

# CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT IN SURFACE COAL MINING

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**Abstract.**-- The provisions of the Surface Mining Control and Reclamation Act of 1977 (PL 95-87) have introduced a new dimension into the process of regulatory approval of coal mining and reclamation operations. The Act requires that no permit shall be approved unless an assessment of probable cumulative impacts of all anticipated mining in the area on the hydrologic balance has been made by the regulatory authority, and the regulatory authority has made a finding in writing that the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area.

This paper summarizes a step-by-step process that may be used by a regulatory authority to develop cumulative hydrology impact assessment (CHIA's) that may satisfy the requirements of the Act and the regulations. Two important elements of the process are the delineation of a cumulative impact area (CIA) and development of criteria for determining material damage to the hydrologic balance. A brief description of each of the six elements of the process is included. Other approaches may also be appropriate and acceptable for developing CHIA's.

## INTRODUCTION

The provisions of the Surface Mining Control and Reclamation Act of 1977 (PL 95-87) have introduced a new dimension into the process of regulatory approval of coal mining and reclamation operations. The Act requires that no permit shall be approved unless an assessment of probable cumulative impacts of all anticipated mining in the area on the hydrologic balance has been made by the regulatory authority (RA), and the RA has made a finding in writing that the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area.

The Office of Surface Mining (OSM) regulations at 30 CFR Parts 780 and 784 implementing the above statutory provisions also require the RA to prepare an assessment of the probable "cumulative hydrologic impacts of the proposed operations and all anticipated mining" which is termed the "cumulative hydrologic impact assessment" (CHIA). This paper describes a step-by-step process that the RA may use to prepare CHIA's that meet the requirements of the Act and regulations. A brief description of each element of the process is included.

## OVERVIEW

With proper enforcement of surface mining regulations, the hydrologic impacts of individual mining operations will be minimized, though not eliminated entirely. Residual impacts, however, may be small and individually insignificant, may,

with the development of additional mines accumulate to magnitudes that are significant and potentially damaging to the hydrologic balance. The cumulative hydrologic impact assessment, thus, was incorporated to assure that such aggregate impacts will not be overlooked in the routine processing of individual permit applications. In effect, the CHIA is an umbrella provision in the Act, and its overall objective is to require routine consideration of the aggregate impacts caused by the disruption of large areas (more than one individual permit area) due to surface mining operations so that they can be dealt with in a timely manner. Depending on the hydrologic setting, the potential for material damage to the hydrologic system, and the evaluation of the significance of that material damage through the application of criteria established by the RA, the probable cumulative hydrologic impact assessment could result in the denial, redesign or potential sequencing of a mining permit.

The CHIA is an assessment distinct and separate from the determination of probable hydrologic consequences (PHC), although elements of the PHC can be used to support and develop the CHIA. The CHIA is the responsibility of the RA whereas the applicant provides the PHC determination with the permit application. The PHC determination addresses hydrologic conditions on the permit and adjacent areas; the CHIA considers impacts over the entire cumulative impact area (CIA), which may include multiple permits as well as areas where mining is anticipated.

Because, through the CHIA process the regulatory authority routinely faces the reality of cumulative impacts, it should not be necessary to completely analyze every facet of the hydrologic system. The process presented in this paper is based on the premise that the scope of the analysis can be tailored and reduced

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to only those facets of the hydrologic system which are available from that system. At the start of an assessment, its scope should cover all possible impact. Thus, the scope of a CHIA should initially include a complete analysis of the ground- and surface-water systems in the CIA from the standpoint of water quantity and quality. This initial scope can then be systematically and logically reduced to include only those concerns considered appropriate to describe and maintain the hydrologic balance of the area. Such concerns might be acid drainage in one area, presence of specific levels of dissolved solids in another and depletion of water supply in a third.

CHIA PROCESS

CHIA development is a process which consists of logically and professionally documented evaluations of a defined set of elements. It basically involves the analysis of critical aspects of the hydrologic system within the CIA. Emphasis of the analysis is on predicting the type and magnitude of impacts to the hydrologic system attributable to the proposed operation in conjunction with existing and anticipated mining operations. Thus, during the CHIA process, the RA should: (1) define the area to be studied, (2) describe the hydrologic system and determine baseline hydrologic resource values, (3) identify hydrologic resources likely to be affected, (4) develop standards for evaluating the impacts, (5) predict the impacts of mining on the hydrologic resources, and (6) compare the impacts with the material damage criteria and then prepare a statement of findings. The RA should address the of elements in a logical sequence based on proper hydrologic practices.

Figure 1 illustrates one such sequence. The arrangement of Elements A, B, and C is meant to suggest that these elements are highly interrelated and that they should be evaluated interactively. As a group, these three elements are evaluated initially in the process because they provide an informational basis for selecting techniques, methodologies and criteria needed for impact prediction and material damage assessment. The sequential arrangement of Elements D through F indicates that completion of these elements is dependent on the prior evaluation of certain other elements. This should not be construed to mean that one element must be totally completed before the next is started. The dashed arrow suggests that the CIA delineation may need modification after the areal extent of potential impacts has been evaluated.

