TRITIUM MIGRATION IN A/M-AREA GROUND WATER (U)

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Received by OSTI
JUL 6 1992

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Publication Date: January, 1992

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UNITS

Tritium Units (TU)

1 TU = 1 ³H per 10¹⁸ Hydrogen Atom

1 TU = 3.2 pCi/L

TU/ 312.5 = 1 pCi/ml

Drinking Water Standard = 20 pCi/ml
 = 6,250 TU

ABSTRACT

Volatile organic compounds (VOC's) have entered aquifers in Cretaceous-aged sediments in the A/M-Area as a result of site operations. Tritium in A/M-Area ground water was investigated as a tracer to determine the movement of ground water in the subsurface and the transport mechanism of VOC's. The investigation was focused primarily on determining the continuity and integrity of the clay layers in the Ellenton Formation and their effectiveness as aquitards below the aquifers in Tertiary sediments.

Tritium has entered the ground water in the A/M-Area of the Savannah River Site (SRS) from several sources. Precipitation has included natural cosmogenic tritium, "bomb tritium" from above-ground testing of nuclear weapons, and tritium released into the atmosphere from SRS facilities. Tritiated water has also been released directly into ground water from point sources such as seepage basins and outfalls by various facilities in the A/M Area.

Over much of the study area the Ellenton Formation serves as a barrier to downward migration of ground water. Beneath the A-Area however, ground water derived from precipitation during the past forty years has penetrated through the Ellenton Formation into the Steel Creek Member of the Peedee Formation; that is, from the water-table aquifer into aquifer unit I/IIB, a drinking water source in the region. The Ellenton is much sandier in this area and apparently provides conduits for groundwater movement under the influence of the downward hydraulic gradient.

Also beneath the A-Area, a pod or plume of ground water containing tritium in concentration above ambient rainfall tritium was detected in the shallow aquifer. Some samples from this plume or pod contained tritium in excess of drinking water standards. The most probable source of this water is the seepage basins or drains and outfalls in the Savannah River Laboratory area.

INTRODUCTION

Artificial tracers are commonly used to investigate the movement and dispersion of ground water. In most instances however, the usefulness of the tracers is limited by the short durations of the experiments, by the large dilution effects of groundwater mixing, and by physical or chemical reactions between the framework materials of the aquifer and the tracers. In recent years, tritium has been found to be an extremely useful tracer because it occurs in ground water as part of the water molecule and because rainfall was "spiked" with tritium over the northern hemisphere during the early 1960's by thermonuclear weapons testing programs. At the Savannah River Site, local sources have also contributed to the levels of tritium detected in rainfall.

The current investigation was undertaken to determine whether tritium could be used as a tracer of groundwater movement in the A/M-Area. In particular, discontinuities in the aquitard separating the shallow aquifers in Tertiary sediments from the deeper aquifers has been inferred based on geologic information and on contamination of 2 production wells in the A/M-Area by volatile organic compounds (VOCs). This investigation focused on determining whether recent precipitation has infiltrated through the aquitards into the aquifers in the Cretaceous-aged sediments below the confining layers.

In most areas of the world, the infiltration rates of recent, tritium-enriched rainfall can be measured based on the migration rates of the tritium spike from the weapons testing programs. Because tritium has a relatively short half-life, about 12.3 years, naturally occurring tritium is in very low concentrations (<0.005 pCi/ml) in ground waters older than about the mid 1950's making it possible to distinguish between recent and these pre-1950's water.

The decay of tritium produces ^3He as a daughter product and, as another portion of the study, a review of recent research on $^3\text{He}/^3\text{H}$ dating techniques was undertaken to determine if this dating method could be used at the Savannah River Site (SRS) to calculate vertical and horizontal groundwater flow rates. While ^3He measurements were not undertaken for this study, this information was assessed to determine whether future studies would benefit from this technique.

DISCUSSION

A/M-Area Low-Level Tritium Survey

Background

The Savannah River Site occupies a portion of the Aiken Plateau (Siple, 1967) within the Atlantic Coastal Plain Province. The A/M-Area is located in the northwest portion of the site (Figure 1). Most of the facilities in the A/M Area (Figure 2) are located on the level plateau portions of the site. The area on the eastern side of A/M-Area has been dissected by several small gullies that lead into Tims Branch, an intermittent stream tributary of Upper Three Runs. On the western side of the A/M-Area, drainage is into a closed depression called "Lost Lake" and toward an unnamed drainage basin on the fringe of the Savannah River flood plain. The relief on the area shown in Figure 2 is approximately 180 feet.

