

RECOMMENDATIONS FOR PHASE 1 EROSION STUDIES

*WEST VALLEY DEMONSTRATION PROJECT (WVDP) AND
WESTERN NEW YORK NUCLEAR SERVICE CENTER (WNYNSC)*



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EXECUTIVE SUMMARY

This document presents the Erosion Working Group's (EWG) recommendations for Phase 1 Studies to address the long-term effects of erosion at the West Valley Demonstration Project (WVDP) and the Western New York Nuclear Service Center (WNYNSC). The studies described herein constitute the EWG's consensus recommendation to the United States Department of Energy (DOE) and New York State Energy Research and Development Authority (NYSERDA) (collectively "agencies"). The recommendations are submitted in satisfaction of the requirements of TASK 1 of the Subject Matter Expert (SME) Scope of Work document (SOW).

As part of its scope under TASK 1, the EWG has evaluated whether further scientific study would facilitate agency consensus. The EWG's assessment is that perceptions of uncertainty associated with long-term projections of the effects of erosion on critical facilities presented in the Final Environmental Impact Statement (FEIS) lie at the root of differences in agency views. Consensus may be achieved if this perceived uncertainty could be better quantified and reduced.

The EWG believes that this goal may be accomplished through additional targeted studies that acknowledge and build on the previous work, rather than simply re-visiting existing data. The recommended studies will be designed to fill key data gaps, and to produce converging lines of evidence that may reduce uncertainty, improve scientific defensibility, and strengthen confidence in long-term erosion projections.

The Phase 1 studies recommended in this document are designed to be synergistic, with each study providing critical components that are parts of a whole. The EWG emphasizes that this holistic approach is envisioned as producing greater value than the sum of the individual parts, and cautions against viewing individual studies as separate entities.

The EWG also recommends that the Channel Hillslope Integrated Landscape Development (CHILD) model used to develop the FEIS projections of future erosion effects on the site be the numerical tool of choice for the recommended studies. Besides being the numerical tool for the FEIS projections, CHILD represents the current state-of-the-art of predictive numerical landscape evolution models and embodies significant advantages and refinements compared with other generally-accepted numerical models.

The recommended studies are:

- **Study 1 - Terrain Analysis**
- **Study 2 - Age Dating and Paleoclimate**
- **Study 3 - Recent Erosion and Deposition Processes**
- **Study 4 - Model Refinement, Validation, and Improved Erosion Projections**

The document discusses the objectives, major components, and rationale for each of these recommended studies. Individual study plans detailing scope, budget, and schedule for each task will be developed under SOW Task 2 - Scoping. The overall schedule objective is to produce results by roughly late 2018, to enable agency decision making by 2020.

In summary, the EWG recommends these studies because together they may improve the scientific defensibility of the assessment of long-term erosion effects based on converging lines of evidence that may reduce uncertainty, strengthen confidence in the results, and facilitate agency consensus.

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ACRONYMS AND ABBREVIATIONS

BP	before present
CHILD	Channel Hillslope Integrated Landscape Development
DOE	United States Department of Energy
ECS	Enviro Compliance Solutions, Inc.
EWG	Erosion Working Group
FEIS	Final Environmental Impact Statement
ISP	Independent Scientific Panel
LEM	landscape evolution modeling
Lidar	light detection and ranging
m	meter(s)
NDA	NRC licensed disposal area
NRC	United States Nuclear Regulatory Commission
NYSERDA	New York State Energy Research and Development Authority
OSL	optically stimulated luminescence
SDA	State licensed disposal area
SME	subject matter expert
SOW	scope of work
U-Pb	uranium-lead
WNYNSC	Western New York Nuclear Service Center
WVDP	West Valley Demonstration Project

1. INTRODUCTION AND BACKGROUND

This document presents the Erosion Working Group's recommendations for Phase 1 Studies to address the long-term effects of erosion at the West Valley Demonstration Project (WVDP) and Western New York Nuclear Service Center (WNYNSC). The studies described herein constitute the EWG's consensus recommendation to the United States Department of Energy (DOE) and New York State Energy Research and Development Authority (NYSERDA) (collectively "agencies"). The recommendations are submitted in satisfaction of the requirements of TASK 1 of the Subject Matter Expert (SME) Scope of Work document (SOW). The SOW TASK 1 scope description is attached for reference as an appendix.

