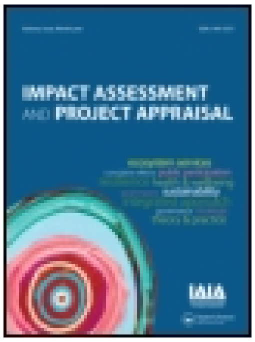

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Adaptive management (AM) is being used as a follow-up tool within EIA/CEAM. Such uses include reducing cumulative effects uncertainties, and informing decision making on practices to minimize the incremental effects of proposed actions and the management of regional cumulative effects resulting from multiple contributors. Based upon a review of fundamental concepts, practices and case studies, the following key lessons have been identified: (1) AM can be a useful tool for coping with uncertainty in CEAM, improving the knowledge base and enhancing the effectiveness of cumulative effects mitigation and management at the project and regional level respectively; (2) decision flowcharts can facilitate the learning and necessary adaptations associated with AM programs, and such flowcharts should be both understandable and integrative in relation to developing an holistic perspective on management choices and their environmental implications; and (3) there is a primary need for comparative case studies illustrating how AM has been incorporated in NEPA compliance documents which address cumulative effects management.

Keywords: adaptive management, uncertainty, elements of AM, NEPA, documents, decision making

THE DEVELOPMENT OF ADAPTIVE management (am) programs as a follow-up (or follow-on or follow through) to the traditional preparation of environmental impact statements (EISs), particularly for large-scale planning efforts that have numerous potential cumulative effects and other uncertainties, is currently receiving attention in National Environmental Policy Act (NEPA) compliance practice in the USA, as well as internationally. Reviews of NEPA documents are increasingly including comments on the uncertainties of cumulative effects and the need for AM programs. This paper describes the multiple features of AM and how it can be used in local to regional efforts to address cumulative effects assessment and management (CEAM).

The topics addressed herein include: multiple definitions of AM; uncertainties related to CEAM; the context of an emerging NEPA model, and international and national practices; fundamental elements in an AM program; examples of AM within NEPA documents; incorporating AM within an EIS; getting started on planning an AM program; and conclusions and lessons learned. The information and case studies discussed have applicability for CEAM-focused AM programs beyond the USA.

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Multiple definitions of AM

There is no single definition of AM that is uniformly accepted and utilized. One reason for this is that the term has been and is being used for a wide range of studies; for example, in relation to natural resources management (for over three decades), project planning and evaluation of resultant cumulative and other environmental impacts (for about one decade), and studies of project operations and their impacts (for less than one decade) (Collaborative Adaptive Management Network, CAM*Net*). In the USA, there is heightened interest in incorporating AM as a planning and operational tool when major scientific and policy uncertainties are encountered in decision making, and when the decision making is accompanied by a NEPA compliance document (either an EIS or Environmental Assessment, EA).

Examples of the range of definitions include the following:

- For natural resources management: AM is a system of management practices based on clearly identified outcomes, monitoring to determine if management actions are meeting outcomes, and, if not, facilitating management changes that will best ensure that outcomes are met or that the outcomes are re-evaluated. AM recognizes that knowledge about natural resource systems is sometimes uncertain and thus it is the preferred method of management in these cases (US Department of the Interior, 2004).
- For water resources projects: AM promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. AM also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a ‘trial and error’ process, but rather emphasizes learning while doing. AM does not represent an end in itself, but rather a means to more effective decisions and enhanced water resources benefits. Its true measure is in how well it helps meet environmental, social and economic goals, increases scientific knowledge, and reduces tensions among stakeholders related to water resources planning (Panel on Adaptive Management for Resource Stewardship, 2004: 1–2).
- For ecosystem restoration associated with the Comprehensive Everglades Restoration Plan (CERP) in central and southern Florida: AM is a science- and performance-based approach to ecosystem management in situations where predicted outcomes have a high level of uncertainty. Under such conditions, management anticipates actions to be taken as testable explanations, or propositions, so the best course of action can be discerned through rigorous monitoring, integrative assessment and synthesis. AM advances desired goals by reducing uncertainty, incorporating robustness into project design, and incorporating new information about ecosystem interactions and processes as understanding of these relationships is augmented and refined. Overall system performance is enhanced as AM reconciles project-level actions within the context of ecosystem-level responses (Comprehensive Everglades Restoration Plan, 2008: 1–2).

Common features from the above definitions include the use of terms or concepts such as process; management goals or objectives; test and adjust policies, practices and actions; and monitoring and feedback (inferred) relative to future decisions. Further, some definitions of AM distinguish between ‘passive AM’ and ‘active AM’. Passive AM refers to a situation where a single course of action is selected, monitoring is conducted and subsequent management decisions are adjusted based on the outcomes. This passive approach could be a useful entrée into the NEPA process. In contrast, active AM refers to situations where multiple courses of actions are planned from the outset, experimental objectives are delineated, monitoring is conducted and subsequent management decisions are adjusted. This active approach is more aligned with the traditional use of AM for natural resources management.

