

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of)
)
U.S. ARMY) Docket No. 40-8838-MLA
)
(Jefferson Proving Ground Site))

PREFILED TESTIMONY OF A. CHRISTIANNE RIDGE

1 Under penalty of perjury, I, A. Christianne Ridge, declare as follows: I attest that the
2 factual statements herein are true and correct to the best of my knowledge, information, and
3 belief; and the opinions expressed herein are based on my best professional judgment.

4 **Q.1 Please state your name and employment.**

5 A.1 My name is A. Christianne Ridge. I am a Systems Performance Analyst at the
6 U.S. Nuclear Regulatory Agency in the Division of Waste Management and Environmental
7 Protection.

8 **Q.2 Are there any acronyms or abbreviations in your testimony that should be**
9 **identified?**

10 A.2 Yes, the following acronyms or short names have the meanings shown:

11 The "Staff" refers to the NRC Staff;
12 "DOE" refers to the U.S. Department of Energy;
13 "DU" refers to depleted uranium;
14 "EPA" refers to the U.S. Environmental Protection Agency;
15 "FSP" refers to the Field Sampling Plan as amended and supplemented by the
16 Army;
17 "JPG" refers to Jefferson Proving Ground;
18 "STV" refers to Save the Valley, Inc, the intervenor;
19 "XRD" refers to X-ray diffraction; and
20 "XPS" refers to X-ray photoelectron spectroscopy.

21
22 **Q.3 Please describe your professional qualifications including education,**
23 **training, work experience, and publications.**

24 A.3 I have a Ph.D. in Environmental Engineering from the University of California,

1 Berkeley, an M.S. in Environmental Engineering from Cornell University, and a B.A. in Physics,
2 *summa cum laude*, from Drew University. My doctoral training focused primarily on aquatic
3 chemistry. While working at the NRC I have had specific training in conducting performance
4 assessments to support decisions about site decommissioning. I have worked for the Nuclear
5 Regulatory Commission for four years. A copy of my *curriculum vitae*, which supplies additional
6 details about my training, work experience, and publications, is attached.

7 **Q.4 What are your job duties and responsibilities as a Systems Performance**
8 **Analyst?**

9 A.4 My responsibilities include the review of environmental models used to support
10 decisions about waste disposal sites and sites undergoing license termination.

11 **Q.5 Please provide an example of your work performed as part of your job**
12 **duties.**

13 A.5 As part of my job duties, I reviewed performance assessment models developed
14 by the U.S. Department of Energy (DOE) to estimate the potential dose to hypothetical
15 receptors living near two disposal sites for reprocessing waste on DOE's Savannah River Site.
16 These reviews both included the review of the selection of solubility limits and distribution
17 coefficients (Kd values) to represent radionuclide release from waste and transport in
18 groundwater.

19 **Q.6 Please describe your involvement and responsibilities regarding the Staff's**
20 **review of the Jefferson Proving Ground application.**

21 A.6 I have reviewed and am familiar with the technical issues pertaining to uranium
22 release and transport at Jefferson Proving Ground (JPG). I also am familiar with the technical
23 details of the geochemical modeling process Save the Valley (STV) recommends that the Army
24 use to model uranium transport at JPG. Further, I have analyzed Bases "J" and "Q" raised by
25 STV to support Contention B-1. After performing my analyses of Bases "J" and "Q", I have

1 reached conclusions as to their validity for the JPG Field Sampling Plan (FSP) based on my
2 professional opinion. In addition, I have calculated a bounding value for the potential
3 radiological dose from uranium to a member of the public who consumes deer taken from JPG.

4 **Q.7 Did you review or rely on any specific documents to prepare for or conduct**
5 **your analysis of STV's Bases "J" or "Q"?**

6 A.7 In addition to the Army's Field Sampling Plan (FSP), FSP addendum related to
7 soil verification, testimony of Charles H. Norris, and testimony of Dr. Diane S. Henshel, I have
8 reviewed the following items during the preparation of this affidavit:

9 (1) American Society for Testing and Materials (ASTM). *Standard Test Method*
10 *for Distribution Ratios by the Short-Term Batch Method*. ASTM D4319-93.
11 Philadelphia, PA. 1993.

12 (2) American Society for Testing and Materials. *Standard Test Method for*
13 *Distribution Ratios by the Short-Term Batch Method*. ASTM D4319-83.
14 Philadelphia, PA. 1984.

15 (3) Dong, W. Xie, G., Miller, T.R., et al. (2006). "Sorption and Bioreduction of
16 Hexavalent Uranium at a Military Facility by the Chesapeake Bay",
17 *Environmental Pollution*. P. 132-142.

18 (4) Nuclear Energy Agency (NEA). (2001). *NEA Sorption Project Phase II:*
19 *Interpretation and Prediction of Radionuclide Sorption onto Substrates Relevant*
20 *for Radioactive Waste Disposal Using Thermodynamic Sorption Models*.
21 Organisation for Economic Co-Operation and Development (OECD), Nuclear
22 Energy Agency, Paris, France.