Stratigraphy and Hydrogeology of A/M-Area.

The major water-bearing units beneath the A/M-Area are Cretaceous and Tertiary clastic sediments, primarily silicate sands and clays, deposited in terrestrial to shallow marine environments. The clastic sequence is from 700 to 800 feet thick and was deposited on a basement composed of Paleozoic and Precambrian metamorphic and igneous rocks.

As is characteristic of nearshore deposits, the depositional environments of the principal sedimentary units change dramatically over short lateral distances. Similarly, there are significant changes in the depositional environments with time, resulting in rapid vertical changes in lithology. Discontinuities in the depositional record are indubitably common but not always clearly identifiable on the basis of available cores. As a consequence of these conditions, many units in the A/M-Area are not easily correlated across an area or to lithologies at the type localities of established stratigraphic units. As a consequence, the stratigraphic nomenclature applied to A/M Area has been successively modified and reinterpreted based on the predilections of various investigators.

Figure 1 Savannah River Site location map and study area.

Figure 2. A/M-Area well location map.

The most recent interpretation of the A/M-Area lithostratigraphy, and the one used in this study, is that of Fallaw (1990). Figure 3 compares the stratigraphic interpretations of Fallaw with those of previous investigators. The interpretations and nomenclature of Siple (1967) have been widely used on the Savannah River Site and have provided a point of departure for subsequent stratigraphic interpretations. Bledsoe (1988) modified the terminology used by Siple based on a detailed lithologic examination of cores collected for the SRS regional hydrogeologic baseline investigation and on a review of current literature on Coastal Plain stratigraphy. Fallaw (1990) has recommended some modifications to the nomenclature applied to the A/M Area stratigraphy based on lithological and paleontological examination of cores from the A/M-Area.

Figure 4 shows a cross section through the A/M-Area. The tops and bottoms of the formations were picked from Fallaw (1990). Fallaw's study, as well as those of early investigators, shows that there is considerable lithologic variation within each stratigraphic unit across the study area. For instance, both the "green clay" that marks the base of the Santee Formation, and the "tan clay" at the top of the formation, are discontinuous in the A/M area and cannot be traced in cross section. In the southern portion of the Savannah River Site, these beds provide excellent stratigraphic marker horizons and hydrogeologic boundaries.

The terminology used for the hydrostratigraphy in the area has likewise evolved. Aadland and Bledsoe (1990) have suggested dropping the traditional names of the major water-bearing units that correspond to formational names, such as the "Congaree Aquifer," etc., in favor of a nomenclature that is independent of stratigraphic interpretations. A comparison between the lithostratigraphic and the proposed hydrostratigraphic nomenclature is illustrated in Figure 3. In the A/M-Area, the principal transmissive units are separated by less transmissive zones, or aquitards, corresponding to clay-rich beds. These aquitards occur in the A/M-Area at the base of the Santee Formation ("green clay"), throughout the thickness of the Ellenton Formation, and within the Steel Creek Formation. The continuity of the aquitards and their ability to retard the migration of water and contaminants is the subject of several current investigations including this study.

Stratigraphic and hydrostratigraphic nomenclature, A/M-Area

Age	Siple, 1967	Bledsoe, 1988	Fallow, 1990	Aadland and Bledsoe 1990
Tertiary	Hawthorn Fm.	Upland Unit	Upland Unit	
	Barnwell Fm.	Barnwell Group Tobacco Rd. Fm. Dry Branch Fm.	Barnwell Group Tobacco Rd. Fm. Dry Branch Fm.	
	Mc Bean Fm tan clay green clay	Orangeburg Group Mc Bean Fm.	Orangeburg Group Santee Fm.	
	Congaree Fm.	Congaree Fm.	Congaree Fm.	
	Ellenton Fm.	Black Mingo Group Williamsburg Fm. Ellenton Fm.	Black Mingo Group Fournile Mbr. (Fishburne Fm.) Ellenton Fm.	
Cretaceous	Tuscaloosa Fm.	Lumbee Group PeeDee Fm. Black Creek Fm. Middendorf Fm.	Lumbee Group Steel Creek Mbr. (PeeDee Fm.) Black Creek Fm. Middendorf Fm.	
		Cape Fear Fm.		
		Triassic or Paleozoic basement		

Figure 3. Comparison of stratigraphic and hydrostratigraphic nomenclatures used at A/M-Area.

