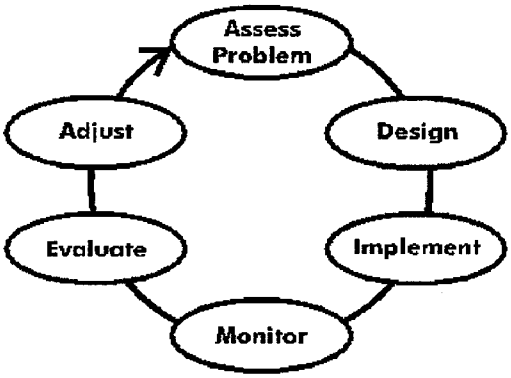
APPENDIX F

Appendix F
A Framework for Adaptive Environmental Management for Exploration and Development on the Pinedale Anticline

1.0 Introduction

The potential value of Adaptive Environmental Management (AEM) to the NEPA process was recently discussed by Carpenter (1997)[1] and is strongly supported by a number of agencies at a national level including EPA, the BLM and the U.S. Forest Service. Carpenter summarized his review as follows: "*It is increasingly recognized that human interventions into natural systems seldom proceed as originally planned. Scientific uncertainties prevent environmental impacts from being reliably or precisely predicted. Thus, the style of management must provide for monitoring to guide mid-course corrections in adapting to inevitable surprises.*" AEM is designed to address these types of concerns. An AEM Plan defines a process to increase the speed at which managers learn from their decisions about resources and how development activities affect them. An adaptive management framework consists of several basic steps including:

- Assess problem
- Design management plan
- Implement monitoring plan
- Monitor
- Evaluate
- Adjust



The AEM process follows the diagram shown on the adjacent figure.

BLM has determined that an AEM Plan for this project would be prepared and implemented generally following the framework contained in this appendix. It is anticipated that a draft AEM Plan would be developed during the spring and summer of 2000 and presented for public review and comment by the end of 2000. There are a number of good models for AEM Plans. BLM will review these models in the near future and further refine this framework to address additional site-specific issues unique to the PAPA. A revised framework for the AEM Plan will be provided to workshop participants (see discussion below).

2.0 Purpose and Need for the AEM Plan

The EIS for this project contains a detailed description of the speculative nature of exploration and development in the PAPA. Indeed, based on the limited exploration that has taken place to date, it is impossible to predict how future development will proceed. The extent and nature of gas reserves in the PAPA are unknown and are expected to remain so for several years. Some believe that development potential in the PAPA is enormous and that thousands of wells may be necessary to adequately drain all the reserves. Others believe that development potential is much more modest and essentially limited to the crest of the anticline and perhaps a few small, isolated areas away from the crest. All agree that there is a great deal of uncertainty about future development. Because of this uncertainty, a number of assumptions were necessary to predict the impacts associated with future development. Those assumptions may or may not be correct.

There is at least equal (if not more) uncertainty regarding how the environment will react to future development in the PAPA. For instance, will a buffer of 1,000 feet around nesting ferruginous hawk nests prevent nest abandonment in all cases? Will best management practices be adequate to prevent water quality degradation in the New Fork River? Will deer and antelope respond to new development as predicted in the

[1] Carpenter, R. A. 1997. The Case for Continuous Monitoring and Adaptive Management Under NEPA. In Environmental Policy and NEPA. R. Clark and L. Canter., eds. St. Lucie Press.

wildlife models? As important, how can we answer to these questions? These questions are particularly relevant given our current poor ability to predict cumulative perturbations on the ecosystem. For instance, the big game animals occupying the PAPA do so only seasonally. Impacts occurring elsewhere on their range could affect the number of animals on the PAPA. The same applies to air quality where a number of cumulative sources affect Class I airsheds. Predictions regarding the severity of the impacts are complicated further by the fact that some of the development may occur on private and state lands where protective measures (such as season restrictions to protect big game and raptor nests, no surface occupancy stipulations around wetlands, etc.) are not typically applied. What will be the cumulative impacts on the Sublette deer herd when seasonal restrictions are imposed on only that portion of their winter range that occurs on Federal lands and minerals? Will perturbations on private lands increase density on Federal lands resulting in deteriorating quality of habitat? Some very sensitive resources in the PAPA (such as wetlands and riparian areas) are located almost entirely on private and state lands where adequate controls to protect the resources are lacking.

The uncertainties as to where and at what level development will proceed as well as uncertainties associated with the environmental sciences that were used to predict impacts suggest that the one-time determination of impacts that is included in the EIS may not be appropriate for this project. However, a properly prepared and thoroughly evaluated AEM Plan may be suitable for dealing with these uncertainties. Such a plan would provide a mechanism for continuously modifying management practices in order to allow continued exploration and development while continuing to protect the environment.