Uncertainties related to CEAM

An inferred theme from the definitions is that a comprehensive scientific knowledge base does not exist regarding the sustainability of environmental resources nor cumulative impacts on such resources resulting from multiple past, present and potential future actions (Canter, 1996). Accordingly, AM can be used as a tool to supplement the knowledge base by reducing several types of uncertainties. Examples of uncertainties that can be identified and reduced within CEAM studies include (Council on Environmental Quality, 1997a):

- Identification of future changes in the operation and management of the preferred alternative;
- Assemblage of detailed information related to reasonably foreseeable future actions (RFFAs), including project siting, size, design features, timing and contributions to cumulative effects on selected Valued Ecosystem Components (VECs);
- The characteristics of resultant cumulative effects on VECs; that is, are such effects the result of linear or non-linear, or additive, synergistic or counterveiling combinations;
- The site-specific and regional thresholds, carrying capacities, and sustainabilities of identified VECs (or their indicators); and
- The potential scientific and institutional effectiveness of project-related mitigation measures, as well as regional cumulative effects management policies, programs and practices.

To further illustrate cumulative effects uncertainties, large-scale actions (projects) with multiple components in space and time may be subject to both near-term and longer-term uncertainties regarding the number and sizes of impact-causing activities, and the actual cumulative impacts of such activities in various fragile to robust environmental settings. Four specific examples of benefits of AM programs include:

- Large-scale programs, plans or projects, and their effects, are often associated with large geographical areas which are ecologically diverse. Further, the management of associated land areas typically requires coordination among federal, state and local governmental agencies. AM programs could be used for large areas where cumulative effects management is of concern and collaborative efforts would be useful.
- AM can reduce NEPA-related decision making gridlock by making clear that management decisions are provisional, and that they can be periodically reviewed and adjusted as appropriate. Such reviews and adjustments are routinely accomplished for land areas with management plans, with such plans including AM features. These approaches can also be used in NEPA compliance documents.
- AM goes beyond piecemeal environmental mitigation to consider environmental processes and the life cycle of protected species. Endangered species management programs developed under the auspices of the Endangered Species Act (ESA), and in response to cumulative effects, already exist in many geographical areas, and the centerpieces of such programs involve learning, experimentation with management actions for species protection and habitat conservation planning, and adjustment of such actions based on monitoring their effects. This could be perceived as a dynamic approach for addressing cumulative effects.
- AM is a useful prospective tool that can account for the cumulative effects that occur in ecosystems that are exposed to multiple stressors from various past, present and future actions. In fact, it could be that AM represents the best available approach for managing cumulative effects.

Situational context

Emerging NEPA model in the USA

As noted above, there has been increasing attention given to monitoring and AM within the NEPA process. For example, by incorporating AM into the process, the traditional 'predict–mitigate–implement' model could be expanded to incorporate the 'predict–mitigate–implement–monitor–adapt' model (Council on Environmental Quality, 1997b, 2003). It should be noted that without any 'follow-up' (monitor and adapt), the traditional model does not account for unanticipated changes in environmental conditions, inaccurate predictions, surprise responses of the VECs, or subsequent information that might affect the original environmental protection or mitigation and management measures. Hence the second model could be referred to as the 'adaptive management' model. In addition, the Council on Environmental Quality's (CEQ's) guidance on considering cumulative effects under NEPA highlighted monitoring and AM in the final step of an 11-step process. Specifically, when determining environmental consequences, it was noted that agencies should monitor the cumulative effects on selected VECs and adapt management as appropriate (Council on Environmental Quality, 1997a).

International emphasis on AM

An emerging emphasis in strategic-level (programmatic) impact studies, also referred to as strategic environmental assessments (SEAs) internationally, is the use of targeted monitoring and an AM approach to address large-scale issues and future time frames that may involve both policy and scientific uncertainties. As noted above, AM is a tool which can be used to address scientific uncertainties regarding continuing and future actions and unforeseen cumulative environmental changes. Accordingly, trends are pointing to the emergence of AM as an environmental management tool for inclusion in Programmatic Environmental Impact Statements (PEISs) and EISs in the USA and for SEAs in Canada, the European Community, and elsewhere (Arts and Morrison-Saunders, 2004). Regarding terminology, the monitoring and AM can thus be seen as 'post-EIS activities' or as 'follow-up activities' (Marshall *et al*, 2005).

