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November 26, 2008
Contract No. NRC–02–07–006
Account No. 20.14003.01.007
NMSS06n: PROJ0734; PROJ0735

U.S. Nuclear Regulatory Commission
ATTN: Mr. Michael L. Fuller
Division of Waste Management and Environmental Protection
Two White Flint North
11545 Rockville Pike
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Washington, DC 20555

Subject: Final Software Validation Test Plan and Report Channel-Hillslope Integrated Landscape Development (CHILD) Version 2.3.0 (Deliverable 14003.01.007.340)

Dear Mr. Fuller:

This letter transmits the deliverable 14003.01.007.340 Final CHILD Validation Report.

This report includes the software validation test plan and documentation of validation activities for CHILD Version 2.3.0. This validation was conducted using the Center for Nuclear Waste Regulatory Analyses (CNWRA®) Technical Operating Procedure (TOP)–18. This final version of the report includes changes made in response to NRC staff comments on an earlier version of the report. Responses to specific comments are included with this transmittal. As discussed with NRC staff, the subject validation is limited. Consistent with TOP–018 requirements, selected functions of the code were tested.

Please do not hesitate to contact me (210.522.6260) or Dr. Marius Necsoiu (210.522.5541) with any questions about the subject report or software.

Sincerely,

Ali Simpkins

Ali Simpkins
Assistant Director
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Review of the
SOFTWARE VALIDATION TEST PLAN AND REPORT FOR CHANNEL–HILLSLOPE INTEGRATED LANDSCAPE DEVELOPMENT (CHILD) VERSION 2.3.0
(Deliverable 14003.01.007.240; final: 14003.01.0.07.340)
October 8, 2008
Response (in Italics): October 31, 2008

General Comments/Questions

(1) No mention is given in this report of the Geosciences and Engineering Division Technical Operating Procedure (TOP)–018, Development and Control of Scientific and Engineering Software. How do these procedures work and how do the results of this report fit in with TOP–018? What is the final status of this code based on TOP–018?

Accept. See Page 2.

The report conforms to the software validation requirements of Technical Operating Procedure (TOP–018)—Development and Control of Scientific and Engineering Software. Software is limited validated or fully validated to gain confidence that software successfully implements underlying theory and algorithms. Software validation test plans describe test cases that will provide evidence supporting the correct and successful implementation of software functions.

(2) The report should include an introductory section that discusses the basic features of the code and its capabilities relevant to the types of processes at NDAA sites, and a crosswalk should be provided between the test case examples and these basic processes [see new VADOSE draft report].

Accept. See Page 1.

Major physical processes CHILD can model include fluvial sediment transport, diffusive sediment transport (e.g., soil creep, rainsplash, and rockslide), vegetation cover effects, and the topographic and erosional effects of tectonic uplift, sediment deposition, layered stratigraphy, and storm events.

Table 1. Physical Processes Enabled for Each Test Case

Test Case	Sediment Transport		Vegetation Cover	Tectonic Uplift	Storm Events	Layered Stratigraphy	Sediment Deposition
	Fluvial	Diffusive					
1	X				X	X	
2	X				X	X	
3	X				X	X	X

(3) The report is lacking summary, conclusion, final software validation status, relative usefulness of the code for NDAA-site covers, and possible recommendations. A conclusion section should be added to the report that provides an overall evaluation of

the capability of the code to model cover degradation and performance for radioactive waste disposal performance assessments. What is the CNWRA staff's recommended path forward if CHILD was to be accurately used for future NDAA-site covers? What are ALL the steps to reach such a point?

Accept. See Pages 16–18.

(4) p. 2:
"As discussed in Walter and Dubreuilh (2007), the process models used in CHILD are largely based on empirical relationships developed for natural landscapes (Tucker, et al., 2001). These process models are generally traceable to peer-reviewed technical publications, but due to their semi-empirical nature, cannot necessarily be generally accepted by the scientific community in the same sense that Darcy's Law is generally accepted for simulating groundwater flow." What are these empirical relationships or process models? What similarities/differences do they have with the SIBERIA code?

