Simple Buildup Factor

In simplest terms, buildup accounts for the extra dose that scattered photons contribute through a multiplicative correction to the uncollided dose.

$$D_{tot} = D_{unc} B(E_0, \tau)$$

Buildup data is usually fit to a convenient format. The one that I like the best (hint, hint) is the 1-term Taylor form:

$$B(E_0, \tau) = A_1 e^{-\alpha_1 \tau}$$

Notice that the two parameters are E_0—the initial source energy—and τ—the number of mean free paths traversed through material (usually found by mu times distance).

What makes this so convenient is that the uncollided dose is found from:

$$D_{unc} = \frac{SR}{4\pi r^2} e^{-\tau} B(E_0, \tau)$$

So, including the buildup gives you:

$$\begin{aligned} D_{tot} &= \frac{SR}{4\pi r^2} e^{-\tau} B(E_0, \tau) \\ &= \frac{SR}{4\pi r^2} e^{-\tau} \left[A_1 e^{-\alpha_1 \tau} \right] \\ &= \frac{\left[A_1 S \right] R}{4\pi r^2} e^{-(1+\alpha_1)\tau} \end{aligned}$$

Examining this says that you can solve a buildup problem (a total dose problem) just as easily as an uncollided dose problem. You just have to interpret A1 as a source multiplication factor and $(1+\alpha_1)$ as a mean free path multiplication factor. (In practice, α_1 is negative—but no lower than -1—so that it can be interpreted as the fraction by which the mean free path—or mu, if you prefer—is reduced.)

This interpretation, by the way, makes the 1-term Taylor easy to apply to non-point sources as well—just use the uncollided dose formula with the source multiplied and mu reduced.

For shields with more than one material, it is best to find the buildup for each of the materials and then keep the most conservative. In doing this you have to make sure that you use the TOTAL mean free path through ALL materials in the buildup formula, not just that of the particular material.

In practice, this just means that, for EACH shielding material, you solve the problem with the source multiplied by that material's A and ALL mu values are reduced by that material's $(1+\alpha 1)$. Then the answer is the highest resulting dose.