23 (5) Science Applications International Corporation (SAIC). (2006). *Deer Tissue*
24 *Sampling Results, Depleted Uranium Impact Area Site Characterization,*
25 *Jefferson Proving Ground, Madison, Indiana.*

26 (6) Sposito, G. (1986) "Distinguishing Adsorption from Surface Precipitation," in
27 *Geochemical Processes at Mineral Surfaces*. J. A. Davis and K.F. Hayes,
28 Editors. ACS symposium series. Vol. 323. P. 217-228.

29 (7) U.S. Environmental Protection Agency (EPA). (1999) *Understanding*
30 *Variation in Partition Coefficient, Kd, Values*. Vol. 1. EPA 402-R-99-004A.
31 Washington, DC. ML070160213.

32 (8) U.S. Environmental Protection Agency (EPA). (1989) *Limiting Values of*
33 *Radionuclide Intake and Air Concentration and Dose Conversion Factors for*
34 *Inhalation, Submersion, And Ingestion*. Federal Guidance Report No. 11.
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1 (second printing, with corrections). EPA-520/1-88-020. EPA, Washington, DC.
2 ML052290105.

3
4 (9) U.S. Nuclear Regulatory Commission (NRC). (2006) *Consolidated*
5 *Decommissioning Guidance: Characterization, Survey, and Determination of*
6 *Radiological Criteria*. NUREG-1757, Vol. 2., Rev. 1. NRC, Washington, DC.
7 ML032530405.

8
9 (10) U.S. Nuclear Regulatory Commission (NRC). (2003) *Application of Surface*
10 *Complexation Modeling to Describe Uranium (VI) Adsorption and Retardation at*
11 *the Uranium Mill Tailings Site at Naturita, Colorado*. NUREG/CR-6820. NRC,
12 Washington, DC. ML040210168.

13
14 (11) U.S. Nuclear Regulatory Commission. (1999) *Residual Radioactive*
15 *Contamination From Decommissioning: Parameter Analysis, Draft Report for*
16 *Comment*. NUREG/CR-5512, Vol. 3. NRC, Washington, DC. ML003726967.

17
18 (12) Valocchi, A.J. (1985). "Validity of the Local Equilibrium Assumption for
19 Modeling Sorbing Solute Transport Through Homogeneous Soils", *Water*
20 *Resources Research*, V. 21(6). P. 808-820.

21
22 **Q.8 Please state Basis "J".**

23
24 A.8 I have included Basis "J" in single space below.

25
26 The entire Kd exercise described in Section 2.3.4.3 is inaccurate,
27 unreliable, and, particularly when it forms such a key element of
28 the modeling, rife with opportunities for abuse. It is described in
29 the FSP text as 'an important input parameter' for the results of
30 exposure calculations. But, the exercise does not yield a real
31 number and its functionality is based upon assumptions that are
32 known to be invalid. The biggest erroneous assumption is the one
33 spelled out in the text: 'the underlying assumption is that rapid
34 equilibrium is reached between the dissolved and sorbed
35 concentrations of a chemical species, and that these two
36 concentrations are linearly related through the Kd factor.' At best,
37 there are an infinite number of Kd values based upon the infinite
38 number of combinations of soil types, sorbent contents, ground
39 water compositions and oxidation states that may exist along the
40 flow path from any individual DU projectile. USEPA tried to use
41 the Kd approach in its modeling for solids wastes, and only
42 recently completed spending almost five years to find an
43 alternative way because Kds just do not work. They don't even
44 work for such simple, monovalent contaminants as lead or
45 cadmium; it is preposterous to rely on the Kd approach for
46 something that is so pH-Eh dependent as the uranium system.
47 Field observations should be used to calibrate geochemical
48 modeling with a program on par with Geochemist's Workbench,
49 with a lot of soil analyses to identify the abundances of sorbents in

1 the soil that will control the mobility of the uranium. And, if the
2 exposure program that SAIC is using requires the Kd approach, it
3 should also be replaced with one that has more sophistication.
4

5 **Q.9 Basis "J" introduces the terms "sorbed concentrations" and "Kd". Could**
6 **you explain what is meant by these terms?**

7 A.9 Yes. When a chemical species moves through the soil, it typically moves with
8 the water, then sticks to a soil particle, then is released from the soil particle, moves again with
9 the water, and sticks again, moving in a series of hops. When the species sticks to the surface
10 of the soil, it is said to have "adsorbed" to the soil. When it moves back into the aqueous phase,
11 it is said to have "desorbed". In addition to adsorption, a chemical species may leave the
12 aqueous phase because it has diffused into a particle (called "absorption") or it has precipitated
13 to form a three dimensional matrix, either on the surface of an existing soil particle or to form a
14 new particle. In practice, it can be very difficult to distinguish adsorption from surface
15 precipitation (Sposito, 1986). The term "sorption" typically is used to indicate that the species
16 has left the aqueous phase when it is not known whether it has adsorbed, absorbed, or
17 precipitated.

