CEMVP-PM-E **19 September 2003**

Memorandum For The Record

SUBJECT: Brainstorming Meeting for Ecological/Environmental Modeling Methods – Mississippi Headwaters ROPE Study.

1. Primary Participants: Dr. Steve Bartell, The Cadmus Group Inc.; Dr. Hal Cardwell, Corps of Engineers Institute for Water Resources (COE-IWR); Nick Gervino, Minnesota Pollution Control Agency (MPCA); Jim Hodgson, MPCA; Dan Wilcox, Corps of Engineers (COE); Dennis Holme, COE; Ed McNally, COE; Kenton Spading, COE; Steve Clark, COE. Dr. Bartell provided numerous comments on the first draft of this Memorandum for the Record. Some of those comments have been directly included for reference.

2. On September 17 and 18, 2003, the individuals listed above met at the COE District Office in St. Paul, Minnesota. The purpose of this meeting was to develop ideas for ways in which the ecological/environmental effects of dam operation could be measured and incorporated into the optimization and simulation models. Prior to the meeting, Steve Clark sent out an agenda. The meeting agenda was generally followed. Concurrently with this meeting, a STELLA training meeting was taking place between some of the participants above and Dr. Cardwell of IWR.

3. The meeting was started with introductions and a review of the progress of the ROPE study and the general schedule for the study. The environmental/ecological models are scheduled to be implemented by December 2003. The Draft Environmental Impact Statement (EIS) is scheduled to be available in the winter of 2004-2005.

4. The group briefly reviewed the current and past operational methods for the reservoirs and the resulting hydrology. On the second day, Kenton Spading discussed the current operating plan and the hydrologic characteristics of the system.

5. Kenton Spading presented the STELLA simulation model and answered questions regarding its functions. Members from the STELLA training meeting attended the subject meeting on the morning of September 18 for a STELLA question and answer session.

6. The following are key points resulting from discussions of the PRM optimization model:

a. It is likely that the PRM model will be run on a semimonthly time step. Participants expressed concerns that some ecological resources or environmental factors with inherent time scales of less than two weeks will be inaccurately characterized using the 2-week time step in the PRM and STELLA models.

b. At this point, there is no output directly from PRM that reports how well a particular model run has achieved the desired results. It seems that there should be a simple way for PRM to calculate this. At this time, this would be done by post-processing the stage/flow time-series, possibly in Excel.

Dr. Bartell commented: It may prove economical in the longer term to program the necessary post-processing capabilities directly into the PRM. This should decrease processing time and reduce the likelihood of introducing errors into the post-processing. The ability to characterize the ecological/environmental benefits associated with the PRM results seems critical for assessing the results (i.e., optimal levels and flows) of this model and in establishing a meaningful interaction between PRM and the STELLA model.

7. The following are key points resulting from discussions of the STELLA simulation model:

a. The STELLA model will be run on a semimonthly time step. See the comment above (6.a.) on the time step for PRM. Similar concerns apply for the STELLA time step.

b. It may be possible to run the output of STELLA through PRM.

Dr. Bartell commented: Given the objective of the STELLA model to determine how closely the derived operating plans match the PRM hydrographs, some capability of determining the associated ecological benefits of the STELLA results will have to be developed. If the PRM cannot accommodate the STELLA results, then the ecological benefits curves will have to be added to STELLA. See comment below.

c. Environmental/ecological models that are used to produce the benefit curves in PRM could be added as modules within the STELLA model. It may also be possible to directly include the benefit curves themselves within the STELLA model.

Dr. Bartell commented: The emphasis should be placed on entering the benefit curves, not the models themselves, into the STELLA. This approach reserves the use of the ecological models for generating the benefit curves used by both PRM and the STELLA model. Thus, if changes are made to the ecological models, only the new resulting curves will have to be changed in the PRM and STELLA – otherwise, changes would have to be made in all the versions of the same ecological model. If the benefit curves can be added into the STELLA, there is no real need to run the outputs from STELLA back through the PRM. Again, this would seem to economize the overall effort and reduce the introduction of errors into the assessment.

d. It may be possible to include interannual variability within the STELLA model. For example, define rules to operate for periodic reservoir drawdowns to simulate drought.