CEQ perspective and initiatives

The CEQ's NEPA Task Force Report included a chapter on AM and monitoring (Council on Environmental Quality, 2003). This report was preceded by agency and public inputs (Content Analysis Team, 2002), and followed by further agency and public comments in a 'roundtable format' (The Clark Group, 2005). A systematic review of these pre-report, report, and post-report documents provides useful information on a variety of perspectives on the benefits and concerns associated with the use of AM as a follow-up activity. Identified benefits included the opportunity of disseminating findings to multiple stakeholders, the integration of AM within an operational framework of an Environmental Management System (EMS), and promotion of resource sustainability (Boling, 2005; Council on Environmental Quality, 2007a). Key concerns are associated sidestepping NEPA requirements, long-term funding, and the potential need for Supplemental EISs.

A common cause of many uncertainties is incomplete or unavailable information related to other actions, combination mechanisms for cumulative effects, VEC sustainability conditions, and the effectiveness of mitigation or management measures. Section 1502.22 of the CEQ's NEPA Regulations indicates that agencies can address these types of uncertainties by following a four-step process comprised of literature searching and analysis, summarizing the credible scientific information, consideration of the relevance of the missing information to the decision process, and an overall evaluation of the findings (Council on Environmental Quality, 1986). Planned monitoring within an AM program could be used to address several of the steps. Further, a recent review of US case law related to the four-step process has indicated that the federal courts rely upon the process in evaluating NEPA compliance documents (Atkinson *et al*, 2006).

Incorporation of AM concepts in US planning and management

Several federal agencies in the USA have been or are embracing AM within their programs or initiatives. Examples include the Bureau of Land Management, Bureau of Reclamation, Corps of Engineers, Fish and Wildlife Service, National Marine Fisheries Service, National Park Service, and various services in the Department of Defense. To provide one illustration, all federal agencies have several responsibilities regarding compliance with the Endangered Species Act (ESA); examples include participation in the Section 7 process for threatened or endangered species, information gathering for listing and evaluating such species, incidental take permitting of various activities, preparation of biological assessments, and collaboration in the development of recovery plans and their associated implementation. The responsible federal agency for the ESA is the US Fish and Wildlife Service (the National Marine Fisheries Service has responsibilities for marine resources). In addition, Section 10 requirements related to habitat conservation planning are also germane. However, numerous scientific and policy uncertainties are associated with AM implementation and the resultant findings. Therefore, the inclusion of an AM program could be useful for negotiating permit conditions, and planning and evaluation of recovery plans and habitat conservation plans. Further, monitoring and AM information could be included in pertinent NEPA documents.

AM is also used as a tool within the National Wildlife Refuge System managed by the US Fish and Wildlife Service. Management planning for designated refuges requires the development of Comprehensive Conservation Plans (CCPs), Habitat Management Plans (HMPs), and Annual Habitat Work Plans (AHWPs). Because of both scientific and policy uncertainties related to various refuge management strategies, AM provides an opportunity to explore the effectiveness of options and use the monitoring results to 'fine tune' or formulate new strategies (US Fish and Wildlife Service, 2002). The development of

The AM process is currently a 'work-in-progress', particularly with regard to its inclusion as a 'follow-up' activity to the traditional NEPA model

CCPs is typically supported by the preparation of EISs or EAs, and these documents routinely refer to AM. Further, revisions in strategies (based on the AM findings) may also be accompanied by EAs.

Fundamental elements in an AM program

The AM process is currently a 'work-in-progress', particularly with regard to its inclusion as a 'follow-up' activity to the traditional NEPA model. However, AM is not a substitute or short-cut for performing an up-front analysis of the cumulative effects of a project or plan and its alternatives. As noted earlier, there is no uniform definition for AM across the wide range of its uses. Further, there is no uniform prototype, or set of elements, that would be applicable in every case. Rather, it must be recognized that the key elements need to be identified and tailored to action-specific, site-specific and impacts-specific concerns. However, six such elements which are commonly associated with AM can be identified (Panel on Adaptive Management for Resource Stewardship, 2004). While the elements have generic applicability, the cited reference source was primarily related to AM applications in water resources planning and management. The elements are briefly described below and could easily be adapted for a variety of project types and NEPA compliance documents.

Element 1: Management objectives that are regularly revisited and accordingly revised 'Political differences among stakeholders, or competing paradigms among cooperating scientists, are inherent and unavoidable. Recognition and discussion of such differences should be part of AM and its learning processes. But AM participants must have some level of agreement if AM is to be useful; a setting in which there is no agreement on goals, or modes of progress, is likely to render potential AM applications ineffective … As AM proceeds, not only will ecosystem understanding by participants increase, but social and political preferences are likely to evolve, and environmental and social surprises may occur. Key questions, paths of inquiry, and programmatic objectives should be regularly reviewed in an iterative process to help participants maintain a focus on objectives and appropriate revisions to them' (Panel …, 2004: 24).