18 The concentration of a species on the soil as a function of the concentration of the
19 species in the aqueous phase is called an isotherm. When the concentration of the species
20 adsorbed to the soil is directly proportional to the concentration of the species in the aqueous
21 phase, the isotherm is a straight line and its slope is referred to as a linear partitioning
22 coefficient, distribution coefficient, or Kd. Strictly speaking, a Kd describes the ratio of the
23 concentration of the adsorbed species to the concentration of the dissolved species once the
24 system has reached thermodynamic equilibrium.

25 **Q.10 Do you agree with the conclusion of Basis "J" that it is inappropriate for**
26 **the Army to use Kd values to represent uranium sorption to subsurface material at JPG?**

27 A.10 No, I do not.

1 **Q.11 Why do you disagree with the conclusion of Basis “J”?**

2 A.11 Basis “J” states that uranium sorption should not be modeled with a Kd value
3 because the functionality of the Kd approach is based upon assumptions that are known to be
4 invalid. The intervenor is partially correct in noting that the underlying assumptions of the Kd
5 model may not always be met in natural systems. However, although the validity of the Kd as a
6 mechanistic description of sorption does depend on several assumptions, the functionality of the
7 Kd parameter to conservatively represent or bound uranium transport does not necessarily
8 depend on those assumptions. Essentially, the Army proposes to use empirical Kd values that
9 are relevant to site-specific conditions. The Kd model may not provide a realistic mechanistic
10 model of the interactions between uranium and subsurface material at JPG; however, measured
11 site-specific values can be used to provide a conservative representation of uranium mobility at
12 the site.

13 The Army proposes to collect samples of soil and groundwater from the site, and to
14 measure Kd values with a laboratory test developed by the American Society for Testing and
15 Materials (ASTM D4319-93). This test is one of the methods recommended in NRC’s
16 *Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of*
17 *Radiological Criteria* (NRC, 2006). There do not appear to be any reasons that this test would
18 be less appropriate to characterize JPG than it would be to characterize other NRC licensed
19 sites. For these and other reasons described below, I disagree with the conclusions of Basis “J”
20 and believe that it is appropriate to model uranium transport at JPG with measured site-specific
21 Kd values.

22 **Q.12 Basis “J” includes several specific concerns about the Kd approach. What**
23 **are your conclusions about the first specific concern described in Basis “J”?**

24 A.12 The first specific concern raised in the basis is that the concentration of uranium
25 associated with the soil may not be a linear function of the concentration of aqueous uranium.

1 However, this concern appears to be addressed by the measurements described in the FSP.
2 The method the Army proposes to use to measure Kd values (ASTM D4319-93) strongly
3 encourages that measurements be performed at several different radionuclide concentrations.
4 In addition, in its FSP, the Army indicated it will perform Kd measurements with several
5 contaminated samples taken from the site. Because the samples taken from the site will be
6 expected to have different uranium concentrations, the measurements will reflect Kds based on
7 several solid and aqueous uranium concentrations. The results of these measurements will
8 indicate whether it is appropriate to model sorption as linear in the range of concentrations that
9 are relevant to the site. If the sorption is non-linear in the concentration range of interest, the
10 non-linearity can be modeled explicitly or bounded with a conservative choice of Kd. Thus, the
11 possibility of non-linear sorption is accounted for in the FSP.

12 **Q.13 You mentioned that non-linearity could be modeled explicitly or bounded**
13 **with a conservative choice of Kd. How would that be done?**

14 A.13 Non-linear sorption can be modeled explicitly by fitting a curve to the observed
15 concentration of the sorbed species as a function of the aqueous concentration of the species,
16 and then using that curve to predict sorption during the species transport instead of using a Kd
17 model. If this approach were taken, the characterization data the Army collects as described in
18 the FSP for Kd modeling would still be used even though Kd values would not be used in the
19 exposure model.

20 If non-linearity is not modeled explicitly, a single bounding Kd value could be used to
21 model radionuclide sorption. In most cases, a low Kd value results in a higher modeled
22 potential dose at offsite locations than a high Kd value, because a lower value corresponds to
23 faster movement of the species in the groundwater. If sorption is non-linear and if lower Kd
24 values result in a higher modeled dose, the Army could model uranium transport with a Kd value
25 that corresponds to the part of the isotherm that reflects the least sorption they are likely to

1 encounter on the site. If the model results indicate the site would meet the decommissioning
2 criteria, even though uranium transport (and, therefore, the potential offsite dose) was
3 overestimated with a low Kd value, more complex modeling would not be necessary. The
4 characterization data the Army plans to collect as described in the FSP will be adequate to allow
5 them to choose from these or other methods to account for non-linear sorption in their exposure
6 model, if sorption is observed to be non-linear in the concentration range of interest.

