# APPENDIX B
# IMPACT ON DOSE ESTIMATE
# OF MILDOS PARTICLE SIZE DISTRIBUTION

The CDPHE asked for a technical basis for using the default values in MILDOS to model particle size from the SAG mill, dryer vent, etc. The Final Generic Environmental Impact Statement (FGEIS) on Uranium Milling (NRC 1980) has an extensive discussion of particle sizes associated with various releases from a uranium mill. A complete review of that information is not necessary for this appendix. However, based on the Fig B-1, reproduced from Fig. G-1.1 of the FGEIS, data "suggest that over 95% of the ore mass in a composite ore sample represent non-suspendible particles greather than 100 µm in diameter." Based on that conclusion, it is clear that the amount of particulate material available as a transport vector for potential dose is a small portion of the total ore material.

Concern was also expressed by CDPHE regarding the ratios for particle sizes suggested for use by MILDOS. As outlined by the RFI comment, there are threee suggested particles size sets that are defaults for any MILDOS model run. The fractional size composition of the various particle size sets is summarized in Table B-1. It is important to note that these particle sizes do not represent physical diameter, but activity median aerodynamic diameter (AMAD). The definition of AMAD is " the diameter of a unit density sphere with the same terminal settling velocity in air as that of the aerosol particle whose activity is the median for the entire aerosol considered." Therefore, strictly speaking, even if available, measured particle size distributions are not directly applicable and would need to be converted to AMAD.

**Table B-1 Size Distributions for Default MILDOS Particle Size Sets**

| Default Distribution Set | Median AMAD Composition | Used For |
|---|---|---|
| 1 | 100% 3 µm | Yellowcake dryer packaging or equivalent |
| 2 | 100% 1.5 µm | Crushers, grinders, rod mills, conveyors, fine ore blending, etc. |
| 3 | 30% 7.7 µm<br>70% 54 µm | Tailings dust, ore-storage piles |

Set number 1 assumes that the particles released are well represented by an AMAD of 3 µm. This distribution set is generally reserved for yellowcake dryer packaging or equivalent sources. Particle set 2 assumes that a smaller distribution of 1.5 µm AMAD. This set is generally used for crusher, SAG mills, etc. as listed in Table A-1. Set number 3 is a blend of 30% 7.7 µm AMAD and 70% 54 µm AMAD. Set three is usually assigned to releases from talings piles and ore-storage piles.

According to Strenge and Bander (1981), the original document that describes the MILDOS code, particile size is important in two respects. First, the amount of transportable material is determined by the size of the particles and second, the potential inhalation dose to a receptor is a function of the sizes of the transported particles.