Figure 4. Stratigraphic cross section through A/M-Area.

The hydrologic effects of the various aquitard units are evident when water level data are plotted on the cross section through the area (Figure 5), particularly on the southern end of the section. The convergence of the potentiometric contours near the tops of the Santee and Steel Creek Formations shows areas of steep hydraulic gradients corresponding to low permeability zones. In the northern portion of the study area, the spreading of the potentiometric contours suggests that separation of the lower aquifer from the shallow aquifer units is less effective.

Sources of Tritium in A/M Area Ground Water

Tritium has entered the ground water in the A/M-Area from several sources. These sources include naturally produced cosmogenic tritium deposited by rainfall, "bomb tritium" from above-ground testing of nuclear weapons, tritium released into the atmosphere from SRS facilities, and tritiated water released from point sources by various facilities in the A/M-Area.

Tritium is produced naturally in the upper atmosphere and leaks through to the troposphere during late winter months. The concentrations of natural cosmogenic tritium in precipitation vary seasonally and, depending on geographic location, may range from 4 tritium units (TU) to 25 TU (0.013 to 0.08 pCi/ml). The concentrations are generally higher by a factor of about five in localities above 30° latitude (Gat, 1980).

Massive amounts of tritium were injected into the atmosphere by thermonuclear weapons testing programs during the late 1950's and especially during the early 1960's. The International Atomic Energy Agency has maintained stations to monitor tritium in rainfall. The locality with the longest continuous monitoring record is Ottawa, Canada. Because of its completeness, the Ottawa record is frequently referred to for comparison purposes. This record, illustrated in Figure 6, shows a pronounced spike in 1963, shortly preceding the ban on above-ground testing. The weighted mean tritium concentration in rainfall was almost 3,000 TU (9.6 pCi/ml). This 1963 spike in the precipitation tritium record has been widely observed throughout the northern hemisphere. It has been useful as a tracer to study the infiltration and dispersion rates of rainwater in shallow aquifers (Hendry, 1983; Egboka *et al.*, 1983; and Allison and Hughes, 1974).

Figure 5. Potentiometric cross section through A/M-Area

At SRS, the signatures of both natural tritium and of "bomb" tritium in rainfall are masked by the amount of locally produced tritium reaching the water table from precipitation and point sources. The 1963 tritium tagged waters are not likely to be discernable from the locally produced tritium. Murphy *et al.* (1990) have reviewed and summarized many of the data on tritium in the SRS environment. The vast majority of the tritium in the ground water at SRS comes from release of tritium to the atmosphere by on-site facilities. Over the period 1954 to 1988 approximately 24×10^6 curies have been released to the atmosphere, primarily from the separations areas and secondarily from the reactors. The average annual release of about 0.7×10^6 is about 1/10th of the total natural production of tritium in the upper atmosphere, estimated to be about 4 to 8×10^6 Ci/yr.

About half of the tritium released at SRS is in the form of elemental tritium (HT) and about half as tritiated water (HTO), that is as a normal water molecule with tritium replacing one of the hydrogen ions in the molecule. Tritiated hydrocarbons such as methane are also detected but are not quantitatively significant compared to the other two forms. On-site deposition of HTO is accomplished primarily through wash-out by precipitation. Semi-quantitative estimates of the precipitation tritium can be derived for many of the areas in and around the site. Direct measurement data have also been collected on precipitation tritium from a rain gage just north of the A/M Area since 1973 and from the A-Area since 1988 (Murphy *et al.*, 1990).

At the latitude of SRS, the 1963 tritium spike would not be as pronounced as at Ottawa due to circulation patterns in the upper atmosphere. The peak concentrations from thermonuclear weapons testing would be about 1/2 to 1/3rd that of Ottawa (Egbota *et al.*, 1983) and would be more nearly comparable to the concentration in rainfall at A/M-Area during the late 1980's. Furthermore, because the half-life of tritium is relatively short (12.3 yrs.), the spike will have decayed significantly by the time sampling of ground water took place for this study. The mean annual concentrations from these stations are shown on Figure 6 for comparison to the Ottawa record.