7 **Q.14 Please describe the second specific concern described in Basis “J” and**
8 **your conclusions about that concern.**

9 A.14 The second specific concern STV raised about Kd models in Basis “J” is that
10 equilibrium partitioning may not be reached rapidly. The intervenor is correct in noting that the
11 Kd approach is based on the assumption that there is rapid equilibrium between the sorbed and
12 aqueous concentrations of a species. This assumption is commonly referred to as the local
13 equilibrium assumption. In general, if the local equilibrium assumption is not valid, the arrival of
14 a contaminant will be spread in time so that the contaminant arrives for a longer period of time
15 but the peak concentration is lowered (Valocchi, 1985). The main deleterious effect that could
16 result if the local equilibrium assumption is not valid is that the contaminant could arrive at a
17 location earlier than it is predicted to arrive by a model based on the local equilibrium
18 assumption. Non-equilibrium is expected to have more of an effect on the timing of the initial
19 arrival of a contaminant than on the time at which the peak concentration is reached (Valocchi,
20 1985).

21 Because the NRC bases its decommissioning decisions on the peak dose, the
22 magnitude of the peak concentration is more likely to affect a decommissioning decision than
23 the timing of the peak concentration. The timing of the peak concentration could affect
24 decommissioning decisions if uncertainty in the transport parameters (e.g., Kd, groundwater
25 flow rates, hydraulic conductivity of the soil) caused uncertainty in whether the peak

1 concentration would arrive before or after the end of the 1000 year performance period.
2 However, in general, NRC staff evaluates potential doses after the end of the performance
3 period to ensure that the uncertainty in the timing of the peak dose is accounted for in
4 decommissioning decisions. Thus, the potential for slow equilibrium partitioning is unlikely to
5 have a non-conservative effect on a decommissioning decision.

6 In addition, the method the Army proposes to use to measure Kd values (ASTM D4319-
7 93) requires that partitioning be measured at several different times after sample preparation, so
8 that the time required to reach a steady state partitioning of the contaminant between the solid
9 and liquid phases can be measured. Thus, the characterization data the Army plans to collect,
10 as described in the FSP, will be adequate to alert the Army and NRC reviewers to unusually
11 slow uranium partitioning in the soil and groundwater at JPG. If unusually slow equilibrium is
12 observed, its effects can be conservatively accounted for by using a lower Kd value or values to
13 represent uranium transport, which would accelerate predicted contaminant arrival but would
14 not affect predicted peak uranium concentrations.

15 **Q.15 Please describe the third specific concern described in Basis "J" and your**
16 **conclusions about this concern.**

17 A.15 Basis "J" also raised the concern that Kd values should not be used because
18 there are an "infinite number" of Kd values relevant to the site because of natural variation in soil
19 types, soil chemistries, and groundwater chemistries that a uranium atom could encounter along
20 its flow path. I do not dispute that there are essentially an infinite number of applicable Kd
21 values that may exist along the flow path from any individual point. However, a range of
22 representative Kd values can be developed from the site-specific data the Army indicates it will
23 collect. The soil and subsurface chemical conditions at natural sites typically are
24 heterogeneous. To evaluate the potential importance of heterogeneity to radionuclide transport,
25 a licensee should collect soil samples from various locations at the site, and measure sorption

1 with groundwater taken from the site, to determine whether sorption is significantly different in
2 different locations; this is precisely what the Army proposes to do in the FSP. If the experiments
3 show that different locations have significantly different sorption characteristics, different Kd
4 values can be used to model different areas at the site, or the effects of variability can be
5 bounded with a conservative choice of Kd values. Thus the use of Kd values to model sorption
6 does not preclude modeling of subsurface heterogeneity.

7 In addition, there would not likely be any harm from modeling an “infinite number” of Kd
8 values with a range of Kd values or a bounding Kd value. In general, modeling radionuclide
9 transport with a single value instead of a range of values tends to increase the predicted peak of
10 the mean dose, because radionuclides are predicted to arrive at a potential receptor location at
11 the same time, instead of experiencing increased dispersion due to variations in sorption. Thus,
12 the potential dose predicted by a model using a single Kd value or a small range of Kd values is
13 expected to be larger than the actual dose at a potential receptor location.

14 **Q.16 Were there other concerns raised in Basis “J”? If so, what are your**
15 **conclusions about those concerns?**

16 A.16 Yes, Basis “J” also states that the U.S. Environmental Protection Agency (EPA)
17 recently completed five years of work to find an alternative way to model contaminant transport
18 in the context of solid waste disposal because “Kds just do not work”. Because STV did not
19 supply a specific reference to this work, it is unclear what recent EPA work STV refers to.
20 However, a comprehensive EPA report on the use of Kd values to model contaminant transport
21 (EPA, 1999) emphasized that generic literature values of Kd and Kd values derived from models
22 alone can be unreliable, and that much better predictions can be made if Kds are based on
23 sorption measurements performed with samples of soil and water from the site. In its FSP, the
24 Army indicates it intends to perform exactly this type of site-specific sorption measurement.