Numerous federal agencies already have various program and management objectives related to environmental compliance and management, as well as for the promotion of environmental sustainability. The first step in CEQ's 11-step CEAM process refers to defining the assessment goals (Council on Environmental Quality, 1997a: 10). Examples of such 'management' goals or mission statements for CEAM could include minimizing adverse cumulative effects on specific VECs, restoring degraded VEC conditions due to historical cumulative effects, and enhancing understanding of how cumulative effects actually aggregate. Further, reviews of existing agency statutory or policy requirements could be used as a basis for delineating management objectives for building a consensus for an AM program for a specific project, management activity, plan or widespread program. In effect, these management objectives (goals) could become the focal points of an AM program. Finally, management objectives suggested by various stakeholders could be blended into composite goals for the AM program.

Element 2: A model(s) of the system being managed 'An explicit baseline understanding of and assumptions about the system being managed will help provide a foundation for learning … A system model(s) helps explain responses to management actions and helps identify gaps in and the limits of scientific and other knowledge … Model sophistication and complexity should be tailored to the decision at hand. Active AM may employ multiple, quantitative models to generate hypotheses about the system … These models typically contain clearly defined variables that characterize the state of the system and its rates and directions of change. Mathematical models of the managed system are often developed to help understand systems behavior. But in poorly understood systems, or when the scale or risks of the actions being considered do not justify the expense of rigorous models, simple schematic diagrams can serve as useful conceptual models … Simple models can educate decision makers and participants by facilitating the organization of information, highlighting missing information that might be acquired by monitoring, providing a framework for comparing alternatives, and forcing managers to consider their understanding and assumptions of the system … No matter what the setting or types or sophistication of models used, it is important that AM participants understand the underlying assumptions and limits so that model results are not equated with reality' (Panel …, 2004: 24–26).

One primary point from the above information is that one or more types of models could be used in specific impact studies; however, conceptual models may be the most useful early on. An instructive discussion of models was generated for use by the National Park Service in ecological monitoring and environmental management. Four types of models were defined as follows (Thomas, 2001: 2–3): (1) conceptual model — represents the synthesis of current scientific understanding, field observation and professional judgment concerning the species, or ecological, environmental or economic system; (2) diagrammatic model — pictorially indicates interrelationships between structural components, environmental attributes and ecological and transport and fate processes (it could be based on one or more conceptual models); (3) mathematical model — quantifies relationships between components, attributes and processes by applying coefficients of change, formulae of correlation/ causation, and fundamental scientific knowledge and understanding; and (4) computational models — aid in exploring or solving the mathematical relationships by analyzing the relationships and formulae through the use of modern-day software and computers.

At this time, given scientific knowledge about species, ecosystems and processes and the associated effects from numerous activities, the use of one or more conceptual and diagrammatic models appears to have the greatest general merit relative to planning an AM program. However, depending on the action and its proposed location, it should be noted that more sophistication could be developed as appropriate through specific research emphases. Finally, numerous sophisticated models for multiple stressor contributions to air quality, surface and groundwater quality, and water usage are available. Population models exist for some species, as do energy system diagrams. Further, numerous indicators, indices and habitat suitability models are available. Accordingly, for CEAM studies involving AM, it would be expected that multiple models of several types could be utilized.

Element 3: A range of management choices 'Even when an objective is agreed upon, uncertainties about the ability of possible management (or regulatory) actions to achieve that objective are common. That is, existing data rarely point to a single "best" policy. For each objective, the range of possible management (or regulatory) choices should be considered at the outset. This evaluation addresses the likelihood of achieving management objectives and the extent to which each alternative will generate new information or foreclose future choices. When possible, simultaneously implementing two or more carefully monitored actions can allow for rapid discrimination among competing management (or regulatory) actions' (Panel …, 2004: 26).

The above suggests that a range of incremental effects mitigation measures and/or local to regional cumulative effects management strategies should be considered for different environmental settings and in different phasing patterns. Such measures and/or strategies should be delineated at the outset of an AM program. Further, this infers a type of 'experimental design' for evaluating the management and regulatory actions. Relative to CEAM, initial mitigation measures and management strategies should be identified in NEPA documentation and implemented and evaluated in a follow-up monitoring effort. Pending the findings, adjustments in current measures and strategies may be needed, or new ones developed. Initial planning regarding measures, strategies and responses to monitoring findings will aid the effective use of an AM program.

Element 4: Monitoring and evaluation of outcomes 'AM requires some mechanism for comparing outcomes of management decisions. The gathering and evaluation of data allow for the testing of alternative hypotheses, and are central to improving knowledge of ecological, economic and other systems. Monitoring should focus on significant and detectable indicators of progress toward management objectives. Monitoring should also help distinguish between natural perturbations and perturbations caused by management actions … Monitoring programs and results should be designed to improve understanding of environmental and economic systems and models, to evaluate the outcomes of management decisions, and to provide a basis for better decision making (ideally, independent estimates of the value of monitoring information and programs will be periodically conducted)' (Panel …, 2004: 26).