The EWG convened and held its kickoff meeting on February 13, 2012. The EWG has conducted its work pursuant to the SOW. Accordingly, the EWG has reviewed key documents, including the following, as applicable:

- Forward (NYSERDA's View) of the Final Environmental Impact Statement (FEIS) and DOE's responses
- FEIS Executive Summary
- FEIS Appendix D - Overview of Performance Assessment Approach
- FEIS Appendix E - Geohydrological Analysis
- FEIS Appendix F - Erosion Studies
- DOE's Record of Decision
- NYSEDA's Findings Statement
- Phase 1 Studies Guidance
- Independent expert reports (e.g. Bennett 2009¹, IERT 2008²)

As part of its scope under TASK 1, the EWG has evaluated whether further scientific study would facilitate agency consensus. The EWG's assessment is that perceptions of uncertainty associated with long-term predictions of the effects of erosion on critical facilities presented in the FEIS lie at the root of differences in agency views, and that consensus may be achieved if this perceived uncertainty could be better quantified and reduced. This goal could be achieved through additional targeted studies that acknowledge and build on the previous work rather than simply re-visiting existing data. These additional studies would focus on filling key data gaps and better constraining variables associated with the FEIS erosion assessment. The recommended studies described below are designed to make maximum use of the extant data and evaluations, and may enhance the scientific defensibility of long-term erosion projections.

2. RECOMMENDED STUDIES

The EWG recommends performing independent, but complementary, studies designed to produce converging lines of evidence that may reduce uncertainty, improve scientific defensibility, and strengthen confidence in long-term erosion forecasts. The Phase 1 studies recommended in this document are designed to be synergistic, with each study providing critical components that are parts of a whole. The EWG emphasizes that this holistic approach is envisioned as producing greater value than the sum of the individual parts, and cautions against viewing individual studies as separate severable entities.

¹ Bennett, S.J. 2009. Comments to FEIS App. F Erosion Studies, App. G Models for Long-Term Performance Assessment, App. H Long-Term Performance Assessment Results. October 30.

² Garrick et al. 2008. Independent Review of the Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center; prepared by the Independent Expert Review Team. September 23.

The EWG also recommends that the Channel Hillslope Integrated Landscape Development (CHILD) model used to develop the FEIS projections of future erosion effects on the site be the numerical tool of choice for the recommended studies³. Besides being the numerical tool for the FEIS projections, CHILD represents the current state-of-the-art of predictive numerical landscape evolution models and embodies significant advantages and refinements compared with other generally-accepted numerical models.

The recommended studies are titled:

Study 1 - Terrain Analysis

Study 2 - Age Dating and Paleoclimate

Study 3 - Recent Erosion and Deposition Processes

Study 4 - Model Refinement, Validation, and Improved Erosion Projections

The objectives, components, and rationale for each study are discussed below. Individual study plans detailing scope, budget, and schedule for each task will be developed under SOW Task 2 - Scoping. The EWG notes that individual studies may need to be modified as they progress and data are generated.

2.1 STUDY 1 - TERRAIN ANALYSIS

2.1.1 Objective

The objective of Study 1 is to build on the previous work (e.g. LaFleur 1979⁴, Boothroyd et al. 1979⁵, Fakundiny 1985⁶, etc.) cited in the FEIS to better delineate and enhance understanding of the post-glacial geomorphic history of the site and the larger Buttermilk Creek watershed which may enable more confident projections of future erosion processes. In addition this study will provide enhanced context and perspective for calibrating the numerical model, constraining the ranges of numerical model parameters, and performing sensitivity analyses.

³ Tucker, G. E., 2008, *CHILD Users Guide*, Version R8.11, Draft, University of Colorado, Boulder, Colorado, November 18.

⁴ LaFleur, R. G., 1979, *Glacial Geology and Stratigraphy of Western New York Nuclear Service Center and Vicinity, Cattaraugus and Erie Counties, New York*, U.S. Geological Survey, Open File Report 79-989, Albany, New York.

