M-32

**Department of Energy**
Ohio Field Office
West Valley Demonstration Project
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December 27, 1999

Mr. Larry W. Camper
Chief Decommissioning Branch
Division of Waste Management
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
TWFN, 8 F28, 8 F5
Washington, DC 20555-0001

SUBJECT: Response to Nuclear Regulatory Commission (NRC) Comments on the Use of SIBERIA for West Valley Erosion Modeling

REFERENCES:
1) Letter (66922), L. W. Camper to B. A. Mazurowski, "The U.S. Nuclear Regulatory Commission (NRC) Contractors at the Center for Nuclear Waste Regulatory Analysis (CNWRA) Have Completed their Review of the Report entitled 'Draft Landscape Evolution Modeling of the Western New York Nuclear Service Center'," dated September 3, 1999

2) Letter DWS:073 - 66637, B. A. Mazurowski to J. T. Greeves, "Nuclear Regulatory Commission (NRC) Publicly Notice Meeting August 12, 1999," dated August 27, 1999

Dear Mr. Camper:

Thank you for your letter of September 3, 1999, (Reference 1) transmitting NRC's comments and recommendations on the DOE and New York State Energy Research and Development Authority (NYSERDA) effort to use SIBERIA to evaluate erosion at the West Valley site over long-time periods. As you are aware, this erosion analysis is being prepared for the Environmental Impact Statement (EIS) and is intended to help the DOE and NYSERDA decision makers in their evaluation of alternatives and selection of the preferred alternative for project completion and site management.

The peer review process that was formally initiated in March 1999, has identified a number of issues, all of which are being addressed to the extent practical. These issues include erosion calculation methods, comparison of SIBERIA results to results from other calculational methods, the effect of large storms, uncertainty associated with long-term predictions, and use of the results.

NMSS01 Public

The issues, including the major issues raised in your September 3, 1999, letter are summarized in Attachment A. The attachment presents the planned approach for addressing these issues in the EIS.

DOE and NYSERDA plan to complete the additional analyses indicated in the enclosed Issues in Erosion Modeling, including the analysis of the effects of large storms and sensitivity analysis. The results will be documented in the EIS along with assessments of the realism or conservatism of the analysis and conclusions that are considered appropriate will be presented. Drafts of this material will be provided to NRC staff for review, consistent with the NRC's role as a cooperating agency. NRC's review of draft material is considered consistent with NRC's stated role of providing consultation rather than approval on the EIS technical work (Reference 2).

I look forward to working with the NRC to address any comments on the detailed information and analysis in the Draft EIS.

I am available to discuss further any of the above mentioned topics. I can be reached at (716) 942-4016.

Sincerely,

for DWS

Daniel Sullivan, EIS Project Manager
West Valley Demonstration Project

Enclosure: Issues in Erosion Modeling

cc: R. Pilon, U.S. Army Corp of Engineers, w/enc.
P. L. Piciulo, NYSERDA, WV-17, w/enc.

DWS:081 - 68997 - 451.5.2e

DWS/sdm

# ISSUES IN EROSION MODELING

A peer review of the use of the SIBERIA landscape evolution model for evaluation of long-term erosion impacts at the West Valley site has begun and is continuing. This peer review has identified issues related to need for long-term erosion modeling evaluations, methods used in such evaluations and use of the results of the erosion modeling. This paper summarizes the major issues identified in the peer review, responds to the issue and summarizes plans for revision of the EIS related to the identified issues.

ISSUE 1: No model can accurately predict actual erosion for 1,000- or 10,000-year timeframes.

PROPOSED RESOLUTION:

This observation is correct because the inability to fully characterize initial conditions, to accurately predict the order of occurrence and severity of natural events, to fully understand all physical processes contributing to erosion and to predict the role of outside influences on the natural system preclude exact prediction of rates of erosion or of the impacts of erosion. However, guidance developed under NEPA directs that if information essential to reasoned choice among alternatives is missing and not readily obtained, the agency should include an evaluation of such impacts based on theoretical approaches or research methods (CEQ, 1986). The evaluation should include an acknowledgment of missing information and limitations and a statement of the relevance of the missing information.

