Peer Review of the Rockfort Quarry Adaptive Management Plan

Prepared for:

Caledon Coalition of Concerned Citizens
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By:

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20 November 2008

DAVIS WEBB LLP
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Attention: R.K Webb, QC

Re: Peer Review – Rockfort Quarry Adaptive Management Plan

Dear Sir

We have completed a review of the Adaptive Management Plan for the Rockfort Quarry, prepared by Conestoga-Rovers & Associates. The enclosed report on our findings is intended to assist your deliberations as to how to proceed in regard to the application.

Should you have questions regarding our review comments, we will be please to respond.

Sincerely

Lorne Greig
Senior Systems Ecologist / Principal

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Abbreviations

AEM	Adaptive environmental management
AM	Adaptive management
AMP	Adaptive Management Plan
CBSES	Comprehensive Broader Scale Environmental Study
CVC	Credit Valley Conservation
EIA	Environmental Impact Assessment

1.0 Introduction

This report documents the findings of our peer review of the Adaptive Management Plan for the proposed Rockfort Quarry. The review was undertaken at the request of the Caledon Concerned Citizens.

Scope of Review

Our peer review has been focused by the following specific questions:

Question 1: Is the adaptive management plan (AMP) consistent with the current practice of adaptive management? More specifically:

1a. Does it define adaptive management correctly?

1b. Does the process outlined in the AMP align with how adaptive management should be done?

Question 2: Is an AMP an appropriate solution in the circumstances of this case?

Documents reviewed in conducting this review include:

- Comprehensive Broader Scale Environmental Study (CBSES), Caledon Aggregate Resource Area 9-A, Part A Volume 1 and Part C Volume 1 (Conestoga-Rovers & Associates, 2008a, 2008b)
- Water Resources Evaluation and Design Addendum Rockfort Quarry Town of Caledon, Ontario July 2008 – Section 3 (Conestoga-Rovers & Associates, 2008).
- Updated Adaptive Management Plan Water Resources Protection Rockfort Quarry Town of Caledon, Ontario. July 2008. (Conestoga-Rovers & Associates, 2008).

2.0 Findings of our Review

2.1 Consistency with Current practice of Adaptive Management

Does the AMP Define AM Correctly?

Current Practice of AM

Current practice of adaptive management is reflected in the definitions provided by various authors in the scientific literature (Appendix A). While the definitions are each expressed somewhat differently they typically embody a small set of common themes that can be expressed as

> *Adaptive management (AM) is a systematic and rigorous approach for learning through deliberately designing and applying management actions as experiments* (Marmorek et al. 2006).

Using management actions as experiments is a key component of AM (Bormann et al. 1999, MacDonald et al. 1999, Stankey et al. 2003, Stankey et al. 2005, Bunnell et al. 2007); important gaps in knowledge and the need for learning from planned experimental comparisons in the field was what led to the development of the AM approach (Walters 2007).

Key principles of AM are:

1. explicit recognition of uncertainty about the outcome of management activities,
2. deliberate design of management policies or plans to increase understanding of the system,
3. careful implementation of the policy or plan, monitoring key response indicators,
4. comparing the outcomes to the objectives and predictions, and
5. incorporating the results into future decisions. (McDonald et al. 1997).

A good example of AM in Ontario is the "Stand Level Adaptive Management" (SLAM) project. Information about this project (as well as a useful primer on AM) can be found on the project's website (www.mixedwood.ca/).

A simple diagram illustrating the AM process is shown in Figure 1, however illustration of the steps alone can be misleading. If left to uninformed interpretation this simple view can lead to misunderstandings about what AM really is. Recent work we have done with leading AM practitioners in Canada and the U.S. (Marmorek et al. 2006) led to a comprehensive list of what each step in the AM process should entail. This list is provided in Table1.

Adaptive management can be categorized into two types: "passive AM" which involves implementing a single management treatment believed to be best, and "active AM" which involves implementing and comparing several treatments as management experiments (McDonald et al. 1997, Bormann et al. 1999, Stankey et al. 2005, Gregory et al. 2006).

Passive AM leads to slower learning than active AM; is less powerful because it can be difficult to determine whether observed changes are due to the treatment or confounding factors (Stankey et al. 2005); and is often reduced to trial-and-error learning in which explicit hypotheses are absent or vague, the updating of historical data is haphazard, monitoring is incomplete, and only incremental changes are made to monitoring plans (Gregory et al. 2006). Most leading practitioners cited in this section, when referring to AM, mean the active form.