This paragraph was not particularly important for the validation report and therefore, was removed from Page 2 of the validation report. Regarding the comparison with the SIBERIA code, each code consists of a large number of process models. A complete comparison is outside of the scope of the operations plan.

(5) Why aren't the algorithms for CHILD discussed similar to the VADOSE/W report or the SIBERIA report?

An oversight. The approach of both SIBERIA and CHILD is to use a partial differential equation of the form (Tucker and Bras, 1998)

$$\frac{\partial z}{\partial t} = U - \frac{\partial Q_s}{\partial s} + H(x,y,t)$$

to describe the catchment elevation within a watershed where

z	—	land surface elevation at lateral location (x, y) [L]
U	—	rate of tectonic uplift [L/t]
Q_s	—	fluvial sediment transport flux in the direction, s, of surface water flow [L^2/t]
$H(x, y, t)$	—	function [L/t] describing land surface elevation changes due to diffusive transport processes, such as soil creep, rainsplash, and rockslide

Added to Page 2.

(6) p. 2:
"Validation of CHILD has focused on statistical comparisons between landscapes evolved using the model and observed landscapes. Istanbulluoglu, et al. (2005) reported a comparison between observed and simulated gully formation using CHILD. Campo, et al. (2008) evaluated CHILD to simulate gully erosion using field data collected from Bardenas, Spain. The study calibrated the headcut retreat module of CHILD by adjusting the shape factor parameter."

Briefly state the results/conclusions of these studies.

The calibration and validation of CHILD by others has focused on comparisons between landscapes evolved using the model and observed landscapes developed over as much as 36 years (e.g., Campo, et al. 2008). Campo, et al. (2008) evaluated the capability of CHILD to simulate gully erosion using topographic field data. The study calibrated the headcut retreat module of CHILD by adjusting the shape factor parameter to give results consistent with observed development of a single gully. Modeled headcut retreat rates and observed retreat rates for five additional gullies then differed, on average, by less than 5 cm/yr [2 in/yr] with a standard deviation of 10 cm/yr [4 in/yr]. Reference to Istanbulluouglu, et al. (2005) has been removed because it is more a basic science paper and less an applied CHILD validation paper. Please see Page 3.

(7) p. 2, Sec. 1, 2nd paragraph:
What criteria was used to select from the wide range of CHILD's features those features that would later become part of the software validation exercise?

Features held in common by both SIBERIA and CHILD were selected to facilitate general comparisons between the usability and results of each code. Budget and timing constraints played a role in limiting the scope of the validation in each case.

(8) p. 5, Sec. 1, last paragraph:
Why do the three software validation test case exercises indicate that the CHILD code produces physically realistic and expected landform characteristics?

Because benchmark test cases for landscape evolution codes are unknown, this report describes a "limited validation" of CHILD. The scope of this software validation is limited to confirmation that the software represents physically realistic and expected landscape evolution when applied to several stylized problems. Were laboratory-scale physical analog models of landscape evolution available, such models might provide an avenue for direct comparison of model results with the characteristics of a well-controlled landscape developed on a relatively short time interval. Full validation of software could be enabled by such a comparison. Please see Page 3.

Specific Comments/Questions

(9) If possible, use the term "software validation" in the report instead of just "validation."

Accept.

(10) Can Section 4 "Prerequisites" be removed?

Accept.

(11) p. 7, Sec. 6.1.2, 3rd last paragraph:
"...and information on the mesh triangulation '.tr'."
should be
"...and information on the mesh triangulation '*.tr*'."

Accept.

(12) From R. Codell:
"On Page 14 of the CHILD report, under 6.3.2 item 2, I think they me[a]nt the run command to be "child mound_case3.in," since this was the file they modified. I also wonder if they did the same for case 2, i.e., created a case 2 input file called "mound_case2.in," but it wasn't clear from the text."

Indeed, the issued command was "child mound_case3.in." However, to ensure consistency between the software validation test plan cases, the procedure was slightly modified for 5.3.2. item 1 so that only one input file was used in all three cases (i.e., mound.in). Please see Page 14.