Because erosion is an important consideration in development and analysis of alternatives for management and closure of the West Valley site, use of landform evolution modeling is consistent with guidance on evaluation of environmental impacts. Following CEQ guidance, this analysis is based on credible scientific evidence and is intended to aid in reaching informed decisions. The proposed use of the SIBERIA is consistent with the spirit of this guidance. The results are not intended as high confidence predictions. Rather, the results represent a range of long-term predictions that are based on a range of estimates of local erosion rates. Development of the site model, selection of input data and interpretation of analytical results involve use of engineering judgment. Sensitivity analysis will be used to investigate the range of landscape conditions that may occur at the West Valley site in the distant future. In order to facilitate interpretation of the results of the analysis, description of the analysis will include a discussion of the limitations of the analysis and of use of the results.

REFERENCE

Council on Environmental Quality (CEQ), 40 CFR Part 1500-1508: Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act, CEQ, Washington, DC, July 1, 1986

ISSUE 2:

It is not clear that the averaging approach used in SIBERIA is adequate to represent the effects of storms of all magnitudes. Most erosion occurs in extreme events.

PROPOSED RESOLUTION:

Erosion rates estimated by the SIBERIA model are derived from time-averaged sediment balances formulated over a rectangular grid. A set of time-averaged equations may be derived from sediment balances formulated for discrete events of given magnitude which are then summed over all events of that magnitude and integrated over all magnitudes. The time-averaged equations derived by this summation and integration procedure are the same as those used by SIBERIA. This shows that a properly calibrated time-averaged approach is compatible with analysis of individual storm events.

These derived time-averaged equations are used in conjunction with site-specific rainfall predictions to demonstrate the consistency of SIBERIA predictions with the expectation that a disproportionate amount of erosion is caused by infrequent, large storms. Because site-specific analysis is available for 24-hour storms the following discussion will be limited to storms of that duration but could be extended to storms of all duration. The following paragraphs present a probabilistic-based derivation of the primary sediment balance used in the SIBERIA model and apply that balance to investigate the relative contribution to erosion of storms of differing magnitude.

DERIVATION

A transient sediment balance for a single storm of given magnitude at a grid block may be expressed as:

$$\frac{dz}{dt} = \left[1/\left(\rho L_g^2\right)\right] Q_{si} \qquad (1)$$

where:

$z$ = elevation (ft),
$t$ = time (yr),
$\rho$ = bulk density of the sediment ($lb/ft^3$),
$L_g$ = length of the grid block (ft), and
$Q_{si}$ = time dependent sediment transport rate for storm of magnitude i, lb/yr.

The equation may be integrated over the duration of the storm to derive:

$$\Delta Z_i = [1/(\rho L_g^2)] \int_0^{t_s} Q_{si}(t)dt \qquad (2)$$

where:

$\Delta z_i$ = change in elevation due to a single storm of magnitude i,
$t_s$ = the length of the storm (yr),

and all other variables are as defined above. The total change in elevation over a period of time, ΔT, is the expected value of the consequences of the occurrence of all numbers of storms of the given magnitude. That is, the total amount of sediment removed due to occurrence of storms of a given magnitude is equal to the sum over all numbers of storms of the products of the number of storms, the probability of occurrence of that number of storms and the amount of sediment removed in a storm of that magnitude. This is expressed as:

$$\Delta Z_{iT} = [1/(\rho L_g^2)] \sum_{n=0}^{\infty} \left\{ [n \Pr(n)] \int_0^{t_s} Q_{si}(t)dt \right\} \qquad (3)$$

where:

$\Delta z_{iT}$ = total erosion due to all storms of magnitude i (ft),
n = number of storms of magnitude i during ΔT, and
Pr(n) = probability of occurrence of n storms of magnitude i.

The summation is taken over the numbers of storms of magnitude i occurring during a time period and all other variables are as described above.

