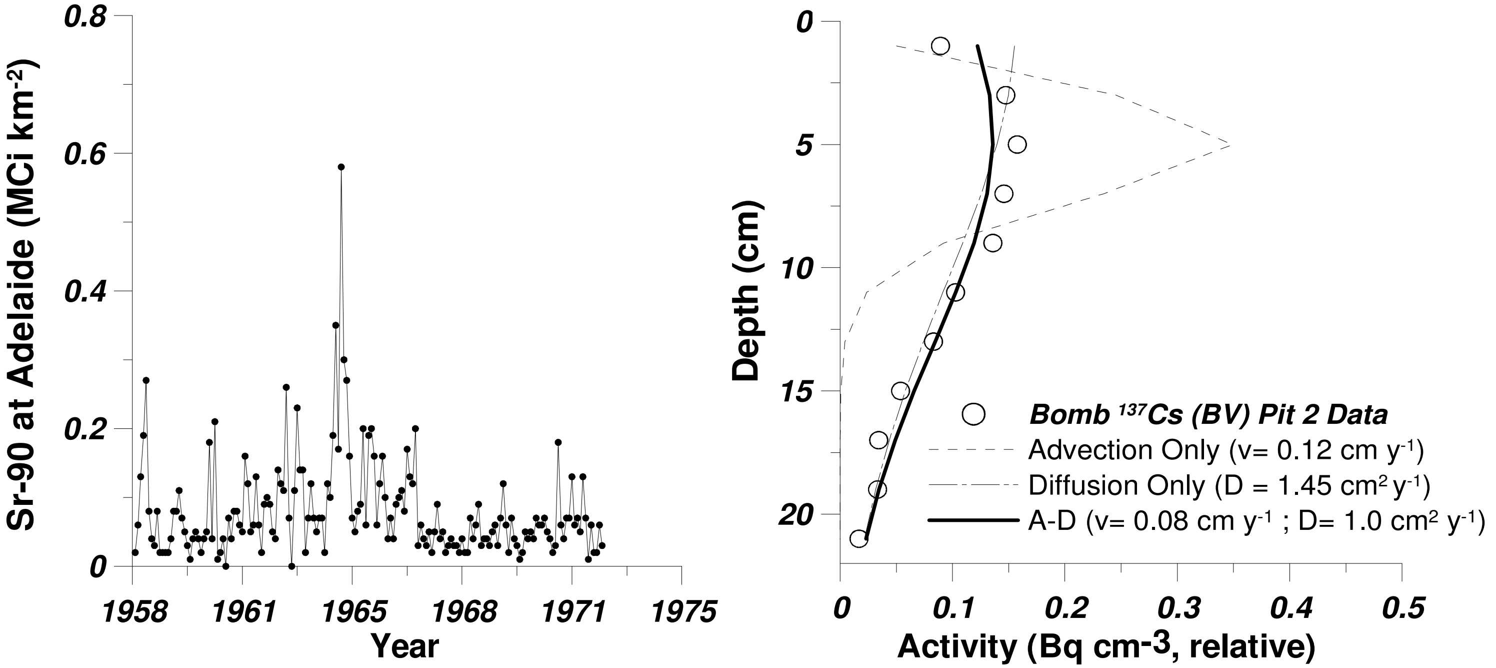
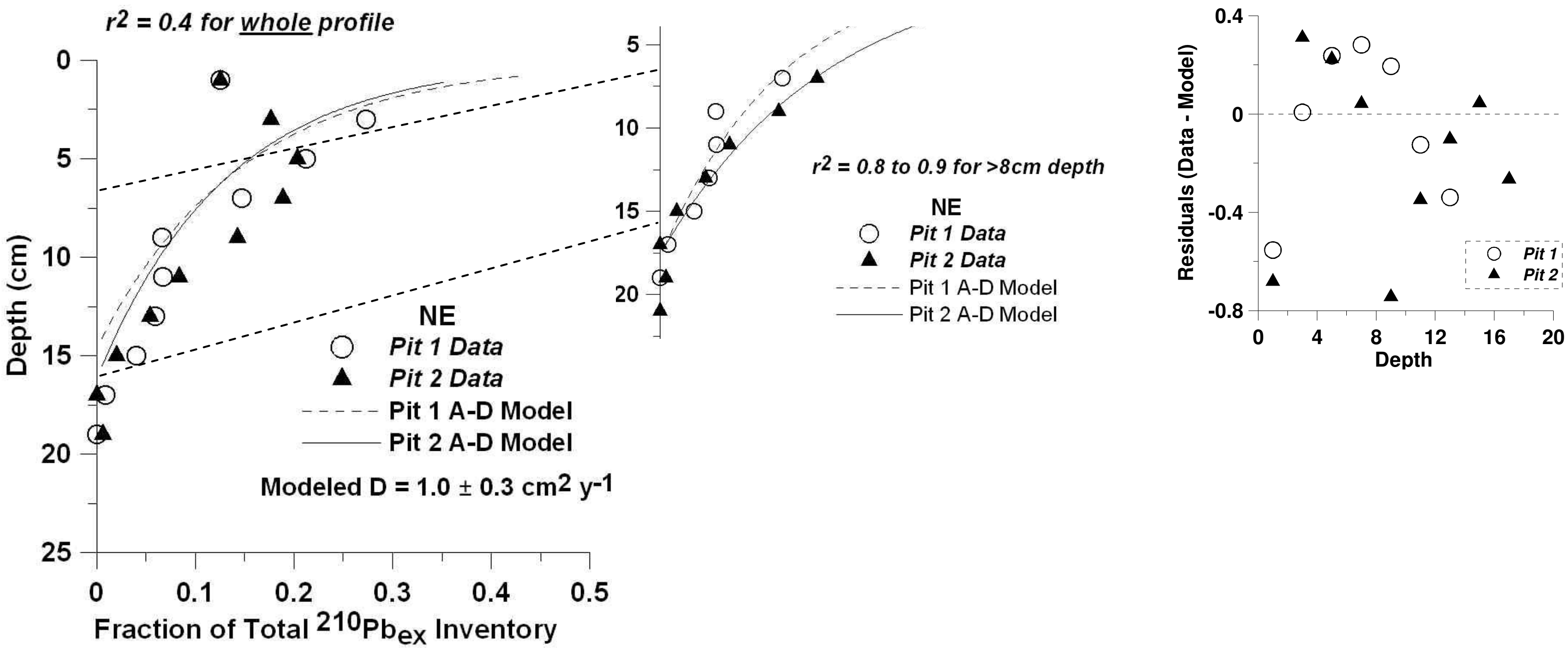
APPENDIX: Testing the ^{210}Pb-derived diffusion values (D) with a numerical simulation of the subsurface weapons-spike profile.