Dr. Bartell commented: This capability seems desirable for both the STELLA and the PRM. Will the PRM be able to address interannual variability as well? The ecological models should also be implemented with the capability to describe the penalties/benefits of interannual variability.

8. The following are key points resulting from the discussion of how PRM and STELLA will operate in conjunction:

a. It is likely that the output from STELLA will not directly feed back into PRM, but it is important that a feedback loop is developed.

b. An option for measuring the benefits from an operating alternative would be to post-process the stage/flow time-series from PRM and/or STELLA by a single method (possibly in a spreadsheet format). See Dr. Bartell's previous comment under 6.b.

c. A trade-off analysis to identify the costs of operation for non-monetary values could be used; however, it is important that this is conducted in a manner such that all costs are included and that environmental gains are not just compared to hydropower losses, for example.

Dr. Bartell commented: The composite risk model can be used to simultaneously address risks-costs-benefits that are quantified in different units. The composite risk model might prove useful in performing the trade-off analysis.

9. The Draft Environmental Modeling Matrix was developed by Steve Clark prior to the meeting as a means to summarize the objectives identified thus far by the Environmental Task Force (ETF). It was agreed that the matrix was a good start in identifying significant resources, but some modifications were suggested. These modifications were included in the version attached to this memo.

10. Two-dimensional hydraulic modeling is planned for 10 river reaches in the study area. Each river reach is approximately 1,000 feet long. Data collected at each reach includes channel geometry, substrate, and cover. This information will be used to help measure impacts of operation on downstream resources.

11. HEC-RAS modeling will be conducted from downstream of Pokegama Dam upstream to Leech and Winnibigoshish. This modeling will enable us to convert the discharge information generated by the STELLA simulation model into river stage data in this region. This information could be used to measure the effects of river discharge on the floodplain in this area.

12. It will be important to quantify the benefits gained from the selected reservoir operation alternative. The models used to develop the benefit curves could be used in this effort as well.

13. The goal of the meeting was to begin to develop a modeling strategy for the environmental effects of water level management (dam operation). Below is a draft process outline that has resulted from the meeting. <u>This draft outline could change as a result of the development of more applicable methods.</u>

14. Dr. Bartell made the following recommendation: There was some discussion concerning the use of the PRM in developing alternative operating plans for analysis via the STELLA model. Kenton Spading's discussion of current operating plans shed some additional light on this subject. However, there still seems to be a critical need for more in-depth discussion and the development of a consistent (i.e., *coherent* in the terminology of decision analysis) methodology for translating PRM outputs to testable operating plans. Given the formalization of the PRM and STELLA models, the key step in the overall ROPE process of developing candidate operating plans should not result from an *ad hoc* process. Perhaps some kind of interactive decision model could be developed (maybe using the STELLA modeling platform) to assist in the derivation of alternative operating plans based on PRM results.

Draft Environmental Modeling Strategy for the Headwaters ROPE Study

I. With the assistance of the Environmental Task Force (ETF), identify all the significant environmental resources within the project area. To be significant in the context of this study, the resource must be demonstrably affected by changes in hydrology influenced by reservoir operation.

A. The locations of significant resources will be identified in relation to modeling node locations.

B. Desired endpoints will be identified for each significant resource. It may be difficult to measure the desired endpoints; therefore, measurable surrogates will be identified for each endpoint. These surrogates will be related to measurable hydrology.

C. This information, and other parameters, will be entered into the Environmental Modeling Matrix (see attached).

D. A report will be written to accompany the matrix and better explain the process by which resources were identified and the reasons for their significance.

II. The Environmental Modeling Matrix will be used to identify and/or develop a suite of simple ecological/environmental models.

Dr. Bartell commented: It is likely that the set of selected models will include models of varying detail and complexity with an emphasis on model simplicity (maybe adequacy?). Perhaps HSI models and simple regression models will constitute this set, along with some population projection models (e.g., Leslie matrix models, bioenergetics-based models); richly detailed and complex ecosystem models will not likely be implemented by December. Note, however, that some of the discussion concerning littoral zone dynamics (e.g., SAV, drawdown, spawning habitat) and associated resources of concern may require the use of more complex ecological simulation in the future. The implementation of the models will probably be based on a combination of site-specific data (where available), data derived from the technical literature, and professional judgment. A process (e.g., data base management) is needed to document sources of information used in the model applications.