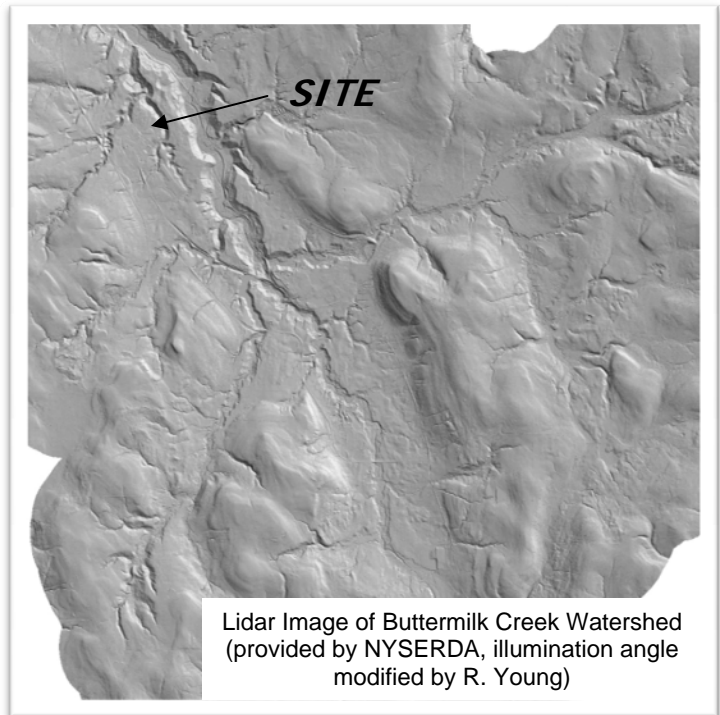
⁵ Boothroyd, J. C., B. S. Timson, and R. H. Dana, Jr., 1979, *Geomorphic and Erosion Studies at the Western New York Nuclear Service Center, West Valley, New York*, NUREG/CR-0795, December.

⁶ Fakundiny, R. H., 1985, "Practical Applications of Geological Methods at the West Valley Low-Level Radioactive Waste Burial Ground, Western New York," *Northeastern Environmental Science*, Vol. 4, Nos. 3/4, p. 116-148.

2.1.2 Components

The components of Study 1 include the following:

- Identify elementary landforms or “land elements” (Evans, 2012)⁷ using Lidar hillshade, slope, and topographic maps in ArcMap (and possibly other spatial analyst tools). (Emphasis on features likely to contain organic or other datable horizons).
- Compare WVDP area with the wider region to identify useful similarities or differences
- Construct geomorphic (land element) maps of key areas (Buttermilk Creek., WVDP site, and potentially a companion basin site such as Connoisarauley Creek or similar, and those of its tributaries that are comparable in dimensions to similar landforms at WVDP).
- Perform field reconnaissance to justify and verify potentials of mapped land elements.
 - Stream terraces and alluvial fans (surfaces, longitudinal profiles, abandoned meanders)
 - Glacial landforms (e.g. kame terraces, moraines, kettles)
 - Landslides (translation of rooted blocks, rotation of masses of widely varying sizes, falls of stiff clay blocks such as large Buttermilk slide of 2009, global slides capable of fragmenting a portion of the facilities such as the Rte 219 (Scoby Hill) landslide; and potential for buried organic debris)
- Evaluate available materials for radiocarbon dating, optically stimulated luminescence (OSL) dating, cosmogenic nuclide analysis, and/or surface exposure age dating
- Build conceptual framework for geomorphic history of Buttermilk Creek and its base level



⁷ Evans, I.S., 2012, Geomorphometry and landform mapping: What is a landform? *Geomorphology*, v. 137, p. 94-106.

- Consider potential low stand of Lake Erie (as for Lake Ontario, see Anderson and Lewis, 2012⁸)
- Consider known glacial/postglacial lake levels (base level impacts)
- Use all of the data collected, in conjunction with existing data, to project erosional and depositional effects within future timeframes.

2.1.3 Rationale

Spatial distribution of landforms that may contain dateable material and can be correlated with known dated features in other basins are needed to constrain three-dimensional and age aspects of the landscape evolution model. The selection of model parameters has to date been based on an imperfect understanding of the post-glacial geomorphic history of the area. Average rates of stream downcutting and valley rim widening have been computed from available age data based on simple assumptions about geomorphic history when, in reality, the geomorphic evolution of the watershed is likely characterized by a more-complicated and possibly episodic sequence of erosion and sedimentation. For example, available data suggest that the rate of stream downcutting has been slowing over time. This may be due in part to a slowing of glacio-isostatic rebound since recession of the Laurentide ice sheet. Enhancing the understanding of the geomorphic history may enable better definition of critical parameters for futurecasting, including numerical simulations of potential future erosion effects on the site, and by so doing, may reduce the uncertainty associated with erosion prediction.