Within the constraints of proper hydrologic practice and those imposed by statutory and regulatory requirements, the RA has wide latitude to determine the exact manner and extent to which individual elements will be evaluated. The specific concerns, procedures, methods, and data needs may vary with each impact area, and the RA has complete latitude to apply those that best suit the particular conditions of each site. However, documentation of the specific assumptions and decisions made during the process should be included in the findings statement. Such documentation should be considered an extremely important aspect of the CHIA process.

Each CHIA should be considered unique to a specific minesite or permit area. A new CHIA may not be necessary for permit renewals and revisions. It should be acceptable to use portions of an existing CHIA; the previous CIA delineation may be appropriate for the CHIA of the updated permit. In addition, documentation of the procedures used to delineate this CIA could be transferable to the CHIA of the proposed mine with only minor modifications. Likewise, once material damage standards have been established for a specific area, they should be applicable to future CHIA's for that same area. Thus, even though a CHIA should be considered unique to each specific permit application, the actual assessment can draw heavily on the previous CHIA.

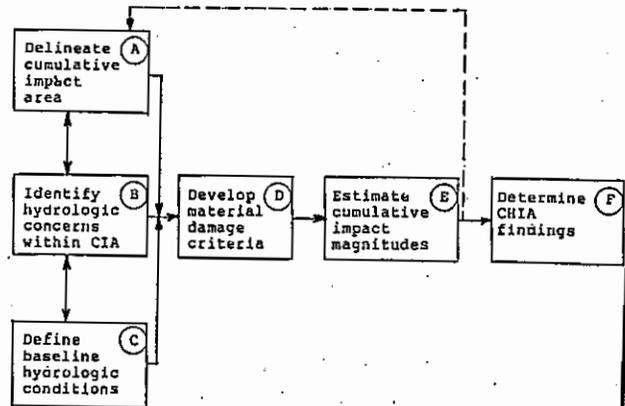


Figure 1.--Flow diagram showing elements of the CHIA process.

## PROCESS ELEMENTS

The following are brief statements of what is envisioned for each element shown in figure 1.

Element A.--Element A addresses the delineation by the RA of the area for which the CHIA is being prepared. OSM refers to this area as the CIA and defines it in the regulations (30 CFR 701.5) in terms of both a physical area and of the type of mining operations existing, proposed, or anticipated, within that area that must be considered.

The proposed delineation process begins at a point downstream from the most downstream operation in the same river basin where the proposed mining operation is located. By procedures developed by the RA, operations spatially and hydrologically distant from the proposed operation are systematically tested to determine the significance of their impacts with respect to the proposed operation. In this way, the CIA is limited to those operations whose impacts are relevant to the CHIA being developed. The process may be iterative with some evaluation of the impacts needed before the limits of the CIA can be finally delineated. Establishing the downstream limit of the CIA at an existing USGS gaging station may be beneficial since it will serve as a check on actual impacts or changes over time and facilitate the hydrologic monitoring plan.

Element B.--Element B involves identification by the RA of specific hydrologic concerns within the CIA. This is a qualitative identification of the aspects of the hydrologic system most likely to be adversely affected by the mining activities. By identifying hydrologic concerns peculiar to the CIA, the CHIA process can focus on these critical components of the hydrologic system, and not on irrelevant issues. The concerns can be identified from the PHC statements in the mine plans of the operations within the CIA, from other baseline data, historical data, or from any source that raises valid questions about some aspect of the hydrology of the CIA. The specific parameters to be used to quantify and evaluate the concerns, and the sites at which the concerns will be evaluated should also be identified. An example of a common concern associated with mining is acid discharge which reduces the postmining pH of the receiving streams.

Element C.--Element C provides for the determination of baseline hydrologic conditions of the CIA. This determination should result in a description of the hydrologic system and how it functions. It should also provide the normal values of the indicator parameters at the beginning of mining. Baseline conditions are, in effect, a determination of the state of the hydrologic balance at the time of the analysis and they provide reference points for evaluating the significance of future impacts (predicted values of indicator parameters) of mining.

Element D.--Under Element D, the RA establishes for the indicator parameters, the values beyond which material damage is likely to occur, or ranges within which acceptable levels exist. It is here that the RA establishes what would constitute material damage for the CIA. Existing State and Federal water-quality standards may be used where applicable. In cases where standards are not already available, the RA may want to develop these values. These values normally will be in the form of maxima or minima, but in some cases, rate of change limits (incremental limits) may be appropriate. When, with increasing numbers of mines in the CIA, impact levels approach material damage levels, the RA may wish to establish secondary limits (parameter value less than the material damage thresholds) to indicate when more rigorous and precise analysis procedures should be used, or when mitigative measures should be applied.

Element E.--Element E involves estimating values that the impacts are expected to attain as a result of the mining and reclamation operations. The following three step procedure is suggested for accomplishing Element E:

1. Select analysis approach.
  - a. Combinational approach.
  - b. Independent analysis approach.
2. Select specific techniques and methodology.
  - a. Qualitative methods.
  - b. Empirical equations and statistical correlations.
  - c. Physical process models.
3. Analyze CIA for cumulative hydrologic impacts.