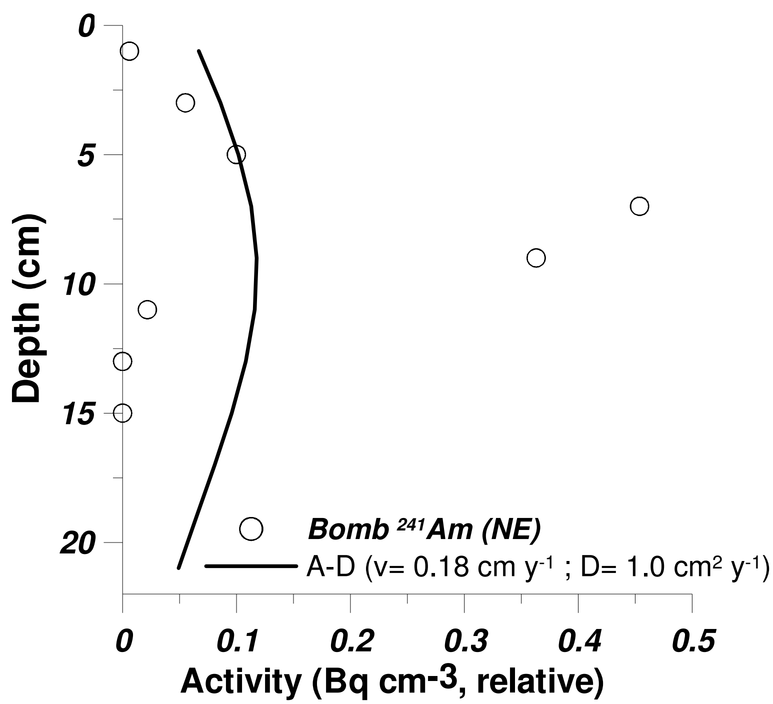
Data Repository Figure A1. Monthly Sr-90 deposition measured in Adelaide, Australia between 1958 and 1974 (U.S. ERDA, 1977). We use this input function (left) to feed a dynamic transport model (right) of the ^{137}Cs profile in soils at BV. We normalized the ^{90}Sr input data to 1, so that that transport model is not dependent on the absolute amount of weapons fallout measured. Instead, the model relies on the measured temporal distribution of the fallout. The transport model was run from 1958 (earliest record of radioactive fallout at Adelaide) until the samples were collected from the field (2001 or 2005). We assume zero weapons fallout after 1974 (end of the US ERDA record), and run the model in 0.1 year time increments to minimize artifacts that could be introduced by numerical diffusion. The "advection-only" model simulates the position of the sub-surface ^{137}Cs peak well (at ~5 cm), but does not accurately recreate the broad shape of the observed profile. The best-fit "diffusion-only" model provides an upper limit of D = 1.45 cm^2 y^{-1} (an upper limit because of the zero advection assumption). However, the "diffusion-only" model fails to recreate the observed subsurface peak. In this case, the best-fit A-D model with D = 1 cm^2 y^{-1} explains 85% of the variance of the data, and the velocity and D values agree well with those derived via the steady-state model of ^{210}Pb transport (Figure 2 in manuscript).

APPENDIX: Advection-diffusion modeling of $^{210}Pb_{ex}$ profiles in NE: Detailed fitting and residuals



Data Repository Figure A2. The advection-dispersion model does not accurately describe the form of the $^{210}Pb_{ex}$ depth-profiles in the whole soil column in NE. This is most apparent by looking at the residuals, which are depth dependent (upper most samples have the largest deviation from the model) and do not sum to zero, indicating that they are not random. However, below 6 cm, the profiles take on a more true exponential form, where the a-d model can account for >80% of the data. This probably represents a change in dominant process: below 6 cm, organic matter is no longer decomposing at a rate that controls $^{210}Pb_{ex}$ concentration, and leaching (advection) probably begins to dominate in the soil profile.

APPENDIX: Testing the ^{210}Pb-derived diffusion values (*D*) at NE with a numerical simulation of the subsurface weapons-spike profile.



Data Repository Figure A3. Dynamic numerical model simulating the weapons fallout profile at a pit in NE using the best fit *D* derived from the steady-state ^{210}Pb A-D model (Figure 2, Data Repository Figure A2). The model itself is similar to that described in Figure A3, although we use input data measured in New York from 1956-1975 (U.S. ERDA, 1977). This simulation shows how poorly the traditional A-D model describes our data in surface soils in NE.