CEQ regulations provide for continual monitoring and assessment. Section 102(2)(B) of NEPA calls for "*methods...which will insure that presently unquantified environmental amenities and values may be given appropriate consideration.*" CEQ regulations state "*a monitoring and enforcement program shall be adopted and summarized where applicable for any mitigation*" and that agencies "*may provide for monitoring to assure that their decisions are carried out and should do so in important cases*".

The purpose of the AEM Plan will be to:

- Determine the effectiveness of mitigation measures contained in the EIS and routinely required by the BLM and modify the measures to achieve the stated goal.
- Assure that non-oil and gas related BLM decisions (such as grazing, recreation, etc.) regarding the PAPA are coordinated with gas-related development.
- Provide a rapid response to environmental change.
- Validate predictive models used in the EIS and revise the models/projections as necessary based on field observations and monitoring.
- Accurately monitor and predict cumulative impacts through BLM maintenance of a GIS for the PAPA including all activities (natural gas, residential, agricultural, etc.) on Federal and non-Federal lands and how they are affecting resources.
- Allow for stakeholder participation in future decision making.

3.0 AEM Plan Learning Model

Three learning models are generally recognized - reactive, passive and active - around which AEM can be developed. BLM intends to adopt a passive model for the Pinedale Anticline Project. The passive approach recognizes that more can be learned from a management action if attention is paid to what actually happened. Learning is advanced when questions and anticipated outcomes are clearly defined and monitoring plans are written before management begins. Monitoring is structured to achieve specific goals - not just collection of data for the sake of data collection. This approach requires patience to allow sufficient time for learning - development must be allowed to proceed before environmental responses can be measured. Under the passive learning model, outside groups play a key role by offering constructive criticism; they may also help to frame questions, anticipate outcomes, and help design and implement a monitoring plan.

EPA, in comments on the Continental Divide Draft EIS described the passive learning model as a mid-level cost option. The EPA description calls for 2 technical working groups: 1) an intra-agency technical work group

of BLM and cooperating agencies' scientists and natural resource economists; and 2) an extra-agency work group of independent scientists and natural resource economists. For the Pinedale Anticline AEM Plan, it is anticipated that this extra-agency work group could include experts from a variety of sources, including:

- U.S. Fish and Wildlife Service
- Sublette County government (particularly planning and zoning and road and bridge)
- U.S. Environmental Protection Agency
- City of Pinedale
- Operators;
- Environmental groups and other members of the public with relative expertise
- PAPA landowners and livestock operators
- University of Wyoming.

Cooperating agencies, such as the U.S. Army Corps of Engineers, U.S. Forest Service and State of Wyoming agencies would participate on the intra-agency technical work group.

It is anticipated that the intra-agency technical work group would draft various management documents including the monitoring plans. The extra-agency work group would review the plans for adequacy and recommend where additional monitoring may be necessary. Public review and comment would be accepted before any of the plans is implemented.

4.0 Identification of the BLM's Project AEM Leader

It is anticipated that coordination of the AEM Plan will be nearly a full-time job for the first year. BLM will assign a single point-of-contact (preferably in the Pinedale Field Office) that will be responsible for implementation of the AEM Plan including coordination with the intra-agency and extra-agency team members and the public. Prior to the first workshop (anticipated for the summer of 2000) the BLM's Project AEM Leader will identify key participants who will be assigned to the intra- and extra-agency work groups.

5.0 First AEM Workshop

The BLM will tailor the first AEM workshop to suit the management problems and available budget. Budget is a concern due to limited funding. BLM and the cooperating agencies lack the resources to adequately implement the monitoring programs recommended. While the BLM and cooperating agencies need to be thoroughly involved in all aspects of monitoring, the costs of these monitoring programs will have to be borne by the operators. It is anticipated that the first workshop would bring together participants with a diversity of skills and expertise to assess management problems and explore management options. The workshop is intended to encourage debate about ecosystem/resource response to management actions and to stimulate a creative search for new solutions, rather than build consensus around a single solution. Participants will be reminded that the scope of the problem and the options explored are bounded by prior mineral leasing decisions.

The workshop is considered valuable for:

- Building a common understanding of the problems associated with future exploration and development on the PAPA.
- Synthesizing existing knowledge (including results of past monitoring funded by Ultra and being conducted by the University of Wyoming - diverse participation would be particularly useful in completing this task).
- Highlighting key uncertainties and clarifying assumptions including those used to assess impacts for the EIS.
- Stimulating creativity and generating new management options.