With the Combinational approach the results (estimated values of indicator parameters) presented in the PHC portions of individual mine plans are combined or integrated into composite impact values for the CIA. Use of this approach may require the RA to develop PHC's or make equivalent analyses, for any "anticipated mining" operations for which PHC's are not available (leases, 2-acre exemptions, etc.).

With the Independent analysis approach an independent hydrologic analysis of the CIA is conducted using the data provided in the two-part permit application package and in the PHC portions of other applicable mine plans, and data from any other source. In a given situation, one or the other of these approaches may be appropriately used. If the Combinational approach is used, specific analysis techniques should not be necessary because adequate impact assessments should already exist in the PHC's of the individual operations. In this case, the RA needs only to develop procedures by which the results of the individual PHC's can be combined. If the independent analysis approach is used, then specific techniques are necessary.

Technique selection depends on many factors, but a primary consideration should be that the technique adequately reflects the dominant physical conditions that characterize the subject hydrologic system. The

Qualitative methods are those which provide for systematic evaluation of qualitative data inputs and predict a range of output values. They rely heavily on the judgement of the user who should be a competent hydrologist and highly knowledgeable about the method and the CIA being assessed.

The second category of methods includes a wide range of techniques, equations, and statistical correlations by which values of various hydrologic parameters, under specific conditions, can be calculated. The Universal Soil Loss equation (Wischmeier and Smith, 1965), the Thesis equation (Thesis, 1935), and the Muskingum flow routing equation (McCarthy, 1938) are examples of techniques in this category. The last category of techniques is comprised of hydrologic models which simulate the physical processes in the hydrologic cycle with mathematical equations. In all but the simplest hydrologic systems, the equations governing the system processes are either too numerous or too complicated to be solved by direct mathematics. Therefore, the high speed computational capabilities of digital computer are usually needed to solve the equations. The selected approach and techniques are applied to the total CIA using data assembled at Element C. The approach and techniques selected are extremely important to the outcome of the CHIA process and should be given appropriate consideration.

Element F.--The RA's final task in the CHIA process is to determine if the hydrologic assessment of the CIA (Elements A through E) indicates that the impacts of the proposed operation may cause material damage to the hydrologic balance outside the permit area, and to write a statement of findings with all supporting evidence and rationale. The determination is the main objective of the whole CHIA process. The supporting evidence and rationale should validate the determination. The following procedure is suggested for accomplishing Element F:

1. Determine potential for material damage.
  - a. Make quantitative comparisons of estimated parameter values with the applicable material damage criteria assembled in Element D.
  - b. Make qualitative comparisons of the parameters for which quantitative evaluations are not appropriate.
  - c. Make a final determination of whether impacts from the proposed operation may cause material damage to the hydrologic balance outside the permit area.
2. Prepare a statement of CHIA findings.
  - a. Introductory information.
  - b. Documentation to justify actions.
  - c. Statement of findings.

The determination should be based on the understanding that hydrologic impact assessment is not a precise process. Because of the many uncertainties associated with hydrologic estimation, the predictions made under the process proposed herein, or under any similar process, must be considered as probable in nature rather than exact. In this case the RA may apply professional judgement to make the final material damage determination.

The written statement of findings with supporting evidence and rationale should describe the actions taken to complete each of the process elements. At a minimum, the statement should cover the three broad topics listed above. The introductory information should include such information as the reason that this specific CHIA is necessary (new application, modification, etc.) and should mention any previously prepared CHIA's for the area that form the basis in the present effort. It should discuss any significant difference between approaches used in the present and previous efforts, and should also include any information of a general nature that adds to the understanding of the situation and conditions dealt

with in this CHIA. A thorough discussion of actions taken in the evaluation of each element will comprise the bulk of the statement and should reflect how the assessment was done and the reasons for specific conclusions and decisions.

The final topic to be addressed in the CHIA is a written finding by the regulatory authority that the proposed mining operation has been designed to prevent material damage to the hydrologic balance outside the permit area. The finding is the ultimate objective of the assessment. The discussion should summarize the major reasons for the findings and state any special conditions or stipulations upon which the finding is contingent.

#### SUMMARY

The development of a CHIA is seen as process in which a defined set of elements is evaluated. The resulting product of the assessment is a findings document that describes the assessment and provides support for the the permitting action taken. It is important to remember that CHIA's deal with future impacts and that magnitudes of the impacts are estimates rather than readily measurable are to be meaningful. Therefore, it is an inexact science at best, and therefore, the utmost care, planning and professional judgement must accompany these determinations if they important that the CHIA process adopted by the RA should be such that it utilizes future hydrologic monitoring data collected by mining companies and governmental agencies to verify the predicted cumulative impacts on the hydrologic balance.

#### REFERENCES

U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement, "Permanent Regulatory Program, Final Rules, Federal Register, Vol. 48, No. 187, Part III, September 26, 1983."