When the precipitation data are corrected for decay (Figure 7), it becomes evident that it would be difficult to pick out the "bomb tritium" peak from the other sources of precipitation tritium at the A/M-Area. In general, the younger waters should have higher

tritium concentration in rainfall

Figure 6. Concentrations of tritium in rainfall at the A/M-Area and at Ottawa, Canada

Decay corrected rainfall data (1988)

Figure 7. Tritium concentration in rainfall corrected for decay to 1988

concentrations and there should be an approximately inverse relationship between tritium concentration and age since the period mid-1950's. The maximum concentration of precipitation in groundwater should be in the range of 1,000 to 1,500 TU on the basis of 1988 decay corrected data.

On the basis of these data, a rudimentary time scale classification of groundwater ages can be devised (see Figure 8). Ground water or recharge waters with tritium concentrations below about 10 TU are derived from groundwater reservoirs containing waters that were present prior to the beginning of the thermonuclear testing and operation of reactors at SRS. Modern waters, i.e. precipitation that has infiltrated the ground water since the late 1950's or early 1960's will have tritium concentrations ranging from 100 TU to about 1,500 TU. Any water with a tritium concentration of about 1500 TU must have a local point source origin. The presence of different age waters as well as imprecision in the analytical procedures can produce uncertain age designations.

Sampling and Analysis

In the spring and early summer of 1989, 61 wells in the A/M-1 area were sampled for tritium. The wells sampled are from 13 well clusters that are aligned approximately NE to SW across the site. Five of the wells were sampled in duplicate to determine reproducibility of the sampling and analytical procedures. The locations of the 13 well clusters are shown on Figure 2. The samples were collected using standard well purging procedures and tritium counting flasks. The Environmental Transport Section (ETS) of the Physics Laboratory analyzed each of the samples in duplicate at the ETS low-level tritium counting facilities. The results of the analyses as well as other pertinent well and sample data are presented in Appendix I.

Figure 9 shows a histogram of the tritium analytical results. The vast majority of the analytical data fall between 0 and 1,500 TU, i.e. the range anticipated from the infiltration of rainwater into the ground surface. Two of the samples, ASB 8C and MSB 47C are far in excess of what would be expected based on the previous discussion and are assumed to have a point source origin. The most probable source of this water is the seepage basin or drains and outfalls in the River Laboratory area.

AGE CLASSIFICATION OF GROUND WATER USING TRITIUM DATA

Figure 8. Age classification of tritium concentration levels. The age of ground water can be broadly categorized on the basis of tritium concentrations. Water containing tritium in concentrations greater than about 100 TU has entered the ground water since the beginning of operations at the Savannah River Site

A/M Area tritium data distribution

Figure 9 Histogram of tritium value distribution. The outlying values are associated with a point source of tritium.

Figure 10. Tritium concentration versus depth.

A large number of the samples have tritium concentration values below 100 TU. These low values indicate water ages greater than about 30 years. When plotted as a function of depth, Figure 10, the highest tritium activities are generally at shallower depths however the obverse is not necessarily true. Older waters with tritium values less than 100 TU are found in shallow as well as in the deep wells.

While most of the samples from below the clay-rich beds of the Ellenton Formation have low tritium concentrations, tritium-rich waters have penetrated through these confining beds in the vicinity of the Savannah River Laboratory. These modern waters are found in the Cretaceous-aged sediments of Aquifer I/IIB in wells MSB 37TA and MSB 47TA and possibly in well MSB 37A (Figure 11). The tritium concentrations are consistent with values expected in rainwater deposited during the years since 1953. Measurable TCE concentrations are detected in these same wells, apparently having migrated into the Steel Creek Member concurrently with the downward migration of modern ground water and not as a separate dense non-aqueous phase liquid (DNAPL).