2.2 STUDY 2 - AGE DATING AND PALEOCLIMATE

2.2.1 Objectives

The objectives of Study 2 include the following:

- Provide additional age data at key locations to better define and constrain past rates of stream downcutting and valley rim widening for the site, the Buttermilk Creek watershed, and potential companion drainages.
- Provide a better understanding of post-glacial climate cycles and their effects on erosion processes to better enable long-term projections of future erosion processes, and to facilitate sensitivity analysis of climate inputs in the predictive model.

2.2.2 Components

The components of Study 2 include the following:

- Excavate and/or examine mapped key “land elements” such as terraces likely to contain reliable materials for dating methods such as radiocarbon, cosmogenic nuclide analysis, and OSL
- Excavate and/or core glacial kettles for “bog bottom” dating (end of glacial stadial)
- Examine relevant landslide toes exposed in channel walls or tributary gullies to search for buried debris (timing of slide activity)
- Core tree rings (determine times of tree deformation from landslide movements, and for local climate proxy [drought] linked to terracing)

⁸ Anderson, T.W. and Lewis, C.F.M., 2012, A new water-level history for Lake Ontario basin: Evidence for a climate-driven early Holocene lowstand. *Paleolimnology*, (online 2011).

- Collect samples for uranium-lead (U-Pb) dating of secondary carbonates
- Dating of post-glacial erosional and depositional features
- Analyze dating samples in laboratory
- Evaluate age data for evidence of possible correlations with known Late Wisconsin glacial or postglacial climatic events, such as:
 - a. Climatic event 535-536 AD⁹
 - b. Medieval warm period (essentially the same as "postglacial climatic optimum") 950-1250 AD
 - c. Little Ice Age 1550-1850 AD
 - d. 8200 BP climatic cooling anomaly
 - e. Younger Dryas cold interval 12,800-11,500 BP
 - f. Heinrich events H0, H1, H2 (circa 12,000, 16,800, 24,000 BP)
 - g. Compile more exhaustive list of potential late glacial and postglacial climatic "events"

2.2.3 Rationale

Age dating of geomorphic features provides the time lines of their formation, and together with spatial distribution of land elements, provides some of the required data for calibrating the landscape evolution model. By reducing uncertainty in key age dates, numerical model calibration could be improved thereby reducing uncertainty associated with erosion prediction. For example, a critical predictive-model boundary condition is the base-level lowering rate. There is currently only one age date from a strath terrace in Cattaraugus Valley near the Buttermilk Creek confluence that can be used to estimate the base-level history for Buttermilk Creek, and as noted in the FEIS, this date was rather poorly constrained. Collection of additional age-date samples from targeted locations in this vicinity would better define the base level lowering history for Buttermilk Creek and would improve confidence in the base level boundary condition used in the predictive model.

In addition, paleoclimate data provide a meteorologic history that can be used for calibrating the landscape evolution model, and to bound ranges of climate inputs for sensitivity analyses. This in turn may help to quantify uncertainty and improve confidence in model predictions.

2.3 STUDY 3 – RECENT EROSION AND DEPOSITION PROCESSES

2.3.1 Objective

The objective of Study 3 is to better quantify and characterize recent rates of surface and near-surface erosion and temporary sediment storage occurring on hillslopes, in regions of concentrated flow, and in stream channels at and near the facility.

2.3.2 Components

The initial foci of these studies would be the regions surrounding the United States Nuclear Regulatory Commission (NRC) licensed disposal area (NDA), the State licensed disposal area (SDA), and the rim of the North Plateau (their slopes and stream channels), and potentially in Buttermilk Creek watershed. Preliminary attributes are listed below.

⁹ Keyes, David, 1999, *Catastrophe*, Random House (Republished by Ballentine Books, ebook, 368p).

