Radiocesium in Pond B

The history of Pond B

Pond B is one of several reservoirs that were constructed on the Department of Energy's Savannah River Site (SRS) to serve as secondary cooling systems for nuclear production reactors. Pond B was filled in 1961 and received thermal effluents from R Reactor until the reactor was shut down in 1964. Since 1964, water levels in the pond have been maintained by precipitation and groundwater seepage. Extensive macrophyte (aquatic vegetation) communities have developed in the shallower waters (littoral zone) of the pond, and a diverse animal community, including at least seven fish species, has become established.

Radiocesium contamination in Pond B

During R Reactor operations from 1961-1964, radionuclides (tritium, cesium-137, strontium-90, americium-241, cerium-244, and plutonium-239, 240) were released to Pond B in effluents. By 1984, cesium-137 (^{137}Cs) accounted for 99% of the total measured radioactivity in the pond, and of the ^{137}Cs inventory, 99% resided in the pond's sediments. Because ^{137}Cs is chemically similar to potassium, it can be assimilated by aquatic organisms and thus can enter the food chain.

Problems with evaluating change in radiocesium levels in pond sediments

Given that most of a lake or reservoir's ^{137}Cs inventory resides in the sediments, export of ^{137}Cs from the whole ecosystem can be calculated as the difference between sediment ^{137}Cs inventory estimates from two points in time. However, because of high spatial variability in the ^{137}Cs contents of individual sediment samples, there is considerable uncertainty associated with estimates of whole-ecosystem inventories. Therefore, using this method to estimate ^{137}Cs export will also involve large uncertainties.

Concerns about the export of radiocesium from Pond B

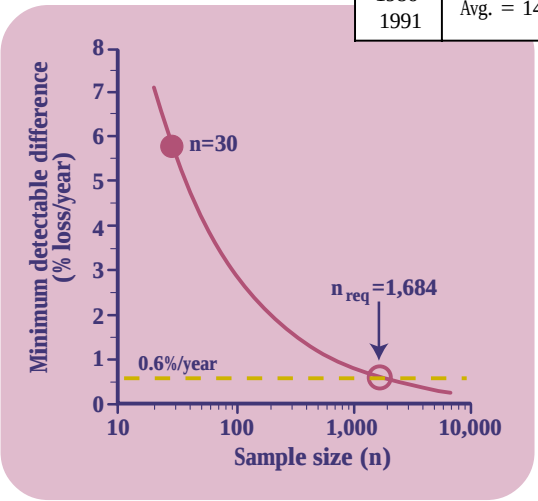
Based on the mean ^{137}Cs inventories in sediment cores collected from Pond B in 1984 and 1994, it was previously estimated that the ^{137}Cs inventory of the sediments had declined by 49% during 1984-1994. This decline represented an effective (ecological) half-life of 10 years and an annual loss of 6.5% of the inventory. The annual loss solely from radioactive decay is only 2.3%. Thus, it seemed that the amount of ^{137}Cs in the pond was declining at a rate of 4.2% per year beyond the known loss due to radioactive decay. One possibility was that ^{137}Cs was being carried out of the pond in surface water flowing through the pond's

The Pond B cooling reservoir on the Savannah River Site received heated effluent from R Reactor from 1961 until 1964. Since cessation of reactor operations, macrophyte communities have developed and a diverse animal community has become established.