The hydraulic gradient in A/M-Area has been discussed above. Over much of the the A/M-Area there is a consistent downward hydraulic gradient from the water table into aquifer I/IIB. (see Figure 5 above). In the vicinity of the Savannah River Laboratory (SRL) in the northern portion of the study area, sufficient permeability apparently exists to allow penetration of the modern waters through the Ellenton Formation confining beds. The origin of this high permeability zone in the aquitard is unknown at present, however several hypotheses have been suggested. In the vicinity of well clusters MSB 37 and MSB 47, moderately to well-sorted sands are uncharacteristically common and the confining beds of the Ellenton Formation thin on the north and eastern edges of the study area (Fallaw, 1990). In addition to the lithologic changes in the area, structural factors may contribute to the existence of a high permeability zone in the confining units.

Seismic reflection surveys have shown the existence of faulting in the crystalline basement rock below the A/M-Area. Fallaw (1990) has suggested that the fault may extend through the Tertiary section displacing or interrupting the lateral continuity of the aquitards in the section. The tritium data in the present study, however, do not indicate downward migration in the vicinity of well cluster MSB 34 that sits astride the possibly faulted section.

Figure 11. Classification of A/M-Area ground water based on tritium concentrations shown in cross section. Modern ground water of meteoric origin has penetrated through the Ellenton Formation and is present in the Cretaceous section at wells MSB 37 and MSB 47.

The sedimentological features noted by Fallaw, thinning of the confining beds and localized well-sorted sands, combined with the downward hydraulic gradient seem to adequately explain the downward movement of water into the Cretaceous Steel Creek Member of the Peedee Formation.

Conclusions and Recommendations

Tritium surveys using the low-level analytical facilities at SRL could be especially effective as an analytical tool at the Savannah River Site. Unlike many areas of the North American Continent where the majority of the tritium in ground water was received during the peak years of above-ground weapons testing, the Savannah River Site has had a nearly continuous supply in the rainwater since the beginning of reactor operations. Because the tritium moves as part of the water mass and is not noticeably involved in chemical or physiochemical reactions, it provides a valuable tracer for the movement of modern ground water. In the present study for instance, the results verify the earlier proposals that a pathway exists for the downward migration of shallow ground water into the Cretaceous sediments below the Ellenton Formation.

Discussion of $^3\text{H}/^3\text{He}$ Dating Techniques

A considerable amount of additional information could be obtained through incorporation of $^3\text{H}/^3\text{He}$ age dating techniques into future tritium investigations. Tritium decay in ground water will produce helium-3 as a daughter product through beta decay,

So long as the system is closed to prevent escape of the ^3He to the atmosphere, the age of the water mass can be calculated

$$2) \quad t \frac{^3\text{He}^*}{^3\text{H}} = \lambda^{-1} \ln \left[\frac{^3\text{He}^*}{^3\text{H}} + 1 \right]$$

where $^3\text{He}^* = \text{tritogenic } ^3\text{He}$.

Within the vadose zone and in the upper few centimeters of the phreatic zone, the system must be considered to be an open system. However, both field studies and theoretical calculations show that below the water table, the system is closed with respect to tritogenic

^3He . Solomon and Sudicky (1991) have mathematically modeled the effects of dispersion and calculated differences between true groundwater travel times and $^3\text{H}/^3\text{He}$ ages. Under conditions such as those encountered in the shallow aquifer zones at SRS, the differences will be relatively small, probably less than 10%.

Two types of information would be available from $^3\text{H}/^3\text{He}$ age dating: (1) shallow groundwater flow models can be accurately calibrated against known travel times through $^3\text{H}/^3\text{He}$ dating. This would be especially useful in developing models in complex flow systems where solute transport of contaminants is of concern. (2) Since in a closed system,

$$^3\text{H}_0 = ^3\text{H}_m + ^3\text{He}^* \text{ where: } \begin{array}{l} ^3\text{H}_0 = \text{original } ^3\text{H} \text{ in precipitation} \\ ^3\text{H}_m = \text{measured tritium} \\ ^3\text{He}^* = \text{tritogenic } ^3\text{He}, \end{array}$$

a historical record of the atmospheric transport and deposition of tritium to distant or to unmonitored areas can be reconstructed based on groundwater measurements. This might be especially useful in addressing questions relating to the long term exposure of residents in the vicinity of SRS.