A. It is anticipated that there will be two to three categories of models of differing time scales.

Dr. Bartell noted: Spatial scaling was not addressed to a great extent at the workshop (except perhaps in distinguishing between river and reservoir resources), but issues of spatial, as well as temporal, scale will need to be considered in identifying and implementing models to derive the ecological and environmental benefits functions.

1. Models designed to operate on the semimonthly time scale that will be directly incorporated into the PRM and STELLA models by inclusion of the derived benefit curves (penalty functions).

Dr. Bartell commented: The benefits curves (penalty functions) seem to be the common currency in interactions between the developers of the candidate operating plans and the PRM and STELLA models. To avoid confusion and reduce the introduction of errors, perhaps all the ecological/environmental modeling should be done external to these two main models and the only connection would be to produce the benefits functions that would be incorporated into both PRM and STELLA. This approach seems to make for a more transparent use of the models.

2. Models designed to operate on a time scale shorter than semimonthly. These models would be needed to measure the effects of ramping rates, flood pulses, and short-term minimum releases, for example. These models would be used somewhat independently of the PRM and STELLA models and would likely be used to aid in the development of operating rules that are designed to work on a daily basis.

3. Models designed to measure the effects of interannual variability; for example, the effects of periodic droughts (simulated by drawdown). It is not clear yet whether or not this can be directly included in the STELLA model, but there has been some indication that it could be. Otherwise, these models would be run independently of STELLA and PRM.

B. There will likely be at least two categories of models based on the system of interest, one set for the reservoirs and one set for the rivers. It may also be necessary to have other categories, depending on what significant resources are identified.

Dr. Bartell noted: Development of more detailed models may be needed to assist in designing feasible operating plans (e.g., side channel – main channel dissolved oxygen (DO) problems). PRM will likely be blind to the inputs of these more detailed models. Note also that violations have been reported in Minnesota for DO, turbidity, bank erosion, and bacteria counts; these water quality issues will likely be addressed by using more detailed models that run external to PRM and STELLA.

C. The number of nodes identified in the system as well as the number of time steps results in a rather large number of benefit curves that could be produced (1,104 for each resource). Therefore, a number of steps have been identified to manage the modeling effort.

1. Limit the resources to be modeled to those that are significant in relation to the scope of this study.

2. Measure and model the effects of the hydrology only at the point in time that currently is limiting the significant resource of interest.

3. Develop the series of models so that they could easily be applied throughout the system with no more than a few simple modifications.

Dr. Bartell commented: Presumably, the general relationships between the hydrological forcing functions (e.g., levels, flows) and the conditions of the modeled resources would not change from reach to reach or for different reservoirs. However, the values of model input parameters might be more site-specific, and the models, as well as data collection, should permit such specification.

D. A number of general thoughts pertaining to the modeling resulted from the meeting.

1. It may be desirable to apply all the models to each node and then use a system by which the output of each model could be weighted. Combining the weighted results could produce a single desired environmental benefit curve for each node. One benefit of this is that it would give the impression that each node in the system was given equal consideration. Also, it would allow the more technically qualified ETF to apply weights to different environmental resources.

Dr. Bartell commented: More than an impression, this approach would indeed require that all the relevant resources of concern (e.g., river resources, reservoir resources, resources common to both) be addressed for each node. The importance of each resource would likely vary across nodes, and this would be characterized through the weighting. The result would be an integrated ecological/environmental benefits curve appropriately defined for each node on the basis of the applied weights. Stakeholders would probably want access to the particular weights used in developing such integrated benefits functions (e.g., how important were wild rice and walleye for nodes of tribal interest?), and these weights should be accessible via reports or maybe an interactive program developed for the internet (i.e., shared vision planning).

2. A method to normalize all models to a similar unit of measurement would be to equate the output to the percent of desired condition.

