



## MEMORANDUM

TO: Nevada Test Site Work Group  
FROM: SC&A, Inc.  
DATE: May 9, 2017  
SUBJECT: SC&A Concerns Regarding the Use of a Beta/Gamma Ratio to Determine External Dose

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The National Institute for Occupational Safety and Health (NIOSH) has developed a beta-to-gamma (BG) ratio to estimate doses from beta particles that can be used when only doses from gamma radiation are known. This methodology will allow external dose to be determined for claimants who worked at the Nevada Test Site (NTS) prior to 1966. NIOSH originally developed a BG ratio of 1.04. Upon reviewing this ratio, however, NIOSH could not ascertain the basis for its development (SC&A 2015). Therefore, NIOSH subsequently reestimated and revised this ratio to a ratio of 1.16. To obtain this ratio, NIOSH analyzed NTS data from 1966 to 1986 using current Energy Employees Occupational Illness Compensation Program Act data files and a value (geometric mean) of 1.16 (with a geometric standard deviation [GSD] of 2.15 and a 95th-percentile value of 4.09) was derived. The published value has a GSD of 2.41 and a 95th-percentile value of 4.59 (NIOSH 2015a; SC&A 2015). NIOSH believes the change in the ratio from 1.04 to 1.16 is due to the increase in available claimant data. The records used to develop this revised BG ratio are only those for which there was both a gamma dose and a beta dose; records that may have had no gamma dose identified, or were below detection, were not used in developing the ratio of 1.16 (NIOSH 2015a).

Other documents directly pertinent to the determination of beta doses for NTS workers and other individuals exposed to nuclear device tests provide beta-gamma ratios much greater than 1.16, depending on the time elapsed after the test and the distance from the source term. These ratios can be as great as 60 to 1, as shown in Appendix C to the NTS technical basis document (TBD) for external dose (NIOSH 2012), also referred to as the “Hicks data.” A paper by Barss and Weitz (2006) showed that the BG ratio associated with nuclear testing could be as high as about 490 to 1 at NTS (reflective of 2 years after detonation and 1 cm from the source plane).

The BG ratio of 1.16, which uses empirical data as presented above, is currently used as a best estimate for determining external dose for dose reconstructions (DRs) (ABRWH 2017, p. 197).

Because of the difference between the NIOSH value of 1.16 and other values cited in the literature, and taking into consideration the procedure established in the TBD, SC&A recommends that the approach to BG doses should be reassessed, keeping in mind the following questions, concerns, and suggestions:

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- The NIOSH dose records used to develop the ratio of 1.16 are taken from badges used to monitor workers (i.e., empirical data), thus representing both the occupational and environmental external dose. The Hicks data in Appendix C to the TBD represent only environmental dose. The fact that the empirical data at least partially represent occupational dose suggests that the beta-gamma ratio may be influenced by specific projects, in different site areas, that are not associated with weapons tests.
- If a higher BG ratio is found to be appropriate (such as from Appendix C and/or Barss and Weitz 2006), then the beta doses could easily be on the order of rems. This is particularly important for claims involving cancers to the skin, lips, testes, and breasts for which shallow doses are assessed.
- SC&A understands that dosimeter measurements typically represent the most “desirable” data source for determining occupational external dose in terms of the hierarchy of data for use in DR. Nonetheless, in this case, the approach to DR of using the empirical data appears to be questionable and not claimant favorable. Given that the source term for beta dose at NTS during this period is predominantly from fallout from nuclear device debris, it would appear that the data in Appendix C to the TBD and/or the ratios provided in Barss and Weitz (2006) would be more appropriate and certainly more claimant favorable. If NIOSH decides not to use these ratios, NIOSH should explain why it believes that its measured ratios are appropriate, given that they are so much lower than would be expected based on Appendix C and Barss and Weitz.
- It appears that most of the empirical data derived from film badge readings in the post-1966 period have zero recorded gamma dose (below detection level). This calls into question the quality and appropriateness of the data for developing BG ratios for use in DR. The proportion of badges post-1966 with no recorded gamma needs to be quantified. If the data derived from post-1966 badges are to be used to assess pre-1966 beta dose, NIOSH needs to develop a methodology for accounting for the sub-method-detection-limit (sub-MDL) gamma readings.
- The potential for situations where the badging records indicate a positive beta dose with a deep dose below the detection limit has not been evaluated. NIOSH should investigate this potential source of negative bias.
- The NIOSH data are from post-1966, when there was only underground weapons testing (with venting being an issue) with intervening periods of no testing. The pre-1966 time frame represents both atmospheric testing and underground testing; therefore, the NIOSH data may not be representative of the diverse external dose potential. NIOSH needs to provide a clear explanation of why it believes that these post-1966 data are appropriate for back extrapolation, given the widely different activities and source terms. SC&A suggests that NIOSH determine the proportion of pre-1966 badges that recorded no measurable gamma dose and compare that to the proportion of post-1966 dose records with sub-MDL readings. Such a comparison might help in determining whether post-1966 data are appropriate for back-extrapolation to pre-1966 exposures. Such

investigations are consistent with the guidance in the March 2015 NIOSH white paper, *Draft Criteria for the Evaluation and Use of Coworker Datasets*, Revision 4.1 (NIOSH 2015b).

- The potential for the empirical data being skewed by badge results dominated by certain claimants or groups of claimants has not been investigated. The issue of data dominance was one of the central reasons why NIOSH developed the time-weighted one person, one statistic approach to coworker model development. It would be beneficial for NIOSH to quantify how many claimants make up the proposed dataset to determine if data dominance may be an issue. It would also be beneficial for NIOSH to record their occupation and work locations, if possible, to see if the data are dominated by certain occupational groupings at certain times. Furthermore, NIOSH has proposed a single BG ratio for the entire period under consideration. Analysis and discussion of temporal, work location, and occupational variations would appear warranted and is consistent with the coworker criteria described in NIOSH 2015b.

## References

ABRWH 2017. Transcript, meeting of the National Institute for Occupational Safety and Health, Advisory Board on Radiation and Worker Health, Nevada Test Site Work Group. January 5, 2017.

Barss and Weitz 2006. N.M. Barss and R.L. Weitz, "Reconstruction of External Dose from Beta Radiation Sources of Nuclear Weapon Origin," *Health Physics*, Vol. 91, No. 4 (2006), pp. 379–389. [SRDB Ref. ID 26776]

NIOSH 2012. *Nevada Test Site – Occupational External Dose*, ORAUT-TKBS-0008-6, Revision 03, National Institute for Occupational Safety and Health, Cincinnati, Ohio. November 9, 2012.

NIOSH 2015a. Microsoft Excel® file, "Privacy Act Protected--NTS Beta Gamma Ratio rev 2\_1966 through 1986\_for DCAS - FINAL 4-21-15.xlsx." April 21, 2015.

NIOSH 2015b. *Draft Criteria for the Evaluation and Use of Coworker Datasets*, Revision 4.1, J.W. Neton, National Institute for Occupational Safety and Health, Division of Compensation Analysis and Support, Cincinnati, Ohio. March 12, 2015.

SC&A 2015, Draft NIOSH updates to *NTS Issues Matrix*, SCA-SP-IM2012-0042. May 15, 2015.