When monitoring outcomes, it is critical that quantitative or descriptive 'thresholds' (including approved numerical standards, policies and guidelines) for interpreting the monitoring results are identified during the planning of a focused monitoring program. In CEAM, it may be necessary to monitor stressors from multiple actions, indicators of VEC sustainability, and changes in VEC indicators over time. A detailed and useful report on the planning and implementation of a NEPA-related monitoring program is available (Marcus, 1979) along with more recent examples from specific AM programs included within NEPA compliance documents (e.g. Jones and Stokes, 2004; National Park Service, 2006; Tennessee Valley Authority, 2004). This element of AM will often require a design based upon scientific knowledge and principles known by subject matter experts. Practical questions to be addressed in planning a monitoring system include what VECs and indicators to monitor, when and where to monitor, and appropriate protocols for use with specific indicators. For large-scale programs, plans or projects, it is assumed that scientifically designed monitoring efforts will need to be focused on natural resources, stressors (human use activities), effects on the resources (VECs), and the effectiveness of the various management measures, along with their social and socio-economic consequences.

Element 5: A mechanism for incorporating learning into future decisions 'AM aims to achieve better management decisions through an active learning process. Objectives, models, consideration of alternatives, and formal evaluation of outcomes all facilitate learning. But there should be one or more mechanisms for feeding information gained back into the management process. The political will to act upon that information must also exist. Without a mechanism to integrate knowledge gained in monitoring into management actions, and without a parallel commitment and the political will to act upon knowledge gained from monitoring — which will not eliminate all uncertainties — monitoring and learning will not result in better management decisions and policies' (Panel …, 2004: 27).

The above suggests the need for both an internal and external information dissemination program on both AM successes and disappointments, and a transparent, streamlined and efficient decision process for adjusting various mitigation or management measures in view of the monitoring findings. This is particularly true when AM is part of a CEAM study. Further, a key need is for a strategic framework that includes periodic comprehensive evaluations of the implementation of features of the proposed action, the monitoring data and other related policy information, and decision making, as appropriate, relative to adapting mitigation or management policies or measures for the resources of concern. Through such a strategy, AM becomes an iterative process in which management objectives are regularly revisited and revised accordingly. Therefore, careful deliberations will be needed to develop an integrated decision process for AM programs included in EISs, PEISs or SEAs. In this sense, integrated infers the use of holistic perspectives by the proponent and key contributors to cumulative effects. The use of CEAM study-specific decision flowcharts can aid this element. A brief example of an integrated decision making approach for a salt marsh restoration project is given below.

Element 6: A collaborative structure for stakeholder participation and learning 'The inclusion of parties affected by ecosystem management actions in decision making is becoming a broadly accepted management tenet of natural resources management programs in the USA and around the world ... Achieving meaningful stakeholder involvement that includes give and take, active learning (through cooperation with scientists), and some level of agreement among participants, represents a challenge, but is essential to AM. This implies that some of the onus for AM goes beyond managers, decision makers and scientists, and rests upon interest groups and even the general public … Stakeholders may also need to exhibit flexibility and some willingness to compromise in order for AM to be implemented effectively' (Panel …, 2004: 27; Shindler and Cheek, 1999).

This element includes both information dissemination to relevant stakeholders, as well as a proactive program focused on soliciting decision-related inputs from a variety of stakeholder groups, including cooperating or collaborating governmental agencies. Collaboration between multiple agencies and specific stakeholder groups is essential in planning and implementing an AM program as a follow-up to the NEPA process, as well as using its results in decision making regarding incremental effects mitigation and cumulative effects management. The potential benefits of such a collaboration process include (Council on Environmental Quality, 2007b: 4–5): better information would be available for all collaborators in the evaluation and response process; traditionally disadvantaged or under-represented communities, or other non-involved stakeholder groups, will be invited to participate; better integration of ideas and opinions, and even the sharing of personnel and monetary resources, can be accomplished; differences among the collaborators can be identified and, one hopes, resolved, thus preventing subsequent conflict or at least mitigating its influence; and the implementation of decisions can be enhanced. For example, if stakeholders feel vested in an AM-related decision, they will have a stake in its implementation and subsequent AM-related decisions involving monitoring, enforcement and other issues.

Discussion of the elements Despite the comprehensiveness of the above six elements, they may not encompass all of the necessary considerations in planning a CEAM-related AM program. Further elements or sub-elements for consideration include: assembling information on historical and current conditions of key indicators for VECs that are potentially subjected to cumulative effects from a plan, program, or project and other actions; and the quantitative prediction or qualitative description of these anticipated effects, along with impacts from other past, present and reasonably foreseeable future actions (i.e. the cumulative effects) on the key indicators. Further, assemblage of information on organizations with responsibilities for VEC management, VEC-specific models and tools, and existing monitoring programs is an important foundational element (Canter and Hollins, 2005; Canter *et al*, 2005).