The sediment transport correlation used in SIBERIA presumes that sediment transport is correlated with discharge and slope at each grid block. For the purposes of this derivation, the sediment transport rate will be represented as proportional to the square of discharge and the square of slope:

$$Q_{si} = \beta_1 S_i^2 Q_i^2 \qquad (4)$$

where:

$\beta_1$ = correlation constant $[(lb/yr)/(ft^3/yr)^2]$
$Q_i$ = time dependent discharge of a storm of magnitude i ($ft^3/yr$),
$S_i$ = slope at the point of interest (dimensionless),

This form of the correlation is supported by results of experiments (Willgoose, 1989). Substituting this relation into the sediment balance leads to:

$$\Delta Z_{iT} = [1/(\rho L_g^2)](\beta_1 S^2) \sum_{n=0}^{\infty} \left\{ [n \Pr(n)] \int_0^{t_s} Q_i^2(t)\, dt \right\} \tag{5}$$

where all variables are as defined above. If hydrographs of storms of differing magnitude have the same shape but are scaled by average discharge, the sediment balance may be expressed as:

$$\Delta Z_{iT} = [1/(\rho L_g^2)](\beta_1 S^2 Q_{ai}^2) \sum_{n=0}^{\infty} \left\{ n \Pr(n) \int_0^{t_s} g^2(t) dt \right\} \tag{6}$$

where:

$Q_{ai}$ = average discharge of a storm of magnitude i ($ft^3/yr$),
g(t) = functional form of the storm hydrograph (dimensionless),

and all other variables are as defined above.

If the storms are distributed according to the Poisson distribution the total change in elevation due to occurrence of all storms of magnitude i is:

$$\Delta Z_{iT} = [1/(\rho L_g^2)]\, [\beta_1 S^2 G(t_s)]\, n_i\, Q_{ai}^2 \tag{7}$$

where:

$n_i$ = average number of storms of magnitude i (dimensionless),
$G(t_s)$ = integral of the square of the hydrograph function (dimensionless),

and all other variables are as defined above. The sediment balance derived above is applicable to storms of all magnitude. The total change in elevation due to all storms of all magnitudes, $\Delta z_T$, is obtained by integrating the sediment balance over all storm magnitudes:

$$\Delta z_T = [1/(\rho L_g^2)]\, [\beta_1 S^2 G(t_s) n_T] \int_0^{\infty} \left[ f(Q_{ai}) Q_{ai}^2 \right] dQ_{ai} \tag{8}$$

where:

$n_T$ = average number of storms of all magnitude (dimensionless),
$f(Q_{ai})$ = probability density of discharge (dimensionless),

and all variables are as defined above.

The probability density of storm magnitude is represented as an exponential function of rainfall rate (Eagleson, 1978):

$$f(r) = (1/r_a)e^{-(r/r_a)} \tag{9}$$

where:

| | | |
|---|---|---|
| f(r) | = | probability density of storm magnitude (dimensionless) |
| r | = | rainfall rate (ft/yr), and |
| $r_a$ | = | average rainfall rate (ft/yr) |

If discharge is proportional to rainfall area and rate, the probability density of discharge can be derived from the probability density of rainfall rate and Equation 8 can be expressed as:

$$\Delta Z_T = [1/(\rho L_g^2)]\,[\beta_1 S^2 G(t_s) n_T](f_r A_r r_a)^2 \int_0^\infty x^2 e^{-x}\,dx \tag{10}$$

where:

| | | |
|---|---|---|
| x | = | $Q_{ai}/Q_a$ |
| $Q_a$ | = | $f_r A_r r_a$ |
| $A_r$ | = | rainfall area ($ft^2$) |

and all other variables are as defined above. The quantity $Q_a$ is the average over all discharges of the average discharge due to each storm. The integral appearing in Equation 10 has a constant value of 2 factorial and the total change in elevation may be expressed as:

$$\Delta Z_T = \left[2/\left(\rho L_g^2\right)\right]\left[\beta_1 G(t_s) n_T\right] S^2 Q_a^2 \tag{11}$$

This equation for over-all change in elevation is the form used in the SIBERIA model. In addition, for an exponential distribution of storm magnitudes, the annual average rainfall rate is proportional to the average over all storm rainfall rates. Thus, the SIBERIA model for the West Valley site can be calibrated against the available average annual rainfall rate data. The above derivation demonstrates that use of averaged flow parameters can provide a correct representation of the effect of a set of storms of variable magnitude and frequency of occurrence.