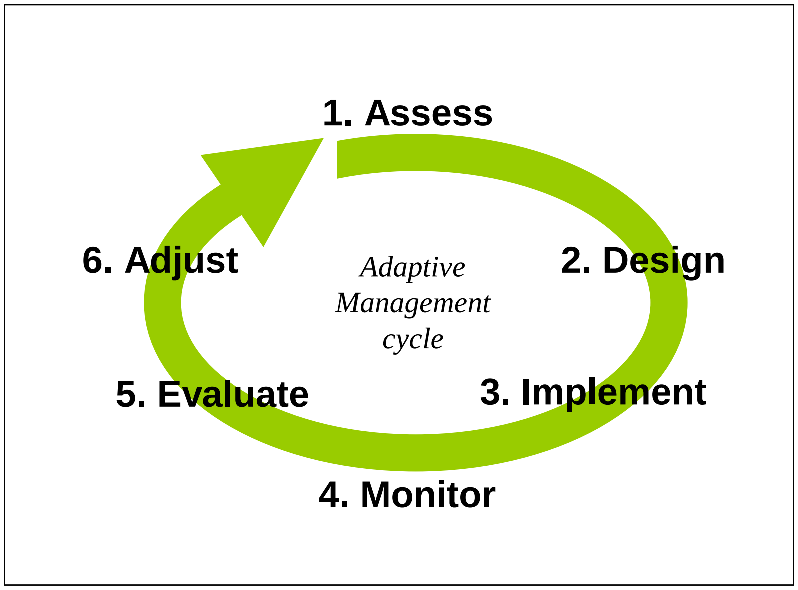
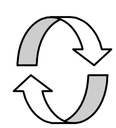
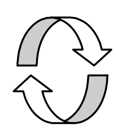


Figure 1. The adaptive management cycle.

Table 1: Elements within Each Step in the AM Cycle

AM Steps	Ideal Elements within each Step
Step 1. Assess and define the problem	a. Clearly state management goals and objectives b. ID key uncertainties (what are the management questions?) c. Explore alternative management actions (experimental "treatments") d. ID measurable indicators e. ID spatial / temporal bounds f. Build conceptual models g. Articulate hypotheses to be tested h. Explicitly state assumptions i. State up front how what's learned will be used j. Involve stakeholders k. Involve scientists l. Involve managers 
Step 2. Design	a. Use active AM b. Include contrasts, replications, controls c. Get statistical advice d. Predict outcomes e. Consider next steps under alternative outcomes f. Develop a data management plan g. Develop a monitoring plan h. Develop a formal AM plan i. Get the design peer-reviewed j. Obtain multi-year budget commitments k. Involve stakeholders 

AM Steps	Ideal Elements within each Step
Step 3. Implementation	a. Implement contrasting treatments b. Implement as designed (or document unavoidable changes) c. Monitor the implementation
Step 4. Monitoring	a. Implement the Monitoring Plan as it was designed b. Undertake baseline ("before") monitoring c. Undertake effectiveness monitoring
Step 5. Evaluation of results	a. Compare monitoring results against objectives b. Compare monitoring results against assumptions, uncertainties, hypotheses c. Compare actual results against model predictions d. Receive statistical or analysis advice e. Have data analysis keep up with data generation from monitoring activities
Step 6. Adjustment / Revision of Hypotheses & Management	a. Meaningful learning occurred (and was documented!) b. Communicate this to decision makers c. Communicated to others d. Actions or instruments changed based on what was learned

Source: Murray 2008, adapted from Marmorek et al. 2006

Interpretation of AM in the Rockfort Quarry AMP

The AMP does not define AM, and the reader is directed to the CBSES for a description of the AM approach taken for the Rockfort Quarry. Part A of the CBSES, chapter 12.1.2, states that *"AEM[1] can be defined as an approach to environmental management aimed at improving understanding of the ecosystems being managed, the institutions charged with their management, and the coupling of the two (CVC et al., 1998)."*

This definition has some similarity to current definitions of adaptive management in that it recognizes AM as an approach to improving understanding. However, unlike many definitions of AM it does not explicitly emphasize the systematic and rigorous nature of AM. The later part of this definition, which asserts that AM is aimed at understanding the institutions charged with ecosystem management and the coupling of ecosystems and institutions is not a part of typical definitions of adaptive management. It is unclear to us just what this means. It might have been intended to reflect the thrust of AM seeking to improve our understanding of how ecosystems respond to our management actions, however this interpretation is supposition on our part.