Dr. Bartell noted: In a sense, this is what the composite risk model does and it might be usefully applied to produce the needed normalizations.

Steve Clark, COE
Environmental Task Force Coordinator

Attached
Environmental Modeling Matrix

DRAFT Headwaters ROPE Environmental Effects Modeling Matrix

Affected System	Directly Affected Significant Resource	Specific Limiting Factor (life stage, season, etc.) for Significant Resource	Targeted Variability and Time Period For Effect	Estimated Current Condition of Affected Resource	Current Hydrology Influencing Limiting Factor	Desired Condition of Affected Resource	Desired Hydrology to Correct Limiting Factor	Desired Endpoint and Units For Affected Resource	Measurable Surrogate for Endpoint for Affected Resource	Benefits (Outputs) of Desired Condition
Reservoir	Walleye	Spawning	Seasonal Spring	OK but could be improved.	Lower water than if reservoirs were unregulated.	Adequate spawning habitat available.	High water corresponding with spring runoff.	More walleyes.	Hydrology that does not adversely affect spawning.	Diverse and robust fish community.
Reservoir	Furbearers	Wintering habitat	Seasonal Winter	Causes increased mortality.	Rapidly falling water levels.	No mortality caused by exposed winter dens.	Stable water levels.			Increased furbearer population.
Reservoir	Whitefish	Spawning	Seasonal Fall/Winter	Causes decreased spawning success.	Rapidly falling water levels.	Not impaired by water levels.	Stable water levels.			Increased whitefish population.
Reservoir	Aquatic and emergent vegetation	High, stable water	Seasonal Summer-Fall	Emergent and aquatic vegetation occurs in a narrower band and is of a slightly different species composition than what would occur naturally.	Stable water levels.	Emergent and aquatic vegetation occurs in a wide band of diverse vegetation.	Gradually decreasing water levels.			Many benefits: improved primary production, fish cover, shoreline stability.
Reservoir	Aquatic and emergent vegetation	Stable water	Interannual Growing Season	Emergent and aquatic vegetation occurs in a narrower band and is of a slightly different species composition than what would occur naturally.	Lack of extreme low water levels.	Emergent and aquatic vegetation occurs in a wide band of diverse vegetation.	Periodic (possibly once every 10 years) extreme low water to simulate drought.			Many benefits: improved primary production, fish cover, shoreline stability.
River	Smallmouth bass	Rearing habitat	Seasonal Spring	Some species are unable to find adequate spawning habitat.	Lower flows than if reservoirs were unregulated.	All species have adequate spawning habitat.	High water corresponding with spring runoff.	More bass.	Hydrology that does not adversely affect spawning.	Diverse and robust fish population.
River	All fish	Wintering	Seasonal Winter	Increased stress and mortality.	Increasing flows.	No mortality due to increased winter flows.	Stable to decreasing flows.			Improved fish community.
River	Aquatic organisms	Low flows	Seasonal Continuous	Good with respect to low flow effects.	Acceptable minimum flows.	No change with respect to low flow effects.	No decrease in allowable minimum flows.			Prevention of low-water-related negative effects.
River Floodplain	Receiving water in river	DO	Seasonal Winter	Low-DO water in late winter.	Increasing, then decreasing, water levels.	Adequate-DO water in winter.	Stable or slightly decreasing water levels.			No harm to aquatic community.
River Floodplain	Wetland vegetation		Seasonal Spring	Less diverse wetland plant community.	Lack of flooding most years.	More diverse wetland plant community.	Annual flooding of floodplain.			Greater diversity of wetland fauna.

General thoughts on the environmental modeling effort:

1. The main project goal of the Environmental Task Force is to change operation of the headwaters reservoirs to mimic an unregulated hydrology as closely as possible. This includes seasonal and interannual variability.
2. For modeling purposes, the project area is being characterized by 46 nodes that were identified as places that are either the locations of significant resources or best represent a larger area.
3. The matrix above is an attempt to summarize the known major concerns with the existing operation of the headwaters reservoirs and the general desired conditions. It is intended to give a starting point for discussions on the methods that will be used to measure environmental effects.