## APPLICATION

The relative contribution of storms of differing magnitude can be evaluated using site-specific information if Equation 10 is expressed in terms of rainfall rate as:

$$\Delta Z_T = \left[1/\left(\rho L_g^2\right)\right]\left[\beta_i S^2 G(t_s) n_T\right]\left(f_r A_r r_a\right)^2 \int_0^R \left(r/r_a\right)^2 e^{-(r/r_a)} d\left(r/r_a\right) \qquad (12)$$

where R is the rainfall rate for the storm magnitude and return period of interest.

Site-specific estimated rainfall rates for 24-hour storms having 2-, 10- and 100-year return periods are 0.26, 0.39 and 0.55 cm/hr, respectively (WVNS, 1993) and the site-specific values of $n_T$ and $r_a$ consistent with these estimates are 20 storms per year and 0.074 cm/hr respectively.

Using these estimates, Equation 12 may be evaluated for storms having magnitude less than a given value and for storms of all magnitudes. The results of this calculation are presented in Table 1.

**Table 1. Dependence of Erosion Rate on Storm Magnitude**

| Return Period (yr) | Rainfall Per Storm (cm) | Fraction of Storms Having Lower Rainfall | Fraction of Total Annual Rainfall | Fraction of Total Annual Sediment Removal |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0.25 | 2.82 | 0.80 | 0.48 | 0.22 |
| 0.5 | 4.03 | 0.90 | 0.67 | 0.41 |
| 1 | 5.24 | 0.95 | 0.80 | 0.58 |
| 2 | 6.45 | 0.98 | 0.88 | 0.71 |
| 5 | 8.05 | 0.99 | 0.94 | 0.84 |
| 10 | 9.26 | 0.995 | 0.97 | 0.90 |
| 100 | 13.3 | 0.9995 | 0.996 | 0.98 |

The above results, developed using the SIBERIA sediment balance and site-specific estimates of storm magnitude, indicate that storms having return period of less than 1 year account for 95 per cent of all storms and 80 per cent of annual rainfall but account for only 58 per cent of total erosion. The 5 per cent of storms having return period greater than 1 year account for 20 percent of annual rainfall and 42 per cent of the total erosion. Thus, this West Valley site-specific analysis is consistent with the general expectation that storms of large magnitude and long return period account for a disproportionately large fraction of erosion. It should be noted that recent research (Baffaut, Nearing and Govers, 1999) indicates that this expectation of the dominant role of long return period storms may not be correct in all cases and that factors such as ground cover may play a role in determining this behavior.

The equations derived above also have potential application in calibration and testing the performance of the SIBERIA model. Firstly, the approach may be used to adjust upward a value of $\beta_1$ derived in calibration of the model against data for a period of time that did not include storms of all magnitude. Alternatively, the approach could be used to adjust downward the value of $\beta_1$ to use SIBERIA to investigate the degree of erosion produced by storms less than a given magnitude.

In summary, the above derivation and analysis demonstrates that a time-averaged approach to long-term erosion analysis can represent the effects of a set of discrete storms, and that for conditions specific to the West Valley site the time averaging is consistent with the expectation that long return period storms account for a disproportionately high portion of erosion.

REFERENCES

Baffaut, C., M.A. Nearing and G. Govers, "Statistical Distributions of Soil Loss from Run-off Plots and WEPP Model Simulations" at http://topsoil.nserl.perude.edu/weppmain/nearing/wepp-stat/text.htm

Eagleson, P.S., Water Research, V14, No. 5, pp 713-721, October 1978.

West Valley Nuclear Services (WVNS), Environmental Information Document, Vol. III, Hydrology, Part 3, Erosion and Mass Wasting Process, WVDP-EIS-009, WVNS, West Valley, NY, December 12, 1993.

Willgoose, G.R., A Physically Based Channel Network and Catchment Evolution Model, Ph.D. Thesis, Massachusetts Institute of Technology, Boston, MA, April 1989.

