APPENDIX 1.

INHALATION RATE

CTUIR Inhalation Rate = 30 m^3/d (adult)

SUMMARY

The inhalation rate in the CTUIR scenario reflects the active, outdoor lifestyle of traditional tribal members, including youth who are learning traditional subsistence skills, adult outdoor workers who also hunt, gather, and fish, and elders who gather plants and medicines, and prepare and use them (e.g., making medicines or baskets, etc.) and who teach a variety of indoor and outdoor traditional activities. Traditional tribal communities have no sedentary members except the frail elderly, whereas one-quarter of modern American adults of all ages report no leisure time physical activity at all.[1] We have documented the activity levels associated with this lifestyle and diet with published anthropological studies, ethnographic literature on foraging theory, hunting-gathering lifestyles, and interviews with Tribal members. Using EPA guidance on hourly inhalation rates for different activity levels, a reasonable inhalation rate for an average tribal member's active lifestyle is an average rate of 26.2 m^3/d, based on 8 hours sleeping at 0.4 m^3/hr, 2 hours sedentary at 0.5 m^3/hr, 6 hours light activity at 1 m^3/hr, 6 hours moderate activity at 1.6 m^3/hr, and 2 hours heavy activity at 3.2 m^3/hr. Unlike most other exposure factors, which are upper bounds, the inhalation rate is an average rate. This is inconsistent with the usual RME approach used in Superfund risk assessments, and could result in under-protection of children, the elderly, athletes, asthmatics, and the half of the population with above-average inhalation rates. Due to a tribal desire to protect more than just the average traditional person, we have chosen to round up from 26.2 m^3/d to 30 m^3/day.

1.0 Population-specific physiology

Perhaps the most relevant factors associated with ethnic specificity of metabolic and inhalation rates are the thrifty genotype(s), insulin use, and oxidation and adiposity patterns (Goran, 2000; Fox et al., 1998; Muzzin et al., 1999; Rush et al., 1997; Saad et al., 1991; Kue Young et al., 2002), as well as ethnic differences in spirometry (Crapo et al., 1988; Lanese et al., 1978; Mapel et al., 1997; Aidaraliyev et al., 1993; Berman et al., 1994). Research on the thrifty genotype suggests that there may be several stress response genes that enable indigenous populations to respond to environmental stresses and to the rapid transition between extremes, including feast and famine, heat and cold, disruption in circadian rhythms, dehydration, seasonality, and explosive energy output or rapid transitions between minimum and maximum exercise and $VO2_{max}$ (Kimm et al., 2002; Snitker et al., 1998). These genes "uncouple" several energy expenditure parameters (Kimm et al., 2002), and

[1] (http://www.cdc.gov/brfss/pdf/ 2001prvrpt.pdf and http://www.cdc.gov/brfss/pubrfdat.htm).

generally support the logic of using a higher inhalation rate for active, outdoor lifestyles, especially in Native American populations.

2.0 Short-term versus long-term inhalation rates.

Most federal and state agencies either use the EPA default value of 20m^3/d or use activity levels to estimate long-term inhalation rates. When we developed the exposure scenario, we evaluated activity levels through anthropological data (foraging theory and activity descriptions in the anthropological literature) and confirmatory interviews with Tribal elders, and used the CHAD-based EPA recommendations for ventilation rate for the different activity levels. Several examples of similar approaches are:

- EPA's National Air Toxics Assessment (homepage: http://www.epa.gov/ttn/atw/nata/natsa3.html) uses the CHAD database in its HAPEM4 model to estimate national average air toxics exposures even though "the lack of activity pattern data that extend over longer periods of times presents a challenge for HAPEM4 to predict the long-term (yearly) activity patterns that are required to determine chronic exposures." Therefore, "an approach of selection of a series of single day's patterns (from CHAD) to represent an individual's activity pattern for a year was developed."
- The California Air Resources Board (CARB, 2000) reviewed daily breathing rates based on activity levels and measured ventilation rates for many activities in the CHAD database. The average hourly rate for sleeping was 0.5 m^3/hr, light activities at 0.55 m^3/hr, moderate activities at 1.4 m^3/hr, and heavy rates of activity levels at 3.4 m^3/hr. The CARB concluded that 20 m^3/d represents an 85th percentile of typical adult sedentary/light activity lifestyles. This is based on 8 hours sleeping and 16 hours of light activity with no moderate or heavy activity, or 1 hour day of moderate and heavy activity each.
- In their technical guidance document, "Long-term Chemical Exposure Guidelines for Deployed Military Personnel," the US Army Center for Health Promotion and Preventive Medicine (USACHPPM) recommended an inhalation rate of 29.2 m^3/d for US service members. Deployed personnel were assumed to spend 6 hours sleeping at an inhalation rate of 0.4 m^3/hr, 4 hours in sedentary activities (at 0.5 m^3/hr), 6 hours in light duties (at 1.2 m^3/hr), and 8 hours in moderate duties (at 2.2 m^3/hr).[2]
- EPA used 30 m^3/day for a year-long exposure estimate for the general public at Hanford, based on a person doing 4 hours of heavy work, 8 hours of light activity, and 12 hours resting.[3]
- The DOE's Lawrence Berkeley Laboratory also used 30 m^3/d: "the working breathing rate is for 8 hours of work and, when combined with 8 hours of breathing at the active rate and 8 hours at the resting rate, gives a daily equivalent intake of 30 m^3 for an adult."[4]

[2] http://www.gulflink.osd.mil/particulate_final/ particulate_final_s06.htm and http://www.gulflink.osd.mil/pm/pm_en.htm.