Methods for measuring low concentrations of tritium in atmospheric and aqueous samples have been developed and are routinely used at the Savannah River Site. The Savannah River Laboratory also has the instrumentation to perform a limited number of ^3He measurements and $^3\text{He}/^4\text{He}$ ratio's. The mathematical treatment for determining $^3\text{H}/^3\text{He}$ ages has been developed and mathematical algorithms using these data to determine flow rates, dispersion coefficients, and recharge rates are maturing.

SUMMARY

Atmospheric transport and deposition of tritium in rainwater have created a unique signature to modern groundwater, which allows its use as a tracer. In the A/M-Area, modern waters have mostly been confined to aquifers above the Ellenton Formation. In one section near the northern end of the study area, modern, post 1950's waters have penetrated into the Cretaceous-aged Steel Creek Member of the Peedee Formation. Sedimentary features appear to be adequate to explain the increase in permeability of the overlying aquitards.

The usefulness of tritium as a tracer would be greatly augmented if future studies are combined with $^3\text{H}/^3\text{He}$ dating techniques. These age-dating techniques are rapidly maturing and should be used routinely for on-site investigation of shallow groundwater movement and contaminant transport.

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Appendix I. Monitoring well Construction and Tritium Analytical data.

WELL NO.	MONITORED UNIT(1)	FORMATION (FALLAW, '90)	AQUIFER DESIGNATION	ELEVATIONS (Ft MSL)	
				Casing	SCREEN *
ASB 8	WT	Santee	I/IIC	349	216.6
" (dupl.)	"	"	I/IIC	"	"
ASB 8 C	Upper Cong.	Congaree	I/IIC	349.7	185.5
ASB 8 B	Lower Cong.	Fourmile	I/IIC	349.8	125.6
ASB 8 A	Ellenton	Ellenton	I/IIB-I/IIC	349.3	80.7
ASB 8 TA	Black Creek	Steel Creek	I/IIB	349.6	22
MSB 12 D	WT	Dry Branch	I/IIC	346.3	234.3
MSB 12 C	Upper Cong.	Congaree	I/IIC	347.9	180.4
MSB 12 B	Upper Cong.	Fourmile	I/IIC	348.4	158.7
MSB 12 A	Lower Cong.	Fourmile	I/IIC	347.8	118.4
MSB 12 TB	Black Creek	Steel Creek	I/IIB	348.5	3.7
MSB 12 TA	Black Creek	Black Creek	I/IIB	348.5	108.7
" (dupl.)	"	"	"	"	"
MSB 33	WT	Dry Branch	I/IIC	256.6	219.3
MSB 33 C	Upper Cong.	Congaree	I/IIC	255.3	170
MSB 33 B	Lower Cong.	Fourmile	I/IIC	255.2	125.1
MSB 33 A	Ellenton	Ellenton	I/IIB-I/IIC	255.4	87.1
MSB 33 TA	Black Creek	Steel Creek	I/IIB	255.5	22.3
MSB 34 C	WT	Santee & Dry Br.	I/IIC	383.2	230.7
MSB 34 B	Upper Cong.	Congaree	I/IIC	383.1	184.3
MSB 34 A	Lower Cong.	Ellenton	I/IIB-I/IIC	383.2	115.8
MSB 34 TB	Black Creek	Steel Creek	I/IIB	382.8	70.8
MSB 34 TA	Black Creek	Black Creek	I/IIB	382.5	-97.7
MSB 36 D	WT	Dry Branch	I/IIC	341.5	239.4
MSB 36 C	Upper Cong.	Congaree	I/IIC	340.8	192
MSB 36 B	Lower Cong.	Fourmile	I/IIC	340.7	162
MSB 36 A	Ellenton	Steel Creek/Ellenton	I/IIB-I/IIC	340.6	99.1
MSB 36 TA	Black Creek	Steel Creek	I/IIB	340.6	52.5
MSB 37 D	WT	Dry Branch	I/IIC	382.8	236.1
MSB 37 C	Upper Cong.	Congaree	I/IIC	383.1	178.7
MSB 37 B	Lower Cong.	Fourmile	I/IIC	382.8	140.9
MSB 37 A	Black Creek	Steel Creek	I/IIB	383.1	71.7
MSB 37 TA	Black Creek	Steel Creek	I/IIB	382.4	34.3
MSB 38 C	Upper Cong.	Congaree	I/IIC	356.3	164.2
MSB 38 B	Lower Cong.	Fourmile	I/IIC	356.6	141.7
MSB 38 TA	Black Creek	Steel Creek	I/IIB	356.7	28.2

Appendix I. Monitoring well Construction and Tritium Analytical data.