ISSUE 3:

Erosion evaluations should provide explicit consideration of underlying processes, such as stream meandering. How can SIBERIA provide meaningful estimates of long-term erosion without incorporating representation of the underlying physical processes?

PROPOSED RESOLUTION:

Descriptions of transport processes are frequently based on phenomenological approaches that are not explicitly based on underlying mechanisms. Examples include correlation of diffusion transport of mass, momentum or heat with gradient of free energy and correlation of erosion rates with surface slope and storm energy. In fact, recent research indicates that analysis of large-scale systems based entirely on an understanding of underlying fundamental processes does not provide a consistent method for modeling of landform patterns (Werner, 1999). Alternatively, large-scale structure may be independent of motion at small scales. Successful description of large-scale structure depends on modeling selected processes at levels above those occurring at the smallest scales (Goldenfeld and Kadanoff, 1999). SIBERIA takes the approach that useful understanding of the behavior of the complex system on the watershed scale can be obtained without representing all contributing processes at a fundamental level. Presently, the lumped parameter approach represents the state-of-the art in landscape evolution modeling.

Ultimately, the utility of the model is determined by its ability to describe evolution of actual systems. Validation studies of the SIBERIA model have been performed (Hancock et al., 1998) at the watershed scale for long time frames (1,000 years) and the individual gully scale for a medium time frame (50 years). These studies indicated that SIBERIA modeled gully and watershed development at time scales of interest for the West Valley project.

REFERENCES

Goldenfeld,N. and L.P. Kadanoff, Science, V 284, p87-89, April 2, 1999

Hancock, G.R., G.R. Willgoose, J.R.W. Bell, K.G. Evans, D.R. Moliere and M.J. Saynor, Simulation of Tin Camp Creek Natural Landscape, Scinto 6 Post Mining Landscape and Gully Development at the ERA Ranger Mine Using the SIBERIA Landscape Evolution Model, Environmental Research Institute of the Supervising Scientist, Jabiru, Australia, September 1998

Werner, B.T., Science, V 284, pp 102-104, April 2, 1999

ISSUE 4:

How can SIBERIA be verified? Can SIBERIA predictions be verified by comparison with models developed by the U.S. Army Corp of Engineers (USACE) or other code developers?

PROPOSED RESOLUTION:

Calculation of sediment balances for a node network is the major function of the SIBERIA model. This function has been verified using hand calculations and a simplified computer code developed for this purpose. A simple case using a linear series of grid blocks having a single flow direction was used. Agreement of nodal changes in elevation for the hand, simplified computer code and SIBERIA calculations indicated that SIBERIA provides the correct solution to the underlying sediment balances.

The SIBERIA model is designed to estimate rates of erosion using long-term average discharges and is readily used for detailed evaluation of transient, single event cases. Models developed by the USACE, such as HEC-6, provide for detailed evaluation of the response of stream channels to time-dependent storm flows but are limited to one-dimensional analyses. Thus, the SIBERIA and USACE codes are not well suited for mutual verification. The HEC-6 model has been used in the West Valley project in conjunction with statistical analysis to estimate a maximum rate of stream downcutting for a combination of storms of differing magnitude. HEC-6 is useful in this manner to indicate that stream downcutting rates predicted using SIBERIA are within the reasonable range but not to verify all SIBERIA results. This is due in part to the fact that SIBERIA solves a complex, multi-dimensional problem that is not addressed by the HEC-6 model. The approach for future analyses will be to retain HEC-6 modeling results as representative of alternative approaches for predicting stream downcutting. Analysis of the effect of single storms will be modeled using both HEC-6 and SIBERIA. Because the codes use differing representations of the spatial distribution of discharge, comparison of the results is expected to illustrate the capabilities of each code rather than provide benchmarking of the codes.