Information in the AMP and CBSES indicates that this application is employing an approach similar to "passive AM", although the following statements in Section 1.2 of the AMP suggest either a misunderstanding of what AM is, or at least an interpretation of AM that differs from that of current AM practitioners:

> *"The purpose of the adaptive management approach is to recognize the inherent variability in the hydrologic, hydrogeologic and ecologic conditions."* (Conestoga-Rovers & Associates 2008, p6)
>
> This is incorrect. Good practice of AM does recognize the inherent variability in ecological systems, and more importantly explicitly recognizes the uncertainty inherent in the ecosystem response to management. However, recognizing natural variability is not the purpose of AM,

[1] The AMP refers to AM as "Adaptive Environmental Management" (AEM).

which is to learn through careful experimentation how to make management policy and practice more effective in achieving desired objectives (i.e. by reducing uncertainty).

"Rather than implement predetermined mitigation measures which may not be the most appropriate for the actual conditions encountered, a flexible system is developed which can be modified based on observed performance ensuring that predetermined mitigation objectives and superior overall mitigation results are achieved". (Conestoga-Rovers & Associates 2008, p6)

The AM approach cannot ensure achievement of desired outcomes; what it can do is improve the chances of achieving them by focusing effort on deliberately learning what works and what does not. In the practice of AM, what may be learned is that desired objectives are not feasible; this is discussed further in response to question 2.

.

Does the process outlined in the AMP align with how AM should be done?

Current Standards of AM Practice

There is a broad agreement in the scientific literature on the overall approach to AM, i.e. the basic steps in the AM process as illustrated in Figure 1. There is not, however, a rich prescriptive literature on how AM should be implemented, except as it may be found in retrospective analysis of AM failures (e.g. Stankey et al 2003, Walters, 2007). Specific detailed guidance on how AM should be undertaken has been developed by some individual management agencies to guide applications of AM that they undertake, for example the BC Ministry of Forests and Range (BC Forests and Range Undated) and the US Department of the Interior (Williams et al 2007) have both developed guides to AM practice. Other agencies advocate AM and may require it, but may not have developed guidance on its application within their particular mandate. A recent review of 20 AM initiatives revealed considerable variation in the details of the elements employed within each step of the AM process (Table 1), and differing degrees of success in carrying out AM (Marmorek et. al. 2006).

Unfortunately the term Adaptive Management is commonly misunderstood and misused (Murray and Marmorek 2004, Gregory et al. 2006, Marmorek at al. 2007), and is often erroneously assumed to refer to any process involving adaptation ("managing adaptively") to changing conditions (regulatory, environmental, institutional or social). AM is more than just monitoring and then responding to unexpected outcomes[2] (Walters 1997). It is driven by a desire to reduce uncertainty and therefore involves significant work up front, including

- the identification of management objectives and key uncertainties about how to best achieve them, expressing them as hypotheses to be tested,
- exploring alternative actions for testing them, and making explicit predictions of their outcomes;
- selecting one or more actions to implement,
- monitoring to see if the actual outcomes match those predicted, and
- finally using these results to learn and adjust future management plans and policy (Walters 1986, Taylor et. al 1997, Stankey et al. 2003, Stankey et al. 2005).

[2] This does not mean that "monitoring and reacting" is not useful; it simply means that it is not the same as adaptive management (although monitoring is a key component of AM).

The AM Process Described for the Rockfort Quarry Application

Part C of the CBSES contains an accurate schematic of the adaptive management cycle, and describes what is similar to a "passive AM" approach whereby mitigations will be implemented if monitoring results reveal a problem.

While the stated *purpose* of AM in the AMP does not align with current AM practice (as discussed above), the monitoring / management response *process* outlined in the AMP is generally consistent with an adaptive management process. Managing a mitigation program such as this, based on detailed monitoring of its efficacy, is both prudent and laudable. However, for developments with potential for significant undesirable environmental impacts (and for AM initiatives in general), such plans should also include:

- explicit estimates of the uncertainty associated with the proposed treatments,
- explicit statistical design analysis such as Power Analysis (Hilborn and Peterman 1996) to determine the feasibility of detecting an effect given the system's natural variability and potential confounding factors, and
- explicit decision rules for triggers which specify the numerical change in indicator values that would trigger a management response.

The reason for this is simply that when there is a possibility for adverse outcomes, it is important to determine beforehand if the monitoring program will be able to detect and warn of the need for change before adverse effects have been effectively committed to in the long term. These key components are not included in the current AMP.