In addition to the intra- and extra-agency work groups, the first workshop may involve:

- Facilitator(s)
- BLM managers including decision-makers from the Pinedale Field Office and the state office

- Pivate landowners in the PAPA and others directly and indirectly affected by the project
- Other PAPA users
- Knowledge experts from a range of disciplines and from a variety of agencies (participation by all the cooperating agencies should be emphasized)
- Operators and BLM geologist so that recent exploration efforts can be used to project development trends and predict impacts
- BLM's mineral staff (to assure that limitations associated with the leases are not overlooked)
- Other stakeholders

The mix and character of participants is critical to workshop success. Participants should not only have relevant expertise, but should also be creative, innovative thinkers. A thorough review of the information contained in the EIS should be completed by the participants before the workshop. The BLM's AEM Leader will be responsible for assuring that information is available to the participants before the workshop.

The BLM's Project AEM Leader will be responsible for providing an initial scope to the participants before the workshop. It will be useful to summarize existing, accepted knowledge about the PAPA's natural resources and impacts expected from continued gas development before the workshop. Issues and potential impacts that are not of concern should be noted so that time is not wasted discussing them. However, the participants will not be constrained by this initial problem scoping; the BLM's Project AEM Leader/facilitators must be prepared to alter or abandon any part of the initial scope for good cause.

It is important that the decisions made by the AEM participants not conflict with or supersede those made by other processes (i.e., mineral leases). The BLM's Project AEM Leader must be thoroughly familiar with the rights granted to the operators by the leases (Federal and state).

During the first workshop participants should establish a common understanding of the problem by:

- Defining measurable management objectives.
- Identifying key indicators for each objective.
- Identifying possible management actions. Actions and indicators should be grouped into logical sub-groups (e.g., based on theme or scale). Participants should be assigned to these sub-groups based the knowledge and skills they can contribute. In each sub-group:

  - Draw impact hypothesis diagrams (for a given group of actions and indicators).
  - These diagrams outline the linkages between management actions and indicators and represent a synthesis of existing knowledge on each subsystem. Participants will be asked to evaluate links in the impact hypothesis diagrams considering: quality of existing information, level of influence on outcome, feasibility of filling information gaps, etc.
  - Impact hypothesis diagrams are not intended to show detailed links between all components of the system - only those that affect management outcomes/decisions.
  - Identify and assess key information gaps (very important).

6.0 AEM Plan Framework

After the first workshop the AEM Plan will be developed. The BLM's Project AEM Leader will be primarily responsible for drafting the plan but would solicit assistance from workshop participants. The plan will be developed/implemented using the following steps:

Step 1 - Problem Assessment. This step would be conducted in the first workshop. Participants will define the scope of the management problem, define existing knowledge about the PAPA resources and potential natural gas development, and explore the potential outcomes of various management actions (including mitigation opportunities addressed in the EIS).

Workshop participants would first synthesize existing knowledge by developing a model of the system and then use a simulation model to explore different management options. For simple problems, the model may be a simple diagram or graph. For more complex problems (e.g., those where actions are projected over time and space, such as for wildlife), a computer simulation model may be more valuable. Models developed for the EIS provide a starting point. The steps outlined below are applicable regardless of the type of model used.

1.1 Define scope of management problem.

- Define an acceptable level of change for each resource found in the PAPA.
- Define the sensitivity of each resource (e.g., consider risk of damage including spatial and temporal threats).
- Define how management actions could affect each resource (direct, indirect, cumulative, etc.).
- Avoid defining problems in terms of preconceived solutions, since this would limit the development of imaginative alternatives.
- Honestly consider the effectiveness of BLM's standard stipulations as well as other cooperating agency requirements (i.e., seasonal restrictions, allowable development levels within wetlands, etc.).
- Rank resources in the PAPA by sensitivity and threat. Apply this ranking to both federal and non-federal lands.
- Consider long-term, cumulative and large-scale effects of management actions.

1.2 Define measurable management objectives and list potential management actions.

1.3 Identify key indicators for each objective.

- Indicators are measurable attributes of system behavior that allow you to weigh management options and, eventually, assess outcomes.
- Select indicators that are relevant to objectives and responsive to management actions.
- Take into account the cost and practicality of measuring each indicator.
- Select some indicators that respond in the short- term, some in the medium term, and some in the long-term. Select indicators that respond at different spatial scales (e.g., site-specific, landscape, region).