25 **Q.17 Please provide a comparison of the alternative method proposed by the**

1 **intervenor in Basis “J” with the Kd approach.**

2 A.17 STV suggests that instead of using Kd values, the Army should calibrate a
3 geochemical model of sorption with field observations. I infer, although STV does not state, that
4 STV would recommend that that the calibrated geochemical model then be used as the basis of
5 uranium transport calculations. Based on STV’s description that the model should be calibrated
6 with “field observations”, it is unclear whether STV intends for the geochemical model to be
7 based on measured abundance of various soil components and thermodynamic complexation
8 constants found in the literature (typically called a “component additivity” model) or whether STV
9 intends for a geochemical model to be calibrated with site-specific sorption measurements
10 (typically referred to as a “generalized composite” model). In general, component additivity
11 models are likely to introduce greater uncertainty into the transport calculations than models
12 based on measured site-specific Kd values because (1) it is not possible to completely
13 characterize soil minerals that may affect contaminant sorption, (2) naturally-occurring minerals
14 are likely to have complexation constants that differ from the complexation constants of pure
15 mineral phases found in the literature, and (3) the underlying assumption that sorption due to
16 various mineral phases can be summed may not be correct (NEA, 2001). Because generalized
17 composite models are calibrated with sorption measurements, they typically produce more
18 accurate predictions of radionuclide sorption than component additivity models (NEA, 2001).
19 Sorption measurements used to calibrate a generalized composite model are likely to be
20 performed according to a method similar to ASTM method D4319-93, which the Army proposes
21 to use to measure site-specific Kd values. Thus, a generalized composite model and a Kd
22 model are likely to predict similar extents of sorption at JPG.

23 The geochemical approach STV describes may be particularly useful at sites with
24 chemical conditions that change significantly as a function of plume movement. For example,
25 this process can be used to model radionuclide transport in a contaminant plume that alters the

1 groundwater pH, so that chemical conditions at the site change as the plume moves (see, e.g.,
2 NRC, 2003). At a site at which the chemical conditions the contaminant encounters do not
3 change significantly as the plume moves, similar results can be obtained by using a Kd value or
4 range of Kd values that are based on site-specific data. Because there is no reason to believe
5 that there is a plume of contaminants that are likely to alter uranium sorption at JPG (e.g.,
6 contaminants that would change the pH, Eh, or carbonate concentration in groundwater), it
7 seems likely that a model based on site-specific Kd values will produce results similar to the
8 results of a geochemical model calibrated to site-specific sorption measurements.

9 Because limitations of the Kd approach typically can be mitigated by using different Kd
10 values to represent sorption under different conditions or by using a conservative Kd value or
11 range of values, NRC recommends using the Kd approach in its guidance for license
12 termination (NRC, 2006). The method the Army proposes to use to measure site-specific Kd
13 values, ASTM D4319-93, is one of the methods NRC recommends in its license termination
14 guidance (NRC, 2006).

15 **Q.18 Please state Basis "Q".**

16 A.18 I have included Basis "Q" in single space below.

17 In its January 3, 2006 Reply, STV accepted the representation in
18 the Army's Response that DU dissolution rates would be
19 calculated in multiple soil types, so this part of this Basis is
20 withdrawn. However, DU dissolution rates should also be
21 calculated under different site-specific wetness and temperature
22 regimes in order to measure accurately DU dissolution at JPG.
23 Thus, Table 4-1 and related text of the FSP are inadequate
24 because they do not specify such multiple measurements. A
25 recently published study of DU samples taken at Aberdeen
26 Proving Ground demonstrates that some oxides of U are indeed
27 relatively insoluble, and that U(VI) sorbs efficiently to soil.
28 However, other U oxides are water soluble, and will wash out and
29 through the soil. And, as clearly pointed out in this paper, U is not
30 static in the environment, it changes valence state and interacts
31 with other elements variably over time and space, given other
32 changing parameters like moisture, soil content, and pH. See W.
33 Dong, et al., *Sorption and Bioreduction of Hexavalent Uranium at*

1 *a Military Facility by the Chesapeake Bay, Environmental Pollution*
2 (2006), 132-142, esp. at 142.
3

4 **Q.19 Do you agree with Basis “Q” that the FSP fails to specify that the**
5 **Army will calculate DU dissolution rates relevant to different specific moisture**
6 **levels and temperatures? If not, please describe your analysis and state your**
7 **conclusion for Basis “Q”.**

8 A.19 No, I do not agree that the FSP fails to specify that the Army will calculate DU
9 dissolution rates relevant to different specific moisture levels and temperatures.