In addition to SIBERIA, two landscape evolution models have been recently developed. First, the GOLEM model was developed as a research tool to simulate landscape evolution on a regional scale. Second, the CHILD model (sponsored by the USACE) was developed as a research tool to investigate landscape evolution on scales similar to that modeled with SIBERIA. However, the CHILD and GOLEM models are in the research phase and have not been extensively tested. The technical approach used in the CHILD and GOLEM models is similar to that used in the SIBERIA model and use of the CHILD or GOLEM codes would not resolve the fundamental issues of accuracy of erosion predictions over long time frames that has been raised in review of SIBERIA analyses.

ISSUE 5:

Limitations of erosion modeling must be discussed.

PROPOSED RESOLUTION:

Limitations of long-term erosion modeling will be discussed in the EIS. The proposed approach is to add introductory text related to modeling erosion processes prior to specific discussion of use of the SIBERIA model and to insert text in the description of SIBERIA where the particular issues arise. Assumptions will be noted with each calculational result and degree of conservatism will be discussed. The text will be used in conjunction with the text developed in response to Issue 1. Proposed material includes but is not limited to the following text.

Environmental protection regulations and potentially applicable guidance direct that impacts of disposal of radioactive waste be evaluated for long periods of time.

Assessment of degree of erosion involves description of processes that occur both at small and large spatial scales and over short and long intervals of time. The need to consider processes that occur over a wide range of scales introduces limitations in availability of data, in accuracy obtainable with practical computational techniques and in the conceptual approach used to describe behavior of the natural system. These three types of limitation are sources of the uncertainty associated with the results of erosion modeling as discussed in the following three paragraphs.

Limitations related to the availability of data include inability to 1) know the prior topography and the sequence of meteorological and erosional events that led to the present configuration of the system, 2) specify exactly the current state of the system and 3) accurately measure changes in the system and relate these changes to observable causes. Inability to know the sequence of events leading to the current configuration of the system has implications for validation of erosion models. Validation in this sense means demonstrating that the model accurately predicts erosion rates and future topography given a set of initial conditions and sequence of storms. Because landforms evolve slowly, the length of the time frame important for erosional processes relative to human activities precludes accurate knowledge of prior conditions and causative events and thereby limits the degree of validation possible. The problem of specification of current conditions for initialization of a model involves measurement of natural conditions such as ground elevations. Potential ranges of error for available measurements are frequently on the order of magnitude of changes occurring over decades of time during which conditions have been observed. Thus, there is an unavoidable uncertainty in specification of initial conditions that may effect model predictions. Inability to measure with precision changes in a natural system and to correlate these changes with observable causes introduces limitations in calibration of erosion models. Considerations discussed above in relation to validation also apply to calibration of erosion models. In addition to those considerations, representation of natural systems often involves use of empirically based correlations that relate rates of transport to driving forces. Natural variability both in the driving forces and in the conditions affecting transport rate precludes precise calibration of the correlations to measured conditions and thereby limits the reliability of the erosion model.

Limitations in accuracy obtainable with practical computational techniques are related to the large time and space scales and the non-linear nature of natural processes. Evaluation of erosion processes for long time and space scales involves storage and manipulation of large blocks of data. The large size of these data blocks may preclude storage of conditions for all points in space and time. Solution of non-linear equations for a large number of points in space and time implies long time for completion of calculations.

Limitations in the conceptual approach used to describe natural systems are related to the range of spatial and temporal scales over which erosion processes occur and the available computational power. For example, fluid dynamic and sediment transport processes contributing to sheet and rill erosion act at scales of fractions of a meter and may show sensitive dependence on initial conditions. Mathematical description of the sheet and rill process at this scale in a kilometer-scale model is both impractical and unlikely to provide a basis for realistic predictions at the larger scale. Thus, erosion modeling at the watershed scale requires judicious choice of features comprising the model and is limited in the range of spatial scales that may be explicitly considered. Statistical techniques are frequently used to generate time series representing the variability in rainfall expected over a period of time. Long-time frame erosion models incorporating this approach are currently not available due to computational constraints.

ISSUE 6:

How can the SIBERIA model be calibrated?