1.4 Explore effects of alternative actions on indicators.

- Develop a conceptual model of the system: outline linkages and describe the functional relationships between actions and indicators (e.g., using box-and-arrow diagrams, graphs, equations).
- If warranted, build a conceptual model. Simulation models are particularly valuable for projecting changes over time and space and assessing the integrated consequences of a suite of actions.
- Use the model (whether it is a simulation model or conceptual model) to explore the effects of alternative actions.

1.5 Make explicit forecasts about response of indicators to alternative management actions.

- Forecasts can be based on outputs from simulation models or, for simple problems, on the graphs or diagrams used to describe the relationships between actions and indicators.

1.6 Identify and assess key gaps in understanding (key uncertainties).

- Uncertainties regarding future development in the PAPA cannot be currently overcome. This will complicate the AEM Plan. Monitoring will need to be constantly adjusted to respond to development potential.
- Express key uncertainties as alternative hypotheses of system function. Hypotheses can be expressed as simple graphs, or where appropriate simulation models exist, as functional relationships or sets of model parameters.
- Consider the relationship between action(s) and indicators over a range of conditions (i.e., how will an indicator respond to different degrees of a protection?).

- Assess the sensitivity of forecasts and management choices to alternative hypotheses. If different hypotheses lead to different forecasts or management choices, then it is worthwhile designing a management experiment that will discriminate between them. (In modeling, this step is commonly referred to as "sensitivity analysis" because it involves assessing how sensitive model outputs are to different model assumptions or inputs).

Step 2 - Designing Management and Monitoring Programs. This step involves designing a management plan and monitoring program that will provide reliable feedback. Ideally, the plan should also be designed to yield information that will fill the key gaps in understanding identified in Step 1. It is useful to evaluate one or more proposed plans or designs, on the basis of costs, risks, informativeness and ability to meet management objectives.

The most informative plans are those that are deliberately designed as management experiments, to discriminate between the alternative hypotheses formulated in Step 1. Typically, this involves comparing a range of management actions. This approach is referred to as "active adaptive management". The alternative, referred to as "passive adaptive management", is to assume that the most plausible hypothesis is true, and then implement the action or set of actions that the model forecasts will have the best outcome. Active adaptive management usually provides feedback that is more reliable and less ambiguous than passive adaptive management. However, passive adaptive management may be the best (or only) alternative where:

- It is impossible or impractical to design a powerful experiment.
- The ecological costs of testing a range of actions is unacceptably high (true for some resources in the PAPA).
- There is a high level of certainty and agreement about which hypothesis is true, and thus which action is best.
- Past actions or natural disturbances provide reliable information about response over a range of conditions.

2.1 Design management plan and monitoring program.

- Consider a number of management options, for example: a passive approach, where one action is implemented; an active approach, where several alternatives are compared; or testing a range of options at a pilot scale, before testing one or more at a larger scale.
- Ideally, a well-designed management experiment should include controls; replication of treatments in space and time; allocation of treatments to control for bias and environmental gradients, and to ensure statistical independence; and evaluation of confidence levels and power. Researchers and statisticians can provide valuable assistance in designing management experiments.
- If necessary, consider how and when to relax some of the design principles; note the consequences this will have for how the results are interpreted, and for the value of the resulting information.

2.2 Evaluate management options/alternative designs, and choose one to implement.

- Evaluate the proposed plan or plans, on the basis of ability to meet long-term objectives, ecological and economic costs, risk of negative outcomes, and ability to fill key gaps in understanding. Decide which proposed plan to implement.

2.3 Design monitoring protocol.

Any monitoring protocol developed for the PAPA should specify:

- The type and amount of baseline (pretreatment) data required.
- Frequency, timing, and duration of monitoring.
- Indicators to be monitored at each interval.
- Appropriate spatial scales for monitoring different indicators.
- Who is responsible for undertaking different aspects of monitoring.

- Who is responsible for the cost of the monitoring program.

2.4 Plan data management and analysis.

- Specify method(s) that will be used to analyze data.
- Set up system for managing data over the long-term.
- Agree on who will interpret data and who will have access to it.

2.5 State how management actions or objectives will be adjusted.

- Identify who needs what information when in order to make timely changes.
- Define the intensity and degree of response in an indicator that will trigger a change in management actions or objectives.
- Adjustments should reflect the trade-off between the costs of acting if preliminary results later prove to be incorrect, and the costs of not acting if they later prove to be correct.

2.6 Set up system to communicate results and information.

- Consider providing results of data analysis on the web for general public access.

Step 3 - Implementation. The plan is put into practice.