Another element involves collaborative long-term agreements among pertinent federal, state, tribal and local environmental agencies, and a program management board (or steering committee) comprised of representatives from these agencies. Another consideration includes adequate budgetary and personnel resources. Given the finite nature of public funds and other resources, cumulative effects management enables agencies to engage in careful selection of achievable goals, to efficiently allocate monetary and personnel resources, and to generate useable and cost-effective outcomes. Finally, a peer group of advisors with expertise in the science of the key VECs, in public policy analyses, the planning and conduction of environmental monitoring and research, and environmental decision making, would be highly desirable.

A final element for consideration is alignment of AM and EMS as coordinated follow-up activities to the traditional NEPA process. One reason for considering a closer alignment between the NEPA compliance process and a follow-on EMS is that several fundamental EMS elements could be used in the implementation of an AM program (Boling, 2005; Eccleston, 2003). Examples of similar EMS elements include objectives, targets and environmental management programs, monitoring and measurement, and corrective and preventive actions.

AM programs are already being addressed in some EISs prepared in the USA, and this practice is expected to increase

Examples of AM within NEPA documents

AM programs are already being addressed in some EISs prepared in the USA, and this practice is expected to increase. Two brief examples are noted herein: (1) an AM program for the operation of an existing regional system of dams and reservoirs; and (2) a salt marsh ecological restoration project. In addition, an agency-focused guidelines document for AM is also summarized. These documents could be useful in planning and implementing CEAM-focused AM programs. The third example highlights recent AM guidance developed by the US Department of the Interior (USDOI).

PEIS of the Tennessee Valley Authority

In 2004, the Tennessee Valley Authority (TVA) released a Programmatic EIS (PEIS) which addressed the operation of the highly integrated, multipurpose system of 49 dams and reservoirs in relation to TVA's goals for navigation, flood control and power production in the Tennessee River Valley (Tennessee Valley Authority, 2004). Uncertainty about, and the need to reassess periodically the balance, focus and cumulative effects consequences of TVA's management of the system was a major factor in taking an AM approach to support decision making on reservoir operational policies.

In the record of decision (ROD) for the PEIS, new reservoir operational policies directing and bounding actions to be taken, but allowing for the necessary information and flexibility to respond to changing, uncertain or unforeseen conditions on both daily and long-term bases, were identified. As part of this process, measurable targets were set for several key goals and objectives of water resource management, but allowance was given for a breadth of possible operational decisions and responses to achieve these goals. The targets included average daily flow targets for key points in the river system; reaffirmation of target summer pool elevations at certain dates; adequate flood storage volumes in reservoirs at particular times; thermal compliance of TVA coal-fired and nuclear generating electric facilities; and minimum flow and dissolved oxygen level targets for releases from particular TVA dams to protect and enhance aquatic habitats.

The PEIS and ROD also addressed uncertain cumulative effects to numerous biological, physical, cultural, economic and social resources resulting from implementing changes in the operational procedures for a constantly varying reservoir system across an 80,000 square-mile (over 207,000 square kilometer) area. The ROD either renewed commitments to ongoing resource (VEC) monitoring of select parameters, or established additional operational factors that vary by the month, week, day and hour. Results from the continuing monitoring program are being used in subsequent decisions on operational policies.

EIS of Napa River Salt Marsh Restoration

In 2004, a final EIS was released on a salt marsh restoration project adjacent to the Napa River about 30 miles (48 km) north-northeast of San Francisco, California (Jones and Stokes, 2004).The Napa River Salt Marsh Unit (9,456 acres or 3,827 ha) is located at the northeast edge of San Pablo Bay (this bay connects to the San Francisco Bay to the south). This Unit is now a part of the Napa–Sonoma Marshes Wildlife Area. The Unit comprises 7,190 acres (2,910 ha) of salt ponds and levees and 2,266 acres (917 ha) of fringing marsh and slough. A total of 11 ponds needing attention are at the site. The Unit itself was first diked off from San Pablo Bay during the 1850s to enable hay production and cattle grazing. Dike construction continued for several decades and much of the land was converted to salt ponds in the 1950s for salt production through the solar evaporation of bay water.

In the early 1990s, Cargill Salt Company stopped producing salt in the ponds on the west side of the Napa River and sold the evaporation ponds to the State of California. The state then assigned ownership to the California Department of Fish and Game (DFG). Restoration of the tidal nature of the Unit, as well as enhancement of the current aquatic and terrestrial habitats, has, for several decades, been a vision of resources agencies, conservationists and planners. The EIS is focused on salinity reduction and habitat restoration for the Unit. The project proponents include the DFG, the California State Coastal Conservancy and the US Army Corps of Engineers. The overall goals for the project are included in a separate regional Baylands Ecosystem Habitat Goals project and report.