10 Table 4-1 indicates that the Army plans to perform two different types of activities to
11 establish a dissolution rate for penetrators subject to the environmental conditions specific to
12 JPG. The first activity is to study penetrators taken from various locations on the site. By
13 collecting penetrators at various locations and depths (as specified in Sections 6.7.2 and 6.8.1
14 of the FSP), the Army will collect penetrators that have been in contact with the primary soil
15 types present at JPG, and have been subject to the moisture levels and temperatures relevant
16 to the site. The Army indicated it would characterize the mineral phases formed during
17 corrosion using X-ray diffraction (XRD) and may also use optical microscopy and scanning
18 electron microscopy with energy-dispersive X-ray analysis to support characterization of the
19 corrosion products. Identification of the phases present in the corrosion products could support
20 estimates of the solubility of the corrosion products. If XRD measurements can provide clear
21 identification of the mineral phases present in the corrosion products, supplementary analyses
22 with optical microscopy or scanning electron microscopy with energy dispersive X-ray analysis
23 may not be necessary. The Army also indicated it may use X-ray photoelectron spectroscopy
24 (XPS) to determine the average uranium valence state in the corrosion products. XPS analysis
25 could be used to support a conclusion that uranium is present in a reduced form (e.g., U(IV)). If
26 the Army does not base its prediction of uranium dissolution or mobility on an assumption that

1 uranium is present in a reduced form, XPS analysis may not be necessary.

2 The second activity the Army has indicated it will perform to support estimates of
3 penetrator dissolution and corrosion rates is to complete laboratory tests designed to measure
4 penetrator corrosion and dissolution under different environmental conditions. In the FSP, the
5 Army indicated that it would perform leaching tests using the ANS/ANSI-16.1 protocol on
6 penetrators recovered from the site. The Army indicated that it would perform these tests both
7 on a penetrator coated with a site-formed corrosion rind and a penetrator from which the
8 corrosion products have been removed. Because the Army proposes to use a leachant
9 designed to simulate site groundwater, these tests should provide estimates of the rate at which
10 uranium is released from penetrators when they are submerged in groundwater at the site. The
11 Army also indicated that it would subject new penetrators to controlled environmental conditions
12 to measure their dissolution rate and to compare this dissolution rate to the rate measured with
13 the tests performed according to ANS/ANSI-16.1. During these tests, the Army could control
14 the temperature, humidity, and other environmental conditions the penetrators are subject to.

15 STV specifically cited a study (Dong, 2006) in which researchers measured uranium
16 partitioning onto natural organic matter in soil samples taken from the Aberdeen Proving Ground
17 and isolated bacterial populations responsible for uranium reduction in the soil samples. STV
18 stated that the study demonstrated that uranium is not static in the environment, but changes
19 valence state and changes how it interacts with other elements based on spatial and temporal
20 variation in parameters such as moisture, soil content, and pH. STV's conclusion is correct that
21 uranium may change valence state and chemical properties based on site-specific conditions.
22 However, the multiple measurements described in the FSP should enable the Army to account
23 for the variation. By collecting penetrators from multiple locations and depths and
24 characterizing the phases of uranium present on the surface of the penetrators as described in
25 its FSP, the Army should be able to determine what mineral phases govern penetrator corrosion

1 and dissolution under the environmental conditions relevant to JPG.

2 **Q.20 Did you read the testimony of Charles H. Norris, and, if so, what are your**
3 **conclusions about the testimony?**

4 A.20 Yes, I read the testimony of Charles H. Norris. The testimony did not appear to
5 address Basis "J" or "Q" directly, and did not address the use of a Kd approach to model
6 uranium transport or the corrosion or solubility of DU penetrators. However, Mr. Norris did
7 make several statements about chemical effects on uranium transport and the characterization
8 of site chemistry necessary to model uranium transport that I would like to address.

9 At A.016, Mr. Norris states that "Transport of dissolved DU is independent of water
10 velocity". This statement is incorrect because dissolved uranium moves at the same velocity as
11 the water it is dissolved in. Dissolved uranium may stop moving with the water when it adsorbs
12 to soil particles or precipitates, at which point it would cease to be dissolved.

13 At A.019, Mr. Norris states that meaningful fate and transport modeling requires
14 measurement of chemical parameters that control uranium mobility at places and times
15 sufficient to establish spatial and temporal variability along each critical groundwater path. In
16 general, I agree that it is important to understand the variability of chemical conditions in the
17 area in which DU may be transported. As described in Section 6.2 of the FSP, the Army plans
18 to measure water pH, dissolved oxygen, conductivity, and temperature of water samples from
19 several locations on the site. However, the necessary amount of characterization of variability
20 depends on the assumptions made in the performance assessment model used to support a
21 decommissioning decision. For example, Basis "J" correctly indicates that uranium transport is
22 sensitive to redox conditions (often quantified as Eh). Oxidized uranium (U(VI)) is more mobile
23 than reduced uranium (U(IV)). If the Army takes credit for reduction of uranium to limit modeled
24 uranium transport, relatively detailed characterization of redox conditions would be needed to
25 support the Army's assumptions about where and for how long uranium would be present as

1 U(IV). However, if the Army assumed that all of the uranium is present in the more mobile U(VI)
2 form, less characterization of redox conditions would be needed because the assumption would
3 maximize predicted offsite concentrations of uranium (i.e., the assumption would be
4 conservative).

