumping is multiplied by 0.33 to reflect transmissivity												
TOTAL FROM RECOVERY WELLS=			508 GPM									
PERIOD 10/90 to 12/90												

TABLE 2. RECENT PUMPING RATES FOR A/M AREA WELLS

[illegible]

WATER TABLE GROUND WATER CAPTURE ZONE

**FIGURE 2: ZONE OF CAPTURE FOR THE WATER TABLE
(TOTAL RECOVERY WELL PUMPING OF 427 GPM)**

- 100 • ESTIMATED EXTENT OF GROUND WATER CONTAINING TOTAL VOLATILE ORGANICS GREATER THAN 100 PPM
- 212 — WATER TABLE ELEVATION (NGVD)
- RECOVERY WELL
- ROADWAY
- SWAMP
- - - SRP PROPERTY BOUNDARY
- 5 YEAR CAPTURE ZONE
- 15 YEAR CAPTURE ZONE
- 30 YEAR CAPTURE ZONE

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UPPER CONGAREE GROUND WATER CAPTURE ZONE

**FIGURE 3: ZONE OF CAPTURE FOR THE UPPER CONGAREE
(TOTAL RECOVERY WELL PUMPING OF 427 GPM)**

- 100 --- ESTIMATED EXTENT OF GROUND WATER CONTAINING
TOTAL VOLATILE ORGANICS GREATER THAN 100 PPB
- 210 --- WATER TABLE ELEVATION (NGVD)
- RECOVERY WELL
- ROADWAY
- SWAMP
- SRP PROPERTY BOUNDARY
- 5 YEAR CAPTURE ZONE
- 15 YEAR CAPTURE ZONE
- 30 YEAR CAPTURE ZONE

7/8/91

LOWER CONGAREE GROUND WATER CAPTURE ZONE

FIGURE 4: ZONE OF CAPTURE FOR THE LOWER CONGAREE
(TOTAL RECOVERY WELL PUMPING OF 427 GPM)

- 100 ESTIMATED EXTENT OF GROUND WATER CONTAINING
TOTAL VOLATILE ORGANICS GREATER THAN 100 PPB
- 105 WATER TABLE ELEVATION (NGVD)
- RECOVERY WELL
- ROADWAY
- ... SWAMP
- SRP PROPERTY BOUNDARY
- 5 YEAR CAPTURE ZONE
- 15 YEAR CAPTURE ZONE
- 30 YEAR CAPTURE ZONE

7/8/81

WATER TABLE GROUND WATER CAPTURE ZONE

**FIGURE 5: ZONE OF CAPTURE FOR THE WATER TABLE
(TOTAL RECOVERY WELL PUMPING OF 508 GPM)**

- 100 ESTIMATED EXTENT OF GROUND WATER CONTAINING TOTAL VOLATILE ORGANICS GREATER THAN 100 PPB
- 212 WATER TABLE ELEVATION (NOVD)
- RECOVERY WELL
- ROADWAY
- - - SWAMP
- - - SRP PROPERTY BOUNDARY
- [Stippled Box] 5 YEAR CAPTURE ZONE
- [Cross-hatched Box] 15 YEAR CAPTURE ZONE
- [White Box] 30 YEAR CAPTURE ZONE

8/27/91

UPPER CONGAREE GROUND WATER CAPTURE ZONE

**FIGURE 6: ZONE OF CAPTURE FOR THE UPPER CONGAREE
(TOTAL RECOVERY WELL PUMPING OF 508 GPM)**

- 100 ESTIMATED EXTENT OF GROUND WATER CONTAINING TOTAL VOLATILE ORGANICS GREATER THAN 100 PPB
- 210 WATER TABLE ELEVATION (NGVD)
- RECOVERY WELL
- ROADWAY
- SWAMP
- SRP PROPERTY BOUNDARY
- 5 YEAR CAPTURE ZONE
- 15 YEAR CAPTURE ZONE
- 30 YEAR CAPTURE ZONE

LOWER CONGAREE **GROUND WATER CAPTURE ZONE**

FIGURE 7: ZONE OF CAPTURE FOR THE LOWER CONGAREE
(TOTAL RECOVERY WELL PUMPING OF 508 GPM)

- 100 ESTIMATED EXTENT OF GROUND WATER CONTAINING TOTAL VOLATILE ORGANICS GREATER THAN 100 PPB
- 185 WATER TABLE ELEVATION (NGVD)
- RECOVERY WELL
- ROADWAY
- SWAMP
- - - SRP PROPERTY BOUNDARY
- [Stippled Box] 5 YEAR CAPTURE ZONE
- [Cross-hatched Box] 15 YEAR CAPTURE ZONE
- [Outlined Box] 30 YEAR CAPTURE ZONE

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APPENDICES

Figure 19. Calibrated Leakance Map for Model Layer 1.

A Ground Water Flow Model for the A/M Area of the SRS (U)

Figure 20. Calibrated Leakance Map for Model Layer 2.

A Ground Water Flow Model for the A/M Area of the SRS (U)

Figure 2. Calibrated Leakance Map for Model Layer 3.

A Ground Water Flow Model for the A/M Area of the SRS (U)

Figure 22. Modeled Rainfall Recharge.

A Ground Water Flow Model for the A/M Area of the SRS (U)

A Ground Water Flow Model for the A/M Area of the SRS (U)

Figure 16. Boundary Conditions and Transmissivity in Model Layer 2.

A Ground Water Flow Model for the A/M Area of the SRS (U)

Figure 17. Boundary Conditions and Transmissivity in Model Layer 3.

A Ground Water Flow Model for the A/M Area of the SRS (U)

B1

EXPLANATION

- Calculated Extent of Zone of Capture
- Average Total Volatile Organic Concentration in 1985, in ppb
 - < 10
 - 10-100
 - 100-1,000
 - > 1,000
- 100 Estimated extent of ground water containing total volatile organic compounds greater than 100 ppb
- 100,000 Calculated areal extent of zone of capture

FIGURE
5

AVERAGE TOTAL VOLATILE ORGANIC CONCENTRATIONS IN 1985 AND
CALCULATED AREAL EXTENT OF ZONE OF CAPTURE IN LAYER 3

S. S. PAPADOPULOS & ASSOCIATES, INC.
CONSULTING GROUND WATER HYDROLOGISTS

B2

FIGURE 6

AVERAGE TOTAL VOLATILE ORGANIC CONCENTRATIONS IN 1985 AND CALCULATED AREAL EXTENT OF ZONE OF CAPTURE IN LAYER 2

S. S. PAPADOPOULOS & ASSOCIATES, INC.
CONSULTING GROUND WATER HYDROLOGISTS

Plant True North

0 2500
Scale Feet

EXPLANATION

Calculated Extent of Zone of Capture

△ < 10

△ 10-100

■ 100-1,000

● > 1,000

Average Total Volatile Organic Concentration in 1985, in ppb

— 100 —

Estimated extent of ground water containing total volatile organics greater than 100 ppb

S. S. PAPADOPOULOS & ASSOCIATES, INC.
CONSULTING GROUND WATER HYDROLOGISTS

AVERAGE TOTAL VOLATILE ORGANIC CONCENTRATIONS IN 1985 AND
CALCULATED AREAL EXTENT OF ZONE OF CAPTURE IN LAYER 1

FIGURE
7

B3

END

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