Due to the large scale of the Napa River Unit project, as well as numerous uncertainties as to the cumulative effectiveness of water flow management measures for salinity control, and the cumulative benefits of habitat restoration efforts, the project proponents decided to integrate AM within the planning and implementation schedules. Accordingly, the final EIS includes three management objectives, two broad and six specific hypotheses, six success criteria for salinity reduction and habitat restoration, the planned monitoring program, and a decision flowchart for evaluating monitoring results, assessing potential changes and developing AM scenarios (Jones and Stokes, 2004: 2-68a and 2-68b). The flowchart includes a series of specific questions related to indicator monitoring results associated with complying or not complying with the specified management objectives for each pond, pond-specific contingency measures which could be implemented in response to the results, and options for changing the objectives for individual ponds considered in isolation as well as as part of the overall system. More specifically, the flowchart indicates that if a selected VEC responds in X manner as indicated by a Y indicator, then contingency action Z should be implemented.

USDOI guidelines for AM

Finally, the USDOI, a mega-agency involved in both natural resources management, and land, water and forest management, recently published guidelines for AM (Williams *et al*, 2007). The guidelines address four key questions — what is AM, when should it be used, how should it be implemented, and how can its success be recognized? While the focus is on applying AM in natural resources management, it does address compliance with the requirements of NEPA, the ESA and the Federal Advisory Committee Act. The guidance includes a two-phase operational sequence for AM. The first phase, referred to as the 'set-up phase', contains five structural elements, while the second 'iterative phase' uses these elements in an ongoing cycle of learning and management. More specifically, the set-up phase involves the following five steps (Williams *et al*, 2007: 22–32):

- Step 1: Stakeholder involvement — ensure stakeholder commitment to adaptively manage the enterprise for its duration.
- Step 2: Objectives — identify clear, measurable and agreed-upon management objectives to guide decision making and evaluate management effectiveness over time.
- Step 3: Management actions — identify a set of potential management actions for decision making.
- Step 4: Models — identify models that characterize different ideas (hypotheses) about how the system works. Note: models can range from a verbal description of system dynamics (e.g. a simple description of reservoir size that is positively influenced by runoff and negatively influenced by water release) to a formal detailed mathematical expression of change (e.g. an

age-structured multi-species model with density-dependent vital rates that are affected by random environmental changes (Williams *et al*, 2007: 29)).
- Step 5: Monitoring plans — design and implement a monitoring plan to track resource status and other key resource attributes.

The iterative phase involves three steps utilized in a cyclical manner as follows (Williams *et al*, 2007: 33–38):

- Step 6: Decision making — select management actions based on management objectives, resource conditions and understanding (and the use of systematic decision making processes and flowcharts).
- Step 7: Follow-up monitoring — use monitoring to track system responses to management actions.
- Step 8: Assessment — improve understanding of resource dynamics by comparing predicted and observed changes in resource status.

To summarize, comparisons of the six basic elements described above with the eight steps from the USDOI guidelines reveals both their consistency and compatibility. The elements/steps could be used in a blended manner to actually plan and conduct an AM program within a CEAM study. Further, they could be used in describing the features of a CEAM-focused AM program within EISs, PEISs or SEAs.

Incorporating AM within an EIS

Incorporation of AM within the NEPA process could occur in several ways. For example, following traditional NEPA practice, alternatives could be identified and evaluated, and the preferred alternative which is selected could be enhanced by the incorporation of an AM program. At the opposite end of the spectrum, AM could be included in each identified and evaluated alternative; thus the decision process would incorporate AM considerations, and the preferred alternative would already include such a program. Further, for either case, the resultant EIS (or EA) could either address AM in a cursory manner, or it could include more detailed information.

To date, no specific guidelines have been developed on the extent of coverage. For example, a cursory approach could include a commitment to an AM program, but no detail would be provided in the NEPA document. In contrast, a detailed approach could include a description of the anticipated AM actions associated with each alternative and the preferred alternative, their expected environmental consequences, and a presentation of information on the management objectives, monitoring program, decision process, stakeholder involvement and information dissemination. Further, it would be desirable to indicate any known ‘thresholds’ which might trigger the need to prepare a Supplemental Environmental Report or Supplemental EIS or EA based on follow-up monitoring results and decision making. Finally, if a comprehensive AM effort is critical to approvals of a proposed project, plan or multi-action program, then a commitment to such an effort could be included in the ROD and developed in the immediate post-EIS time frame.