2.2 APPROPRIATENESS OF AM IN THE CIRCUMSTANCES OF THIS CASE

While the techniques employed in AM have relevance to improving the outcomes in EIA (Jones and Greig 1985) **it is critical to understand that taking an AM approach cannot guarantee that unwanted outcomes will be avoided**.

When there is uncertainty regarding how a proposed management action will affect the environment, it is sensible to reduce that uncertainty by undertaking a rigourous experimental (AM) approach to evaluating the consequences of the action. The context in which this occurs, however, is critical to determining the appropriateness (acceptability) of how the management experiment is conducted. The reason for this is simply that due to the inherent uncertainty, experiments can and do fail. This is fundamental to scientific investigation.

Adaptive management practitioners are cognizant of this risk, and seek to design experiments that are ***safe-fail*** (not fail-safe, which cannot be assured). This means designing AM experiments in which failure is a safe and acceptable outcome. This context occurs when

- the scale and location of the experiment is such that adverse impacts can be tolerated (e.g. in small agricultural or forest management plots), and / or
- adverse impacts are reversible (e.g. a fish harvest policy might result in reduced population numbers, but with timely monitoring and adaptation would be expected to recover once the policy was changed).

In cases involving major development projects which can have adverse environmental effects it is the second of these criteria, reversibility of effect, that is most critical.

In the case of the Rockfort Quarry application the key consideration in determining whether AM is an appropriate approach rests on whether a failure in the mitigation strategy could be reversed, or if detected early whether the effect could be limited to a level that would be acceptable. Since the AMP states that

> *"The potential changes in groundwater levels around the quarry that could arise from dewatering activities during the active quarrying stages, and the creation of lakes under rehabilitation conditions dictate the need for groundwater mitigation measures to prevent potential unacceptable effects to the water resources in the vicinity of the Site"*

we conclude that the consequences of mitigation failure, unless such effects could be reversed, would also be unacceptable.

The acceptability of the proposed approach thus rests with the answers to two key questions:

1) What is the level of certainty / uncertainty regarding a failure of the primary mitigation strategy (grout curtains and recharge wells)?
2) In the event that a problem was detected in the surveillance wells and either additional mitigation was implemented or the operation ceased, would undesirable effects be reversible or acceptably small?

The AMP does not explicitly state the level of uncertainty. Since our expertise is not in the area of geo-hydrology or ground water mitigation engineering we cannot respond to the technical aspects of these questions. However, from our reading of the AMP at least a partial answer to the first question is that there is some level of uncertainty regarding whether the strategy will be successful. If this were not the case, the monitoring program described in the AMP would not be necessary.

Determining the answer to the second question depends on the sensitivity of the chosen monitoring targets (i.e. the ability of the program to detect change early) which requires peer-reviewed technical assessment, and input from the management agencies and stakeholders as to the acceptability of different degrees of long term change. In regard to the technical assessment a critical issue is whether the intensity of monitoring and analysis is sufficient to determine negative effects before they would be irreversible. Given the proposed intensity of sampling, considerations relevant to this determination may include:

- Whether the onset of negative effects on ground water transmission would occur gradually, or whether it could exhibit a sudden threshold response as different layers of rock are excavated.
- The lag time in observations of change attributable to excavation effects: at surveillance wells, and at selected ecological features, in the context of the rate of excavation. This is inter-related with the above consideration.
- The length of time necessary to conclude that changes observed at the selected ecological features are attributable to quarry operations in light of the natural variation, and influences such as shifts in weather cycles and other confounding factors.
- The engineering feasibility of reversing unacceptable effects.
- Other considerations as may be deemed appropriate by experts knowledgeable in geo-hydrology and engineering mitigation.

3.0 Summary Conclusions

In brief, our conclusions are:

1) The definition of AM provided in the CBSES has some similarity to current definitions of adaptive management in that it recognizes AM as an approach to improving understanding. It is however missing key characteristics of many definitions of AM, most importantly explicit emphasis of the systematic and rigorous nature of AM. The later part of the definition, which asserts that AM is aimed at understanding the institutions charged with ecosystem management and the coupling of ecosystems and institutions is not a part of typical definitions of adaptive management. It is unclear to us what this means.