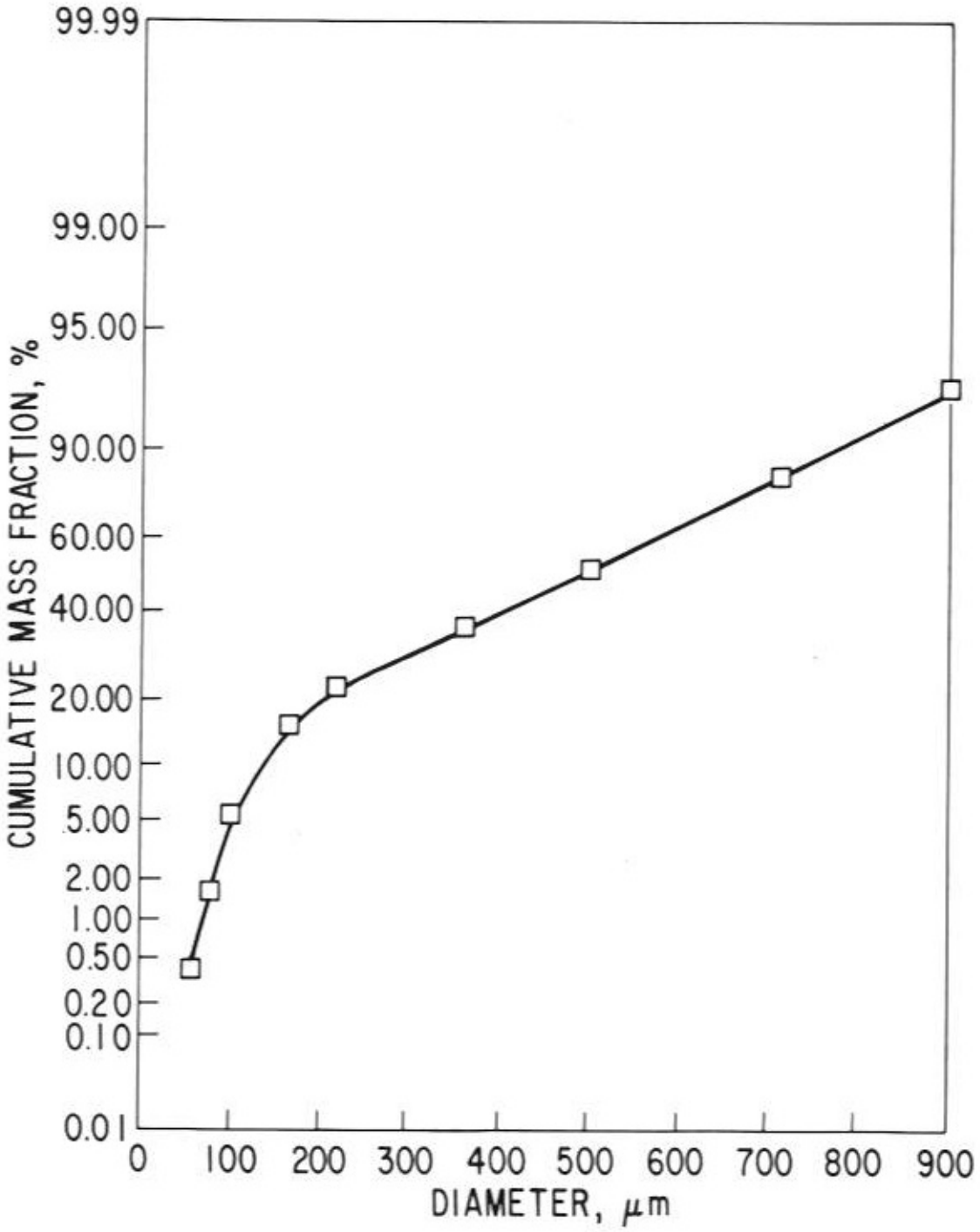


**Figure B-1 Particle Size Distribution of Composite Uranium Ore Feed (reproduced frm Fig. G-1.1 of NRC 1980).**

Rather than attempt to recreate a technical treatise on the methodology for both of those processes, we performed a sensitivity analysis of the impacts of choosing one or the other particle size on the dose of boundary and off-site receptors.

For this exercise, we used stack releases that are described in the text above and performed MILDOS runs using 1.5 µm, 3 µm and 7.7 µm particles. Results are shown in Table B-2. The dose to any boundary location from 1.5 µm partifcles was 1.64 times that to the same receptor from 3 µm particles and 3.06 times the dose if 7.7 µm particles were assumed. This is not surprising, given that the same algorithm applies in all cases.

**Table B-2 Effect of MILDOS Particle Sizes on Predicted Dose at Boundary.**

| | TEDE (mrem/yr) | | |
|---|---|---|---|
| **Name** | **1.5 um** | **3 um** | **7.7 um** |
| Fence 1 | 4.51E-01 | 2.76E-01 | 1.50E-01 |
| Fence 2 | 3.16E-01 | 1.92E-01 | 1.04E-01 |
| Fence 3 | 7.07E-02 | 4.31E-02 | 2.34E-02 |
| Fence 4 | 1.92E-01 | 1.17E-01 | 6.33E-02 |
| Fence 5 | 7.15E-02 | 4.36E-02 | 2.36E-02 |
| Fence 6 | 5.11E-01 | 3.11E-01 | 1.67E-01 |
| Fence 7 | 1.41E-01 | 8.67E-02 | 4.76E-02 |
| Fence 8 | 4.89E-02 | 3.00E-02 | 1.65E-02 |
| Fence 9 | 3.36E-02 | 2.06E-02 | 1.13E-02 |
| Fence 10 | 3.84E-02 | 2.35E-02 | 1.28E-02 |
| Fence 11 | 4.36E-02 | 2.67E-02 | 1.45E-02 |
| Fence 12 | 4.79E-02 | 2.93E-02 | 1.60E-02 |
| Fence 13 | 9.32E-02 | 5.71E-02 | 3.12E-02 |
| Fence 14 | 3.02E-01 | 1.85E-01 | 1.02E-01 |
| Fence 15 | 4.40E-01 | 2.70E-01 | 1.48E-01 |

Likewise, doses to off-site receptors from the stack releases were also modeled. Results are shown in Table B-3. As with the doses to the boundary receptors, the estimated off-site doses from the 1.5 µm particles is 1.64 and 3.01 times that from the 3 and 7.7 µm particles, respectively.

**Table B-3 Effect of MILDOS Particle Sizes on Predicted Dose to Off-site Locations.**

| Location | TEDE (mrem/yr) for MILDOS particle sizes (AMAD) | | |
|---|---|---|---|
| | 1.5 um | 3 um | 7.7 um |
| Bed Rock | 7.56E-03 | 4.62E-03 | 2.51E-03 |
| Boren Residence | 3.19E-02 | 1.95E-02 | 1.06E-02 |
| Davis/Fehlman Residence | 2.06E-02 | 1.26E-02 | 6.86E-03 |
| Herron Residence | 4.66E-02 | 2.85E-02 | 1.55E-02 |
| Hogan Structures | 9.12E-03 | 5.57E-03 | 3.02E-03 |
| Hurdle Residence | 1.56E-02 | 9.51E-03 | 5.17E-03 |
| Kinder Residence | 1.54E-02 | 9.41E-03 | 5.13E-03 |
| Moab | 2.79E-04 | 1.70E-04 | 9.26E-05 |
| Montrose | 9.65E-05 | 5.89E-05 | 3.20E-05 |
| Naturita | 5.93E-03 | 3.62E-03 | 1.97E-03 |
| Norwood | 5.22E-04 | 3.19E-04 | 1.73E-04 |
| Telluride | 9.68E-05 | 5.91E-05 | 3.21E-05 |

The 1.5 µm particle size distribution represents particle size set number 2, which is generally used to represent releases from grinders, etc. Hence, it appears that using the default particle size value is conservative regarding predicted dose and it appropriate to use for stack releases, including those from a SAG mill.

It is also important to note that the predicted doses from all stack releases repreresent only about 10% of the total dose to any given receptor from potential mill releases. The maximum dose to any receptor (Fence 6) is approximately 0.5 mrem/yr under the conditions modeled.

## REFERENCES

U.S. Nuclear Regulatory Commission (NRC), 1980. Final Generic Environmental Impact Statement on Uranium Milling. NUREG-0706, Vol. III. Office of Nuclear Material Safety and Safeguards.

Strenge, D.L. and T.J. Bander. 1981. MILDOS – A Computer Program for Calculating Environmental Radiation Dose from Uranium Recovery Operations. NUREG/CR-2011, PNL-3767, April.