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- Hillslopes—building on studies completed to date, determine rates and mechanisms of mass-wasting, including landsliding for all slopes of critical concern, and assess their stability;
- Rills and gullies—map locations and determine the erodibility and erosivity of all concentrated flow channels of critical concern, and monitor flow and sediment transport (if possible);
- Streams—define their hydraulic characteristics and geomorphic stability (bed and banks), monitor flow and sediment transport (if possible), assess knickpoint development and migration, and assess recent channel evolution.
- Surfaces--identify additional postglacial surface forms, both erosional and/or depositional, such as alluvial fans, debris flows, possible pro-glacial lake deltas, and other possible sites of sediment capture.

This study would make full use of all previously-collected field data (reports, surveys, aerial photography). It would develop a field campaign for in situ measurements and characterization of geomorphic and geologic materials of interest (ground-based surveys and Lidar, erodibility determinations, stratigraphy, pore-water pressure, streambank stability, geotechnical determinations), and it would institute a field-monitoring campaign to determine short-term time-variations of geomorphic, hydrologic, and geologic phenomena of interest using devices such as flow rates, suspended sediment fluxes, tensiometers, piezometers, and erosion pins.

2.3.3 Rationale

While much emphasis has been placed on the long-term evolution of the WVDP, earth surface processes currently in operation (over periods of decades) offer an important opportunity to assess both past and future landscape trajectories, to support or refute erosion prediction technology, and to facilitate the revision and refinement of landscape evolution modeling (LEM). While very helpful, erosion studies to date have been limited in scope and restricted in spatial coverage and temporal resolution, and therefore limit the ability to assess both past and future erosion trends at the facility. Current rates of gully and stream channel erosion based on these measurements warrant further study. For example, during the past two years, knickpoints as tall as 1 meter (m) have migrated tens of meters upstream along Erdman Brook, threatening the integrity of slopes near the SDA, while a 2m high knickpoint on Frank's Creek has migrated nearly 10m in 2011 alone, causing significant channel development, bed incision, and streambank widening. Such aggressive channel degradation has prompted both NYSERDA and DOE to institute emergency management actions to arrest these processes using erosion-control techniques (e.g., grade-control structures, channelization, rip-rap installation).

Consensus amongst agencies with respect to erosion processes and landscape evolution, therefore, depends critically on assessing and quantifying current erosional and depositional processes, hence the recommended additional studies. This field-based assessment program



Erdman Brook Feature

may provide useful information to achieve this consensus. Moreover, these data will be used (1) to aid in the interpretation of the long-term geomorphic evolution of the site, and to compare and contrast modern processes with those since the last glacial maximum, (2) to identify, develop, and apply appropriate technology at various scales to predict current rates of erosion/deposition and geomorphic stability/instability based on the assembled database, and to project these current rates into the near-term (next 10 to 20 years), (3) to offer refinements, constraints, and validation to all landscape evolution technology, and (4) to facilitate the continued successful and proactive management of the site by NYSERDA and DOE.

2.4 STUDY 4 – MODEL REFINEMENT, VALIDATION, AND IMPROVED EROSION PROJECTIONS

2.4.1 Objectives

The objectives of Study 4 include the following:

- Reduce uncertainty through the refinement of the CHILD model parameter input values, structure, and calibration.
- Improve confidence in the calibrated erosion model by performing an independent validation test.
- Reduce uncertainty in erosion model projections by running them with the improved parameter-range estimates obtained from calibration and validation studies.

2.4.2 Components

Refinement Components:

- Refine parameter input values: use new site-specific data (collected in Study 3) to narrow the range of plausible values for erosion model parameters, such as those related to channel geometry, soil hydrology, and properties of soil, rock, and sediment.
- Refine model structure: use new site-specific data on erosion processes (collected in Study 3) to determine whether there are simple and scientifically defensible adjustments to the model algorithms that would reduce uncertainty, and if so implement any such adjustments.
- Refine model calibration: reduce uncertainty in the erosion model by refining the calibration to include new site-specific data, such as Lidar topography, improved terrain analysis and age dating (collected in Studies 1 and 2), and process observations (collected in Study 3).

Validation Components:

- Conduct an independent test, whereby the calibrated erosion model is used to simulate the hydrologic and geomorphic conditions of a second (companion) drainage basin (such as Connoisarauley Creek and/or its tributaries, or potentially another drainage, that is comparable in dimensions to similar landforms at WVDP).