5 Similarly, at A.072, Mr. Norris states that “the characterization objective of the FSP is to
6 provide valid, site-specific data that allow a fate and transport model, whether RESRAD or some
7 alternative program, to realistically and reliably predict the future movement and concentrations
8 of DU at places removed from the sampling locations for the purposes of estimating dose
9 exposures.” I disagree with Mr. Norris’s statement and instead believe that the goal of the
10 program is to provide valid, site-specific data to support a decision as to whether the site can be
11 safely decommissioned. As such, the characterization does not necessarily need to support a
12 realistic model of contaminant fate and transport if it can support a model that conservatively
13 bounds the potential doses to a hypothetical offsite receptor.

14 **Q.21 Did you read the testimony of Dr. Diane S. Henshel, and, if so, what are**
15 **your conclusions about the testimony?**

16 A.21 Yes, I read the testimony of Dr. Diane Henshel. The testimony did not appear to
17 address Basis “J” or Basis “Q”.

18 **Q.22 Can you form an overall conclusion as to Bases “J” and “Q”?**

19 A.22 Yes, based on my experience and education and as supported by my analysis
20 above, I conclude that the STV Bases “J” and “Q” do not support Contention B-1 that:

21 As filed, the FSP is not properly designed to obtain all of the
22 verifiable data required for reliable dose modeling and accurate
23 assessment of the effects on exposure pathways of
24 meteorological, geological, hydrological, animal, and human
25 features specific to the JPG site and its surrounding area.

26
27 Rather, the FSP is designed to address the concerns that STV raised in Bases “J” and “Q”, and
28 it will lead to the collection of reliable, site-specific modeling data regarding the issues raised in

1 Bases "J" and "Q", and the data are necessary to the development of a decommissioning plan.

2 **Q. 23 Would a member of the public who consumes meat from deer taken from**
3 **JPG be expected to receive a significant radiological dose from uranium in the deer**
4 **meat? Specifically, does consumption of meat from deer at JPG pose a radiological**
5 **health risk to humans from DU?**

6 A. 23 No, the level of uranium measured in deer sampled from JPG would not cause a
7 significant radiological dose to an individual who consumes deer taken from JPG. Therefore,
8 consumption of meat from deer at JPG is not expected to pose a radiological health risk to
9 humans from DU. I base this conclusion on a simple conservative calculation of the dose an
10 individual would receive from consuming 48.64 kilograms per year (107.2 pounds per year) of
11 deer meat that has a uranium concentration of 0.000759 Becquerels per gram (0.0205
12 picoCuries per gram). This assumed consumption rate represents the sum of the median
13 annual consumption of beef and the median annual consumption of chicken in the United States
14 (NRC, 1999). I believe this consumption rate to be a conservative overestimate of the amount
15 of deer meat an individual would consume in a year. The uranium concentration used in the
16 calculation also is conservative because it represents the maximum measured concentration of
17 uranium detected in the muscle of deer collected from the site (SAIC, 2006).

18 I multiplied the assumed deer meat consumption rate by the assumed uranium
19 concentration in deer meat to find the annual uranium consumption. Although the uranium in
20 the deer is believed to be naturally-occurring uranium, to bound the effects of the depleted
21 uranium I assumed all of the uranium in the deer was due to deer uptake of depleted uranium.
22 Based on this assumption, I calculated the annual consumption of U-238, U-235, and U-234 by
23 multiplying the annual uranium consumption by the activity fraction of each isotope in depleted
24 uranium.

25 To convert the annual consumption into an annual dose, I used the dose conversion

1 factors for ingestion provided in the EPA's guidance document, *Limiting Values of Radionuclide*
2 *Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and*
3 *Ingestion* (EPA, 1989). To account for the contribution of short-lived progeny that are expected
4 to be in secular equilibrium with the uranium isotopes, I added their dose conversion factors to
5 the appropriate parent's dose conversion factor. For each radionuclide, I used the more
6 conservative of the two dose conversion factors provided in the EPA guidance. I then summed
7 the dose from each uranium isotope (including the contribution of its short-lived progeny in
8 secular equilibrium) to find the committed effective dose equivalent of 0.0027 millisieverts per
9 year (0.27 millirem per year). This dose is well below the NRC's decommissioning criteria of
10 0.25 millisieverts per year (25 millirem per year) and is not believed to have a significant effect
11 on human health. Therefore, I conclude that consumption of meat from deer at JPG is not
12 expected to pose a radiological health risk to humans from DU.