[3] "Report of Radiochemical Analyses for Air Filters from Hanford Area" Memorandum from Edwin L. Sensintaffar, Director of the National Air and Radiation Environmental Laboratory to Jerrold Leitch, Region 10 Radiation Profram Manager (http://yosemite.epa.gov/R10/AIRPAGE.NSF/webpage/Hanford+Environmental+Perspective)

[4] (www.lbl.gov/ehs/epg/tritium/TritAppB.html)

- The Rocky Flats Oversight Panel recommended using 30 m^3/d.[5]

3.0 The use of population-specific information rather than national averages.

EPA instructs risk assessors to identify the receptor population and their activities or land use.[6] "Assessors are encouraged to use values which most accurately reflect the exposed population."[7] The OSWER Land Use Directive[8] requires the identification of land uses for the baseline risk assessment; when the affected resources are on reservations or areas where tribes retain usory rights, a subsistence/residential land use must be assumed if the Tribe so indicates. Executive Order 12898[9] requires the identification of subsistence consumption of natural resources, and for Indian Tribes this includes the activities required to obtain those resources.

EPA recognizes that inhalation rates may be higher in certain populations, such as athletes or outdoor workers, because levels of activity outdoors may be higher over long time periods. "If site-specific data are available to show that subsistence farmers and fishers have higher respiration rates due to rigorous physical activities than other receptors, that data may be appropriate."[10] Such subpopulation groups are considered 'high risk' subgroups.[11] EPA (1997) recommends calculating their inhalation rates using the following average hourly intakes for various activity levels (in m^3/hr): resting = 0.4, sedentary = 0.5, light activity = 1, moderate activity = 1.6, heavy activity = 3.2. EPA's average rate for outdoor workers is 1.3 m^3/hr, with an upper percentile of 3.3 m^3/hr, depending on the ratio of light, moderate and heavy activities during the observation time. Other EPA risk assessments typically use 2.5 m^3/hr for groundskeepers.[12]

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[5] RAC (Risk Assessment Corporation). 1999. *Task 1: Cleanup Levels at Other Sites. Rocky Flats Citizens Advisory Board, Rocky Flats Soil Action Level Oversight Panel.* RAC Report No. 3-RFCAB-RFSAL-1999' http://www.itrcweb.org/Documents/RAD-2.pdf

[6] http://www.epa.gov/superfund/programs/risk/ragsd/table4instructions.pdf.

[7] Exposure Factor Handbook, Volume 1, page 5-23

[8] OSWER Directive 9355.7-04, "Land Use in the CERCLA Remedy Selection Process" (May 25, 1995)

[9] White House, 1994. Federal Actions To Address Environmental Justice In Minority Populations And Lowincome Populations: Feb. 11, 1994; 59 FR 7629, Feb. 16, 1994.

[10] EPA (OSWER) "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Support Materials Volume 1: Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities" page 6-4, at (http://www.epa.gov/earth1r6/6pd/rcra_c/protocol/volume_1/chpt6-hh.pdf)

[11] Exposure Factors Handbook, 1997, Volume 1. page 5-24

[12] For outdoor workers, see U.S. EPA 1991a. U.S. Environmental Protection Agency (U.S. EPA). Human health evaluation manual, supplemental guidance: "Standard default exposure factors". OSWER Directive 9285.6-03. An example of use is http://epa-dccs.ornl.gov/radionuclides/equations/outdoor_guide.shtml. Oregon uses 3.66 m^3/hr for penitentiary workers; http://64.233.167.104/search?q=cache:uQII54d5ioYJ:www.doc.state.or.us/fiscalservices/facilities/existing/osp_groundwater/tables/2000/table_5_4.pdf+%22construction+worker%22+%22inhalation+rate%22+epa&hl=en.

Since we have population-specific data, we believe that EPA is required to use it in order to meet its statutory mandate to protect human health – and particularly if members of an explicit population are identifiably discrete. Using EPA guidance on hourly inhalation rates for different activity levels, a reasonable inhalation rate for an average tribal member's active lifestyle is an average rate of 26.2 m^3/d, based on 8 hours sleeping at 0.4 m^3/hr, 2 hours sedentary at 0.5 m^3/hr, 6 hours light activity at 1 m^3/hr, 6 hours moderate activity at 1.6 m^3/hr, and 2 hours heavy activity at 3.2 m^3/hr. Unlike most other exposure factors, which are upper bounds, the inhalation rate is an average rate. EPA says "an upper percentile is not recommended"[13] with no reason given. This is inconsistent with the usual RME approach used in Superfund risk assessments, and could result in under-protection of children, the elderly, athletes, asthmatics, and the half of the population with above-average inhalation rates. Due to a tribal desire to protect more than just the average traditional person, we have chosen to round up from 26.2 m^3/d to 30 m^3/day.