Improved Erosion Projection Components:

- Calculate projections of future erosion: use refined and re-calibrated erosion model to compute space-time patterns of erosion.

- Perform sensitivity analysis: estimate uncertainty by calculating alternative projected erosion scenarios given plausible parameter variations.
- Analyze climate sensitivity: define potential future changes in climate-related parameters, and analyze how these would influence future erosion.

2.4.3 Rationale

By reducing uncertainty in data parameters, model structure, and calibration, CHILD's ability to replicate the hydrologic and geomorphic characteristics of the site may be improved. For example in the current CHILD analysis, independent data (instead of site-specific data) are used to bracket the range of key input parameter values, such as the detachment capacity of West Valley glacial sediments or bedrock in response to applied fluid shear stress. By using site-specific measurements for this parameter instead of independent data, the range may narrow significantly and the degree of uncertainty may be reduced.

In addition, a calibrated erosion model should be capable of simulating the hydrologic and geomorphic conditions within other drainage basins. This concept can be tested through validation testing. In this type of test, field data from a second drainage basin (such as Connoisarauley Creek or another basin) are entered into the calibrated erosion model and the simulation results are assessed to determine the model's ability to replicate the characteristics of the second drainage basin. If acceptable agreement is obtained between the data and the model, a greater degree of confidence in the analysis may be obtained.

The refined calibration and validation studies may provide a basis for reducing uncertainty in erosion projections. Sensitivity analysis may help to define uncertainty in projections. Studying the impacts of potential future climate change on erosion may further help to quantify uncertainty. Together, these improvements may reduce the uncertainty and increase the scientific defensibility of the erosion projections, and by doing so, may help facilitate consensus.

3. SCHEDULE

The overall schedule objective is to produce results by approximately late 2018. The studies will be conducted generally in parallel and will involve feedback loops between individual studies. The studies are considered to have equal priority, but data collection tasks must precede additional numerical simulations. While data collection is proceeding, the CHILD model can be resurrected and readied for use. The overall schedule constraints include:

- Concurrence with the recommended list of Phase 1 Studies (this document) by the agencies.
- Approval of individual study plans, budgets, and schedules developed in TASK 2 of the SME SOW, and agency authorization to proceed.
- Requirement to complete studies and submit findings and recommendations to the agencies by 2018.

The studies will be designed and scoped to comply with these constraints. Work will begin on TASK 2 - Scoping, immediately upon agency authorization to proceed. Detailed study schedules will be created in TASK 2. These schedules will then be refined and updated as information becomes available.

APPENDIX

SUBJECT MATTER EXPERT SCOPE OF WORK - TASK 1 SCOPE DESCRIPTION

TASK 1: Evaluate and make consensus recommendations on Phase 1 Studies

Considering the following:

- The remaining facilities requiring a Phase 2 decision.
 - Analyses and information relevant to the PAS and to Phase 2 decisions.
 - Public input and comment.
 - Funds for Phase 1 Studies are not unlimited.
 - Potential studies must be completed in ~ 6 years.
- After agency authorization to start work on a PAS, the SME will evaluate the PAS and make recommendations to the agencies on whether further scientific study will facilitate interagency consensus on a Phase 2 decision.
 - If differences of opinion prevent the SME from making a recommendation on Phase 1 Studies, the SME may consult with the ISP in an attempt to resolve differences.
 - The SME will provide recommendations for Phase 1 Studies to the agencies within 3 months of the agencies' notification to start work on the PAS. Recommendations shall include:
 - A description of the proposed study or studies that easily communicates how and why the investigation is being conducted.
 - An assessment of the potential of the study or studies to facilitate interagency consensus with respect to decommissioning and/or long-term stewardship of the remaining facilities and prioritize the recommended studies based on this assessment.
 - A schedule for the completion of the recommended studies (The Phase 1 Studies will be completed by approximately 2017-2018).
 - The SME study recommendations will be presented at a public stakeholder meeting.

The agencies will review SME recommendations for Phase 1 Studies and considering input from public stakeholders will make a decision to proceed with those studies both agencies feel will facilitate interagency consensus on Phase 2 decisions.