Step 4 - Monitoring. In this step indicators are monitored to determine how effective actions are in meeting management objectives, and to test the hypothesized relationships that formed the basis for the forecasts. Monitoring is often neglected in conventional approaches to management, yet it is critical to improvement. Monitoring allows you to assess how actions actually affect indicators. This information then allows you to evaluate the effectiveness of alternative actions, adjust models (i.e., hypotheses) of the system functions, and take appropriate corrective action. Monitoring can also determine if actions were implemented as planned, and may detect "surprising " events.

4.1 Monitor for:

- Implementation or compliance (did we do what we planned?).
- Effectiveness (did the plan meet objectives?).
- Validation of model parameters and relationships (which hypothesis is correct?).

4.2 Follow the monitoring protocol designed in Step 2.

Step 5 - Evaluation. Evaluation involves comparing the actual outcomes to forecasts and interpreting the reasons underlying any differences. In this step, data are analyzed and actual results are compared to forecasts made in Step 1. The evaluation should explain why results occurred and include recommendations for future action. Outcomes can be the result of the management action, confounding factors not under your control, or both. The strength of your inferences (e.g., that the action lead to the outcome) depends on the design of the management experiment and monitoring program. Better designs permit stronger inferences. Negative or unexpected outcomes can be as informative as positive, predicted outcomes. Results, whether expected or unexpected, must be documented and communicated, so that knowledge and experience are passed on to others facing similar problems.

5.1 Compare actual outcomes to forecasts made in Step 1.

- Evaluate the reasons underlying any differences between actual and forecasted outcomes. Were the objectives met? If not, why not?
- Evaluate to what degree tested hypotheses are supported by the results.

5.2 Document results and communicate them to others facing similar management issues.

Step 6 - Adjust. Practices, objectives, and the models used to make forecasts are adjusted to reflect new understanding. Understanding gained in the each of these 6 steps may lead to reassessment of the problem, new questions, and new options to try in a continual cycle of improvement. Information must be used in order to have value. Information gained through the preceding 5 steps should be used to verify or update the models used to make the initial forecasts, and adjust management actions as necessary. Objectives should be reviewed and adjusted to ensure that they remain consistent with overall goals and values.

In order to facilitate change, participants should consider at the outset (i.e., in Step 2) how actions might be adjusted. However, results are rarely as clear as anticipated, and thus adjustments are rarely as simple as those proposed initially. In addition, management experiments may yield some useful information that was not anticipated. Well-defined feedback loops are intended to ensure that information is used promptly and appropriately; they are not meant to be rigid rules that frustrate adaptation. Often, new information will suggest new management solutions, or new questions to answer - leading to another cycle of assessment, design, implementation, monitoring and evaluation.

6.1 Identify where uncertainties have been reduced, and where they remain unresolved.

6.2 Adjust the model used to forecast outcomes (Step 1) so that it reflects the hypothesis supported by results.

6.3 Adjust subsequent management decisions and policies, and reevaluate objectives, as necessary.

- In deciding what adjustments to make, consider the reasons underlying differences between expected and actual outcomes (Step 5).
- Future actions should be based on which hypothesis of system function was supported by the results.

6.4 Make new predictions, design new management experiments, test new options.

- i.e., return to step 1 or 2.
- In future management experiments, address unresolved or newly-identified uncertainties that affect predicted outcomes and decisions about which actions to implement.

7.0 Documenting Plans and Communicating Results

Documenting plans and communicating results are crucial elements of adaptive management. The impact of many management activities can be assessed reliably only over the long-term. All aspects of adaptive management, including funding, project coordination, data handling, and dissemination of information, must be designed to accommodate the potentially long time frame.

1. Document all major steps in the process including:

- Functional relationships, models, key uncertainties
- Reasoning behind the choice of management plan, monitoring program and expected outcomes
- Methods, sites, treatments
- Participants and their roles and responsibilities

2. Ensure that such information is accessible over the long-term, and in the event of turnover in participants.

3. Define who is responsible for coordinating and for carrying out each task.

4. Set time lines for carrying out each task or part of project.

5. Distribute interim and final results.

- A number of avenues can be used to communicate results, including written progress and final reports, presentations, seminars, field trips, informal discussions, posters, the internet.
- In communicating the results, specify which uncertainties have been reduced, and how this affects understanding of the system and future management actions.

As was discussed in the EIS, it is anticipated that an annual public review would occur in Pinedale. It is anticipated that the majority of that review will present data gathered as part of the AEM Plan. Most importantly the BLM and the cooperating agencies need to communicate to the public at each annual review how feedback from the management plans and monitoring plans are being used to reduce impacts from natural gas development in the PAPA.