PROPOSED RESOLUTION:

Calibration of the SIBERIA model is best accomplished using paired measurements of rates of precipitation and erosion. Data of this type are not available for West Valley site. Thus, surrogate methods involving use of alternate models that estimate local rates of erosion over differing periods of time are applied in the calibration process. Available estimates of erosion at the West Valley site are those developed for an 1165 acre-portion of site using the USLE and for a 5.5-acre portion of the site using CREAMS. The USLE method is intended to provide estimates of long-term erosion rates while the CREAMS model estimated erosion rate for a single year. These estimates of local rates of erosion incorporate consideration of both long-term variability in climate (USLE) and seasonal changes in precipitation and temperature (USLE and CREAMS). The dependence of predictions of the SIBERIA model on the value of the sediment transport parameter established in calibration with the estimates of local erosion rates will be investigated in sensitivity analyses. The applicability of the WEPP model for calibration of SIBERIA is under evaluation and WEPP analyses will be used if possible.

A limited amount of site-specific data is available for quantification of creek bank erosion rates. Available data include cross-section profiles for 20 locations along Quarry Creek, Erdmann Brook and Frank's Creek for a 30-year period (WVNS, 1993a). These data show some downcutting for a portion of the cross-sections, no erosion for a second set of cross-sections and transverse movement for a third set of the cross-sections. In general, the observed results are within the range of experimental error for the determinations. Thus, these data do not provide an adequate basis for calibration of a landform evolution model for the West Valley site. Measurements of the longitudinal profile of Frank's Creek over a ten-year interval (WVNS, 1993b) were not performed with the accuracy required for calibration of the model.

REFERENCES

West Valley Nuclear Services (WVNS, 1993a), Environmental Information Document, Volume III, Hydrology, Part 3 of 5, Erosion and Mass Wasting Processes, WVDP-EIS-009, WVNS, West Valley, NY, February 12, 1993

West Valley Nuclear Services (WVNS, 1993b), Environmental Information Document, Volume III, Hydrology, Part 1, Geomorphology of Stream Valleys, WVDP-EIS-009, WVNS, West Valley, NY, January 29, 1993

ISSUE 7:

The analysis does not explicitly consider the effect of large storms. A single large storm may change topography in a manner that accelerates future erosion.

PROPOSED RESOLUTION:

Test runs indicate that SIBERIA can simulate the effects of single large storms such as that producing the probable maximum precipitation (PMP). Future analyses will include simulation of single large storms producing high discharge over a short period of time in combination with simulation of storms of all magnitude represented by averaged discharge occurring over a long period of time. In order to incorporate probabilistic considerations to the extent possible, two sets of simulations are planned.

The first set of runs will investigate the impacts of a single large storm, the PMP, occurring at selected times in a 10,000-year period. The second set of runs will investigate the impacts of multiple large storms with 100-year return periods occurring at randomly selected times in a 1,000-year period. The value of $\beta_1$ used for estimation of the long-term average sediment transport rate will be adjusted downward from the base case value to reflect the independent consideration of storms of large magnitude. The approach discussed in the proposed resolution of Issue 2 will be used for this adjustment. Rates of erosion predicted for cases involving single large storms will be compared with rates of erosion predicted for the base case.

ISSUE 8:

Uncertainty and sensitivity analyses should be performed.

PROPOSED RESOLUTION:

For the purposes of this discussion, uncertainty is taken to mean imprecision in SIBERIA prediction of the configuration of the West Valley site landscape in the distant future. This uncertainty derives from incomplete knowledge, inexact information, and spatial and temporal variability. The incomplete knowledge includes limitation in understanding types, rates and interaction of physical processes and of the types of models appropriate for analysis of complex systems over long time frames. In the SIBERIA model, a key parameter is the constant of proportionality (designated $\beta_1$) in the correlation used to estimate sediment transport rate for given discharge and slope. As indicated in the proposed resolution to Issue 2, the magnitude of $\beta_1$ reflects contributions of a group of erosion processes, site-specific storm and run-off conditions and averaging over site-specific distribution of storm magnitude. Paired measurements of rates of precipitation and erosion are not available for the West Valley site. In addition, surrogate data developed at other sites are not fully applicable due to differing distributions of precipitation and differing relative rates of the contributing erosion processes. For these reasons, an experimental basis for selection of the distribution of magnitudes of $\beta 1$ is not available for the West Valley site. Thus, a quantitative uncertainty analysis is not defensible. The range of uncertainty will be addressed through qualitative description of the limitations of available data and analytical techniques and through sensitivity analyses intended to identify the range of landscape conditions that are estimated to be credible at the West Valley site in the distant future. Sensitivity analyses will investigate the importance of rate of sediment transport, annual average precipitation, occurrence of single large storms, downcutting rate of Buttermilk Creek, relative erodability of soil types and size of spatial and temporal integration steps.