4.0 REFERENCES

Aidaraliyev, A.A., Maximov, A.L., & Mala, T. (1993). Physiologic adaptation changes of the "Bering Bridge" expedition participants. *Arctic Med. Res.* 52(2):55-62.

Berman, S.M., Arnall, D.A., & Cornwall, M.W. (1994). Pulmonary function test outcomes in healthy Navajo Native American adolescents. *Am. J. Respir. Crit. Care Med*. 150(4):1150-3

CARB, 2000. *Technical Support Document for Exposure Assessment and Stochastic Analysis.* California Air Resources Board, September 2000. http://www.oehha.ca.gov/air/hot_spots/pdf/contents.pdf (see chapter 3 for daily breathing rates).

Crapo, R.O., Lockey, J., Aldrich, V., Jensen, R.L., & Elliott, C.G. (1998). Normal spirometric values in healthy American Indians. *J. Occup. Med.* 30(7) :556-60

EPA (1997). *Exposure Factors Handbook,* EPA/600/P-95/002Fa, http://www.epa.gov/ncea/pdfs/efh/sect5.pdf

EPA (1999). *Cancer Risk Coefficients for Environmental Exposure to Radionuclides,* Federal Guidance Report No. 13 (EPA/402-R-99-001).

EPA (2000) CHAD User's Guide. EPA National Exposure Research Laboratory, and associated web pages, factsheets, and summaries. Homepage: http://www.epa.gov/chadnet1/

Fox, C.S., Esparza, J., Nicolson, M., Bennett, P.H., Schulz, L.O., Valencia, M.E., & Ravussin, E. (1998). Is a low leptin concentration, a low resting metabolic rate, or both the expression of the "thrifty genotype"? Results from Mexican Pima Indians. *Am. J. Clin. Nutr.* 68(5):1053-7

[13] Exposure Factors Handbook, Volume 1, page 5-23.

Funk, L.M., Sedman, R., Beals, J.A., & Fountain, R. (1998). Quantifying the distribution of inhalation exposure in human populations: 2. Distributions of time spent by adults, adolescents, and children at home, at work, and at school. *Risk Anal.* 18(1):47-56

Goran, M.I. (2000). Energy metabolism and obesity. Med Clin North Am;84(2):347-62
Hartmann HM. 2002 Evaluation of risk assessment guideline levels for the chemical warfare agents mustard, GB, and VX. *Regul. Toxicol. Pharmacol*. 35(3):347-56

Kimm, S.Y., Glynn, N.W., Aston, C.E., Damcott, C.M., Poehlman, E.T., Daniels, S.R., & Ferrell, R.E. (2002). Racial differences in the relation between uncoupling protein genes and resting energy expenditure. *Am. J. Clin. Nutr*. 75(4):714-9

Kue Young, T., Chateau, D., & Zhang, M. (2002). Factor analysis of ethnic variation in the multiple metabolic (insulin resistance) syndrome in three Canadian populations. *Am. J. Human Biol.* 14(5):649-58

Lanese, R.R., Keller, M.D., Foley, M.F., & Underwood, E.H. (1978). Differences in pulmonary function tests among whites, blacks, and American Indians in a textile company. *J. Occup. Med.* 20(1):39-44

Mapel, D.W., Coultas, D.B., James, D.S., Hunt, W.C., Stidley, C.A., & Gilliland, F.D.(1997). Ethnic differences in the prevalence of nonmalignant respiratory disease among uranium miners. *Am. J. Public* Health 87(5):833-8.

Muzzin, P., Boss, O., & Giacobino, J.P. (1999). Uncoupling protein 3: its possible biological role and mode of regulation in rodents and humans. *J. Bioenerg. Biomembr*. 31(5):467-73

Rush, E.C., Plank, L.D., & Robinson, S.M. (1997). Resting metabolic rate in young Polynesian and Caucasian women. *Int. J. Obes. Relat. Metab. Disord*. 21(11):1071-5

Saad, M.F., Alger, S.A., Zurlo, F., Young, J.B., Bogardus, C., & Ravussin, E. (1991). Ethnic differences in sympathetic nervous system-mediated energy expenditure. Am. J. Physiol. 261(6 Pt 1):E789-94

Snitker, S., Tataranni, P.A., & Ravussin, E. (1998) Respiratory quotient is inversely associated with muscle sympathetic nerve activity. *J. Clin. Endocrinol. Metab*. 83(11):3977-9

Steegmann, A.T., Jr, Cerny, F.J., & Holliday, T.W. (2002). Neandertal cold adaptation: physiological and energetic factors. *Am. J. Human Biol*. 14(5):566-83.