WELL NO.	MONITORED UNIT (1)	FORMATION (FALLAW, '90)	AQUIFER DESIGNATION	ELEVATIONS (Ft MSL)	
				Casing	SCREEN *
MSB 39 D	WT	Dry Branch	I/IIC	341.7	230.2
MSB 39 C	Upper Cong.	Congaree	I/IIC	341.5	197.8
MSB 39 B	Lower Cong.	Fourmile	I/IIC	381.8	149.9
MSB 39 A	Ellenton	Ellenton	I/IIB-I/IIC	341.6	110
MSB 39 TA	Black Creek	Steel Creek	I/IIB	341.8	48.3
" (dupl.)	"	"	"	"	"
MSB 40 D	WT	Dry Branch	I/IIC	322.9	226.7
MSB 40 C	Upper Cong.	Santee	I/IIC	322.1	190
MSB 40 B	Lower Cong.	Congaree	I/IIC	321.7	153
MSB 40 A	Ellenton	Ellenton	I/IIB-I/IIC	321.2	114.9
MSB 40 TA	Black Creek	Steel Creek	I/IIB	320.8	28.1
" (dupl.)	"	"	"	"	"
MSB 41 C	Lower Cong.	Fourmile	I/IIC	324.6	150
MSB 41 B	Ellenton	Ellenton	I/IIB-I/IIC	324	112.2
MSB 41 A	Ellenton	Ellenton	I/IIB-I/IIC	323.8	86.3
MSB 41 TA	Black Creek	Steel Creek	I/IIB	323.7	25.5
MSB 47 D	WT	Santee	I/IIC	369.2	229.3
MSB 47 C	Upper Cong.	Congaree	I/IIC	369.3	199.8
MSB 47 B	Upper Cong.	Fourmile	I/IIC	369	168.2
MSB 47 TA	Black Creek	Steel Creek	I/IIB	369	52.8
MSB 54 D	Water Table	Dry Branch	I/IIC	374	234
MSB 54 C	Upper Cong.	Fourmile	I/IIC	373.7	173.1
MSB 54 B	Lower Cong.	Fourmile	I/IIC	373.7	134
MSB 54 TA	Black Creek	Steel Creek	I/IIB	373.8	78.4
" (dupl.)	"	"	"	"	"
MSB 69 D	WT	Santee/Dry Branch	I/IIC	382.2	230.2
MSB 69 C	Upper Cong.	Fourmile	I/IIC	381.8	173.4
MSB 69 B	Lower Cong.	Fourmile	I/IIC	381.7	142.4
MSB 69 TA	Black Creek	Steel Creek	I/IIB	381.5	77.6

(1) unit designated in monitor well data reports and databases.

* MIDPOINT OF SCREENED INTERVAL

Appendix I. Monitoring well Construction and Tritium Analytical data.