A. Christianne Ridge

- Education
- Ph.D., Environmental Engineering, December, 2004
University of California, Berkeley, College of Engineering
Dissertation: Effect of ferric chloride addition on the removal of copper and zinc complexes with EDTA during municipal wastewater treatment
- M.S., Environmental Engineering, August, 1999
Cornell University, School of Civil and Environmental Engineering
Thesis: Effects of sodium, calcium, and ammonium on the dewaterability of anaerobically digested sludge
- B.A., *Summa Cum Laude*, Physics. May, 1996
Drew University, Department of Physics
Thesis: Properties of indium-phosphide lasers simultaneously doped with zinc and sulfur grown by metal-organic chemical vapor deposition
- Training
- Dose Modeling for License Termination, Aquatic Chemistry, Chemical Kinetics, Environmental Monitoring, environmental modeling codes including RESRAD and FRAMES, chemical modeling codes including MINTEQA2, and GoldSim® simulation software
- Experience
- Systems Performance Analyst, U.S. Nuclear Regulatory Commission (NRC), August 2003 to present
- Lead technical review of the waste determination for two high-level waste tanks at the Department of Energy's (DOE's) Savannah River Site, including review of modeling of degradation of engineered barriers, radionuclide release and transport, and radionuclide uptake in the environment
 - Wrote chapters of NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations (NUREG-1854)
 - Reviewed DOE's waste determination for the disposal of salt waste at DOE's Savannah River Site and contributed sections to NRC's technical evaluation report
- Environmental Engineer, U.S. NRC, May to July 2005 (rotational assignment)
- Wrote *Federal Register* notice to withdraw an advanced notice of proposed rulemaking about radioactive discharges to sanitary sewers
 - Responded to questions from the Argentinean government by writing a summary of NRC and U.S. Environmental Protection Agency regulations about uranium contamination
- Environmental Scientist, U.S. NRC, April to June 2004 (rotational assignment)
- Assessed the utility of incorporating reactive transport models into probabilistic risk assessments
 - Recommended development of a software program to compare results of two common models of radionuclide transport and provided input into the software development
- Environmental Engineering, U. C. Berkeley. September 1998 to August 2004
- Developed experiments to study the role of metal complexation in metal

- removal from wastewater by engineered wastewater treatment facilities
- Used atomic absorption spectrometry, high pressure liquid chromatography, and chelating resin competitive ligand equilibrium techniques to study metal speciation in wastewater
- Used a chemical equilibrium model to provide a theoretical explanation of laboratory results

Environmental Engineering, Cornell University. September 1996 to August 1998

- Designed and implemented study to investigate effects of cations on physical characteristics of wastewater sludge
- Used atomic absorption spectrometry to evaluate cation concentrations in sludge filtrate. Used sludge dewaterability measurements, including resistance to filtration and capillary suction time, to characterize sludge samples

Industrial Pollution Prevention, Bell Laboratories, Lucent Technologies, 1996

- Performed experiments to evaluate electrochemical degradation of perfluorocompounds
- Implemented system to characterize effluent of experimental silicon chip manufacturing process

Semiconductor Physics, Bell Laboratories, Lucent Technologies, 1995-1996

- Evaluated the potential to control interstitial zinc movement in semiconductor lasers grown by metal-organic chemical vapor deposition by simultaneous doping with sulfur

Honors & Affiliations NRC Performance Awards in 2006, 2005, and 2004, Bell Laboratories Graduate Research Fellowship, Drew Scholars Full Tuition Scholarship, IBM Undergraduate Scholarship, Election to Phi Beta Kappa

Selected Publications:

Ridge, A.C., Ghosh, S.T., Pinkston, K.E., Esh, D.W., (2006) "Using the SPARC Method to Extract Risk Insights from a Performance Assessment for Review of a Near-Surface Disposal Facility for Radioactive Waste" Society For Risk Analysis, Annual Meeting, Baltimore, Maryland, December 3-6, 2006.

Esh, D.W., Ridge, A.C., Thaggard, M. (2006) "Development of Risk Insights for Regulatory Review of a Near-surface Disposal Facility for Radioactive Waste" Waste Management, Tucson, Arizona, February 26-March 2, 2006.

Ridge, A.C., Cady, R.E., O'Donnell, E., Randall, J.D., Reed, P.R., Veblen, L.A. (2005) "Use of Thermodynamic Sorption Models in Reactive Transport Modeling: Advantages for U.S. Nuclear Regulatory Commission Licensees and Staff and Areas of Research" Waste Management, Tucson, Arizona, February 27-March 3, 2005.

Ridge, A.C. and Sedlak D.L., (2004) "Effect of Ferric Chloride Addition on the Removal of Cu and Zn Complexes with EDTA During Municipal Wastewater Treatment" *Water Research*, Vol. 38, Issue 4, Pages 921-932.