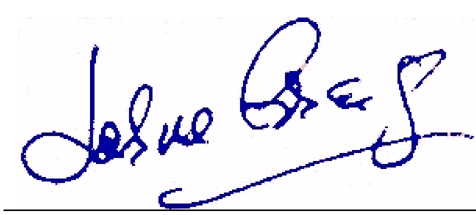
2) The monitoring / management response process outlined in the AMP is generally consistent with an adaptive management process. However, the stated purpose of the program – to adjust mitigation as a means of *"ensuring that predetermined mitigation objectives and superior overall mitigation results are achieved"*, is not the same as the objective of AM which is to learn from experimentation. In the appropriate context AM can help in trying to avoid undesirable management impacts, but it cannot ensure that they will not occur.

3) AM initiatives should be designed in contexts that provide for safe-fail outcomes. This may involve experimentation in locales or at scales where the adverse effects of failure are tolerable, but most importantly this occurs when the consequences of failure are reversible. AM approaches are not advisable when the consequences of failure are irreversible.

   Whether the proposed approach is advisable in this context thus depends on the answers to two key questions:

   - What is the level of certainty / uncertainty regarding a failure of the primary mitigation strategy (grout curtains with pumped recharge wells)?
   - Would undesirable effects be reversible or acceptably small in the event that a problem was detected in the surveillance wells and either additional mitigation were implemented or the quarry operation ceased?

   As our technical expertise is not in the domain of geo-hydrology we cannot give definitive answers to these questions. However, we suggest in the report considerations important to resolving them.



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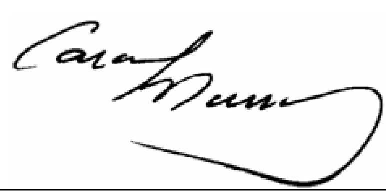

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Appendix A: Selected definitions of adaptive management

Definitions	Source
Adaptive management (AM) is a formal process for continually improving management policies and practices by learning from their outcomes.	Taylor et al., 1997.
AM is a structured process of learning by doing that involves more than simply better ecological monitoring and response to unexpected management impacts. It should begin with a concerted effort to integrate existing interdisciplinary experience and scientific information into dynamic models that attempt to make predictions about the impacts of alternative policies.	Walters, 1997.
AM is an approach to managing complex natural systems that builds on learning – based on common sense, experience, experimenting, and monitoring – by adjusting practices based on what was learned.	Bormann et al., 1999.
AM is a systematic process for addressing the uncertainties of resource management policies by implementing the policies experimentally and documenting the results.	MacDonald et al., 1999.
AM is a structured method for "learning by doing" that includes establishing clear goals, defining practices to achieve those goals, implementing the practices, monitoring the outcome of the practices, assessing how those practices are succeeding relative to the goals, and adjusting management in response to the assessments. It is designed to address questions such as: Where do we want to go? How do we get there? How do we know if we're there? If we're not there, how do we change to improve?	Kremaster, Perry and Dunsworth, 2002.
Adaptive management [is a decision process that] 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. Adaptive management 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. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders.	Williams, Szaro and Shapiro, 2007.
AM treats actions and policies as experiments that yield learning (it mimics the scientific method: specifies hypotheses, highlights uncertainties, structures actions to expose hypotheses to field tests, processes and evaluates results, and adjusts subsequent actions in light of those results), and embraces risk and uncertainty as opportunities for building understanding that might ultimately reduce their occurrence.	Stankey et al., 2003.
AM is "learning by doing" with the addition of an explicit, deliberate and formal dimension to framing questions and problems, undertaking experimentation and testing, critically processing results, and reassessing the policy context that originally triggered investigation in light of the newly acquired knowledge. The concept of learning is central to AM. It is a process to accelerate and enhance learning based on the results of policy implementation that mimics the scientific method: experimentation is the core of adaptive management, involving hypotheses, controls and replication. It is also irreducibly socio-political in nature.	Stankey, Clark and Bormann, 2005.
AM is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. It's most effective form – "active" AM – employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed.	BC Ministry of Forests and Range Adaptive Management
AM is a formal process for continually improving management practices by learning from the outcomes of operational and experimental approaches. Four elements of this definition are key to its utility. First, it is adaptive, and intended to be self-improving. Second, it is a well-designed, formal approach that connects the power of science to the practicality of management. Third, it is an on-going process for continually improving management, so the design must connect directly to the actions it is intended to improve. Fourth, although experimental approaches can be incorporated into adaptive management effectively, operational approaches and scales are emphasized to permit direct connection to the efforts of managers	Bunnell et al., 2007.

AM Definition Sources

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