One suggestion for the AM topical contents to be included in an EIS (or EA) is as follows (Content Analysis Team, 2002): (1) identify the goals (objectives) and desired outcomes of the AM program; (2) identify collaborating agencies and groups and their responsibilities relative to funding, mitigation and AM program implementation; (3) delineate plans for funding and the associated time schedule; (4) identify quantifiable performance measures and ‘trigger levels’ (thresholds) for considering management options; (5) identify commitments to mitigation and monitoring (could be done in a ROD, but could be subject to litigation if not carried out); (6) delineate the review and decision making process; (7) connect AM to identified environmental concerns/effects; and (8) identify the responsibilities of collaborating agencies for evaluating the effects of AM measures. These eight topics provide a useful guide for incorporating AM components within NEPA documents. Further, it should be noted that these topics are related to the above ‘commonly listed’ elements for AM programs.

One approach for incorporating the above information in an EIS is to prepare a separate chapter. It is assumed that such a chapter should be near the end of the EIS. Another approach is to integrate AM information throughout the traditional chapters in an EIS. An example of this approach, which is also an excellent example of planning and describing an AM program, is the National Park Service’s Draft EIS on elk and vegetation management in the Rocky Mountain National Park in Colorado (National Park Service, 2006). This Draft EIS includes AM features in each of five alternatives, and the specification of quantitative threshold criteria for monitoring results for indicator parameters. Decision processes will use these criteria as triggers for mitigation and management changes.

Getting started on an AM program

Following approval of an EIS (EA), the actual planning and implementation of a CEAM-related AM program could occur over time through the combined efforts of many stakeholders; however, it would be unlikely to take place unless several key initiating actions occur in a timely manner. From the viewpoint that a governmental agency would lead in these efforts, the following initiating actions would need to occur: (1) authorization of an agency or public organization to promulgate an AM program, provide continuity and ultimately assume responsibility for the program’s implementation; (2) formation of a broadly representative stakeholder group, including members that would identify and conduct monitoring and other tasks and would be capable of recommending management adaptations in response to monitoring outcomes and other information; and (3) allocation of collaborative funding and personnel sufficient to initiate and sustain the AM program over a test period of several years. Further, a programmatic agreement between the lead agency, other agencies and relevant stakeholder groups should be developed.

Following authorization, agreement and funding, efforts could then be directed toward specific implementation actions. Examples include:

- Conduct a comprehensive survey of existing databases and institutional information related to selected VECs (e.g. aquatic and riparian habitats).
- Establish a management (decision making) board comprised of responsible officials from several governmental agencies.
- Develop or refine the management objectives for the AM program, with such objectives reviewed by the management board and stakeholder group.
- Establish an external peer review committee to examine the scientific and policy features of the AM program.
- Delineate specific questions to be addressed, and monitoring to be conducted, for the initial period (e.g. 2 to 5 years) of the AM program, with the questions and monitoring plans reviewed by the management board, stakeholder group and external peer review committee.
- Over the initial implementation period, conduct the monitoring, review and interpret the collected data in the context of historical information and management objectives, and adapt actions or policies as necessary.
- Disseminate the findings based on the use of annual reports and annual meetings/conferences, with inputs relative to AM being sought from the external peer review committee, stakeholder groups, management board and the general public.

Conclusions and lessons learned

Based upon the above information on concepts, practices and examples, several lessons and needs related to incorporating CEAM-focused AM within the NEPA process can be identified. They are:

- Based upon prior interests, it should be recognized that natural resources management agencies will probably be able to more readily include AM within their NEPA processes. This is in contrast to the relative newness of the subject to infrastructure, energy and military agencies.
- Due to numerous uncertainties associated with CEAM, AM can be a useful tool for increasing the cumulative effects knowledge base, as well as determining the effectiveness of project mitigation and regional management measures.
- Decision flowcharts can facilitate the learning and necessary decisions associated with AM programs. Such flowcharts and other related tools should be both understandable to a range of audiences and integrative in relation to developing an holistic perspective on management choices and their environmental implications.
- There is a fundamental need to develop comparative case studies illustrating exactly how CEAM-focused AM has been incorporated in NEPA compliance documents. Further, it should be recognized that AM can be accomplished in the absence of an EMS, and vice versa; however, assuming that the benefits of a blended approach can accrue, comparative case studies illustrating such benefits would be valuable.
- NEPA practitioners, along with AM practitioners, need to recognize that AM concepts can be included within NEPA documents without specific referrals to AM per se. Further, both types of practitioners need to recognize the broad range of both AM practices and types of NEPA documents. Accordingly, 'strict perspectives' on what AM is, or is not, will not be useful or encouraging.
- NEPA document review agencies need to recognize that 'calls' for the inclusion of AM in such documents can be problematic. Thus review agencies need to be prepared to assist action agencies in the incorporation of AM in the NEPA process.

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