ISSUE 9:

How are the results of the erosion modeling used?

PROPOSED RESOLUTION:

Environmental regulations governing decommissioning of nuclear facilities require estimates of dose impacts for long periods of time. The set of scenarios developed for estimation of doses at West Valley includes cases in which releases of radioactive material are initiated by erosion of individual facilities. Estimates of the time and rate at which erosion effects individual facilities are uncertain and the uncertainty cannot be quantified by analysis based on empirical data. This is due to the fact that knowledge of past conditions is imprecise, all future conditions are unknown and the dominant mechanisms of erosion are not known with precision. Thus, estimates of dose impacts in scenarios involving erosion require estimation of erosion rates based on mathematical modeling that unavoidably involve uncertainty. For analyses of this type, NEPA guidance directs that impacts be estimated based on best available information and credible scientific evidence and that alternate points of view be acknowledged.

Based on review of the literature and evaluation of available analytical tools, the SIBERIA model has been selected as a reasonable analytical method for estimation of erosion impacts for long time periods in a watershed-scale system. Because of the absence of long-term data on rates of erosion, the model has been calibrated to time-averaged estimates of erosion rate developed using the USLE and CREAMS models. If possible, the WEPP model will also be used to calibrate SIBERIA. The empirical USLE model is designed to average out variability and predict long-term average annual soil loss. The CREAMS and WEPP models provide mechanistic bases that can incorporate actual precipitation data. While this analytic basis is not actual site measurements of erosion rate, it represents the best available basis for calibration of a large-scale erosion model. Calibration of the watershed-scale SIBERIA model against the set of soil loss models provides a measure of the sensitivity of SIBERIA predictions to variation in the available information.

The approach for estimation of dose impacts for erosion scenarios is to estimate a range of possible erosion rates based on the available bases for calibration of SIBERIA and use these rates as input to a dose model. This approach requires interpretation of the SIBERIA predictions to develop a representation of radioactive material release modes that is as realistic and practical as possible.

The DEIS analyses were based on an erosional collapse release mode that was consistent with available erosion rate estimates. This DEIS approach resulted in loss of radioactive material to a creek on a trench section basis. Use of SIBERIA predictions provides for modification of this release mode assumption and allows representation of a release mode comprised of both surface soil loss and stream bank collapse components. SIBERIA predictions show erosion impacts as comprised of contributions from stream downcutting, gully advance and surface soil loss. Elevation contours predicted using SIBERIA are resolved into components contributing to surface loss and stream bank collapse components and the dose model is used to estimate impacts from releases generated by the combined processes. These predictions are developed for both calibration cases.

Dose estimates developed using the approach described above are planned for EIS analyses. Representative results for the case of unmitigated erosion (i.e., with no active erosion control measures) are presented in Figures 1 and 2 for the HLW storage area. The results of Figure 1 show relative doses accumulated over a discrete time period while the results of Figure 2 show relative doses accumulated to the given time. The SIBERIA results indicate that the area of the HLW tanks experiences small surface soil loss but may eventually be affected by gullies advancing southward from the north end of the north plateau. The release mode is of a stream bank collapse nature consistent with the rate of advance of the gully. The gully is predicted to reach the area of the tanks after 10,000 years (see Figure 1). Doses will be presented for the range of SIBERIA calibration cases to indicate the sensitivity of dose predictions to the range of available information.

Whenever such results are presented, the EIS will make the assumptions clear, estimate the degree of conservatism in the calculations and clearly state the conclusions that are appropriate to the analysis.