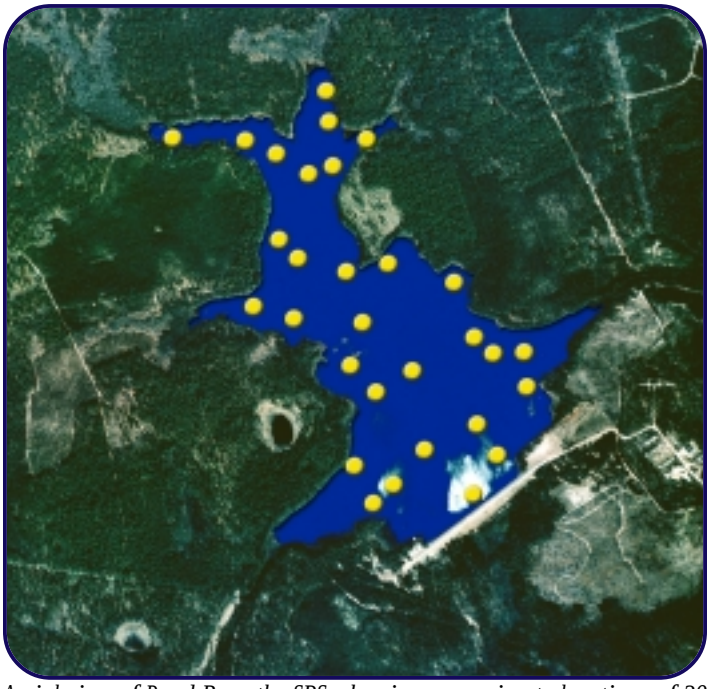
outlet canal. If this was the case, then a substantial amount of the ^{137}Cs from Pond B was being exported to downstream ecosystems such as Par Pond. However, because of the large uncertainties associated with the sediment inventory estimates, it was also possible that there was no statistically significant difference between the two inventory estimates after accounting for radioactive decay.

Estimate of change in sediment inventory

We tested the hypothesis that the sediment ^{137}Cs inventory at Pond B declined faster than expected from radioactive decay. To minimize the error from variability among locations, we used only cores collected from the same 30 locations in both years (additional locations had been sampled in 1984). The mean rate of decline in the ^{137}Cs inventory beyond natural radioactive decay was 2.6% per year, but the 95% confidence interval about this estimate was very broad, ranging from a loss of 7.7% per year to an increase of 0.8% per year. Therefore, we could not conclude that a significant decline beyond natural radioactive decay had occurred. Given the actual sample size of 30 pairs of sediment cores, only a decline of 5.8% per year or more could have been detected.



Minimum detectable difference in sediment ^{137}Cs inventory as a function of sample size. The dashed line indicates the estimated export rate of ^{137}Cs in surface water between 1984 and 1994. The sample size required to detect a change in the sediment ^{137}Cs inventory equal to the surface water export is indicated by the open circle.



Aerial view of Pond B on the SRS, showing approximate locations of 30 sites sampled in 1984 and 1994 to determine the inventory of ^{137}Cs in pond sediments.

Annual discharge of water and estimated export of ^{137}Cs from Pond B during 1986-1991.

Year	Annual discharge (x 10^5 m^3)	Annual % of volume discharged	Annual export of ^{137}Cs (GBq)	Annual % of inventory exported
1986	3.16	8	0.12	0.03
1987	17.7	45	0.70	0.21
1988	0	0	0	0
1989	0	0	0	0
1990	6.34	16	0.43	0.14
1991	58.0	149	3.3	1.1
1986-1991	Avg. = 14.2	Avg. = 36		

Estimate of radiocesium export in surface water

Based on hydrologic data from 1986-1991, we estimate that the amount of ^{137}Cs lost from the pond in surface water outflow was no more than 0.6% per year of the sediment inventory. We believe surface water outflow to be the only plausible mechanism for the loss of ^{137}Cs from Pond B (the loss of ^{137}Cs in animals leaving the pond is miniscule by comparison). To detect a loss of 0.6% per year by sampling sediments in 1984 and 1994 would have required nearly 1,700 samples in each year.

Conclusions

- The sediment data from Pond B yielded no conclusive evidence of a decline of the ^{137}Cs inventory beyond radioactive decay and surface water export.
- Export of ^{137}Cs in surface water from Pond B probably averages <0.6% per year of the sediment ^{137}Cs inventory.
- To have detected a change in sediment inventory equal to the surface water export of ^{137}Cs would have required an impracticably large number of samples in each year.
- Pond B seems to retain ^{137}Cs effectively, preventing it from moving into downstream ecosystems in appreciable quantities.