WELL NO.	SAMPLE DATE	REPLICATE ANALYSES		Mean	Mean
		pCl/g	pCl/g	pCl/g	TU
ASB 8	5/14/89	2.839	2.938	2.889	902.7
" (dupl.)	5/14/89	2.986	2.736	2.861	894.1
ASB 8 C	5/14/89	23.353	24.020	23.687	7402.0
ASB 8 B	5/14/89	1.367	1.482	1.425	445.2
ASB 8 A	5/14/89	0.174	0.154	0.164	51.3
ASB 8 TA	5/14/89	0.029	0.031	0.03	9.4
MSB 12 D	"dry hole				
MSB 12 C	4/27/89	0.245	0.277	0.261	81.6
MSB 12 B	4/27/89	0.349	0.388	0.369	115.2
MSB 12 A	4/27/89	0.020	0.047	0.034	10.5
MSB 12 TB	4/27/89	<.013	<.012	<.012	0.0
MSB 12 TA	4/27/89	0.002	<.018	0.002	0.6
" (dupl.)	4/27/89	0.051	0.034	0.043	13.3
MSB 33	4/25/89	0.869	0.881	0.875	273.4
MSB 33 C	4/25/89	2.288	8.816	5.552	1735.0
MSB 33 B	4/25/89	0.863	0.862	0.863	269.5
MSB 33 A	4/25/89	0.051	0.013	0.032	10.0
MSB 33 TA	4/25/89	0.011	0.053	0.032	10.0
MSB 34 C	5/8/89	0.773	0.821	0.797	249.1
MSB 34 B	5/8/89	0.991	0.972	0.982	306.7
MSB 34 A	5/8/89	0.284	0.271	0.278	86.7
MSB 34 TB	5/8/89	0.010	0.005	0.008	2.3
MSB 34 TA	5/8/89	0.036	0.011	0.024	7.3
MSB 36 D	5/17/89	0.042	0.276	0.159	49.7
MSB 36 C	6/3/89	0.864	0.903	0.884	276.1
MSB 36 B	6/3/89	0.361	0.391	0.376	117.5
MSB 36 A	6/3/89	0.014	0.038	0.026	8.1
MSB 36 TA	6/3/89	0.022	<.019	0.022	6.9
MSB 37 D	5/11/89	1.452	1.272	1.362	425.6
MSB 37 C	5/11/89	0.751	0.739	0.745	232.8
MSB 37 B	5/11/89	0.355	0.331	0.343	107.2
MSB 37 A	5/11/89	0.333	0.280	0.307	95.8
MSB 37 TA	5/11/89	0.805	0.769	0.787	245.9
MSB 38 C	5/16/89	0.859	1.164	1.012	316.1
MSB 38 B	5/16/89	0.475	0.612	0.544	169.8
MSB 38 TA	5/16/89	0.035 +/-		0.035	10.9

Appendix I. Monitoring well Construction and Tritium Analytical data.

WELL NO.	SAMPLE DATE	REPLICATE ANALYSES		Mean	Mean
		pCl/g	pCl/g	pCl/g	TU
MSB 39 D	5/3/89	2.207	0.864	1.536	479.8
MSB 39 C	5/3/89	1.464	1.339	1.402	438.0
MSB 39 B	5/3/89	0.256	0.227	0.242	75.5
MSB 39 A	5/3/89	0.026	0.012	0.019	5.9
MSB 39 TA	5/3/89	<.023	<.017	<.020	0.0
" (dupl.)	5/3/89	0.002	0.035	0.019	5.8
MSB 40 D	5/11/89	2.334	2.172	2.253	704.1
MSB 40 C	5/10/89	0.007	0.004	0.006	1.7
MSB 40 B	5/10/89	0.043	0.031	0.037	11.6
MSB 40 A	5/10/89	<0.134	0.036	0.036	11.3
MSB 40 TA	5/10/89	0.009	0.076	0.043	13.3
" (dupl.)	5/10/89	0.009	0.043	0.026	8.1
MSB 41 C	5/4/89	1.050	1.037	1.044	326.1
MSB 41 B	5/4/89	0.413	0.344	0.379	118.3
MSB 41 A	5/4/89	0.085	0.026	0.056	17.3
MSB 41 TA	5/4/89	0.048	0.025	0.037	11.4
					0.0
MSB 47 D	4/28/89	1.786	1.890	1.838	574.4
MSB 47 C	4/28/89	24.041	22.056	23.049	7202.7
MSB 47 B	4/28/89	5.174	5.169	5.172	1616.1
MSB 47 TA	4/28/89	0.640	0.724	0.682	213.1
MSB 54 D	5/7/89	1.722	1.663	1.693	528.9
MSB 54 C	5/7/89	0.033	0.565	0.299	93.4
MSB 54 B	5/7/89	0.063	0.024	0.044	13.6
MSB 54 TA	5/7/89	0.050	0.074	0.062	19.4
" (dupl.)	5/7/89	0.053	0.069	0.061	19.1
MSB 69 D	4/28/89	1.088	1.677	1.383	432.0
MSB 69 C	4/28/89	0.907	1.122	1.015	317.0
MSB 69 B	4/28/89	<.010	-	<.010	0.0
MSB 69 TA	4/27/89	0.034	0.035	0.035	10.8

**DATE
FILMED
8/20/92**