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Presentation by

Kathy Muller Ogle

Wyoming

Department of Environmental Quality,
Land Quality Division

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Wyoming Cumulative Hydrologic Impact Assessment Process Western Region Presentation

By Kathy Muller Ogle
Wyoming Department of Environmental Quality/Land Quality Division

abstract

The Wyoming cumulative hydrologic impact assessment (CHIA) process as implemented by the Wyoming Department of Environmental Quality (WDEQ), Land Quality Division (LQD) is a reflection of the scale of mining in the state, the legacy of CHIA experience over the last 14 years, and Wyoming's environmental laws. Wyoming produces about 32 percent of the coal in the United States. Although Wyoming has a 134-year history of coal mining, it was not until the 1980's and 1990's that a rapid increase in coal production occurred. While Wyoming's land area makes it the ninth largest state, it has the smallest population. Wyoming's diverse ecosystems provide the framework within which mining occurs.

Wyoming's approach to CHIA's has evolved with experience. Initial CHIA's in Wyoming were general basin-wide CHIA's produced under contracts. The reason for the change from general to specific CHIA's was initiated both by OSM oversight suggestion and by a change in the economics of the coal market. WDEQ now prepares the CHIA's in house with agency staff. The CHIA's are shorter documents with more specific analysis directed at the scale at which cumulative impacts can be measured and using current data from the permits, annual reports, and other published data sources.

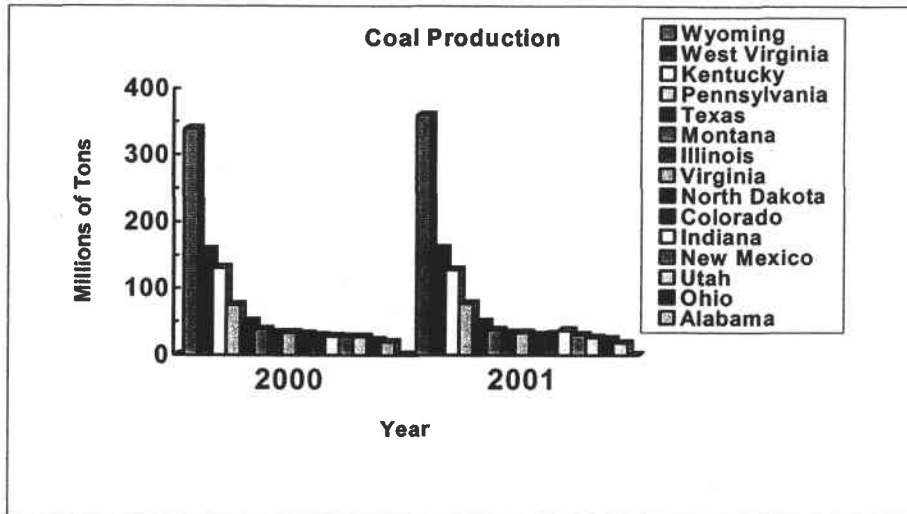
The Wyoming Environmental Quality Act and the associated Rules and Regulations define the framework for the Wyoming CHIA process. The Wyoming CHIA process involves six steps – 1.) Determination of when a CHIA is required, 2.) Defining the type of CHIA needed, 3.) Defining the Cumulative Impact Area (CIA), 4.) Defining pre-mining conditions, 5.) Analyzing the impacts, and 6.) Determining the potential for material damage.

Wyoming is implementing some innovative approaches and anticipating some future issues. Innovate approaches are underway in records keeping, living analysis for backfill, and use of an unsaturated flow model to examine recharge at playa areas. The future issues on the horizon are the interaction of coal mine impacts with other groundwater users, the need to re-activate surface-water gaging stations, the separation of natural variability from impacts in measurements, and the loss of upstream surface water monitoring sites.

Introduction

The Wyoming cumulative hydrologic impact assessment (CHIA) process as implemented by the Wyoming Department of Environmental Quality (WDEQ), Land Quality Division (LQD) is a reflection of the scale of mining in the state, the legacy of CHIA experience over the last 14 years, and Wyoming's environmental laws. The scale of mining, as well as the social and ecological environment where the mines are located, defines the environmental issues and problems that are encountered. Wyoming's approach to CHIA's in the coal mining regulation program has evolved with experience. A brief description of that history is presented to assist in understanding the agency's current approach. Of course, the most important factor in the process is Wyoming's environmental laws and regulations and how the CHIA's meet those requirements.

Wyoming produces the most coal of any state in the United States. In 2000, 32 percent of the coal production in the United States came from Wyoming (Frame, 2000). Based on tonnage, Wyoming now produces more coal than the combined production of the next two largest coal-producing states, West Virginia and Kentucky (figure 1). Wyoming's largest mine, North Antelope/Rochelle Complex, produced

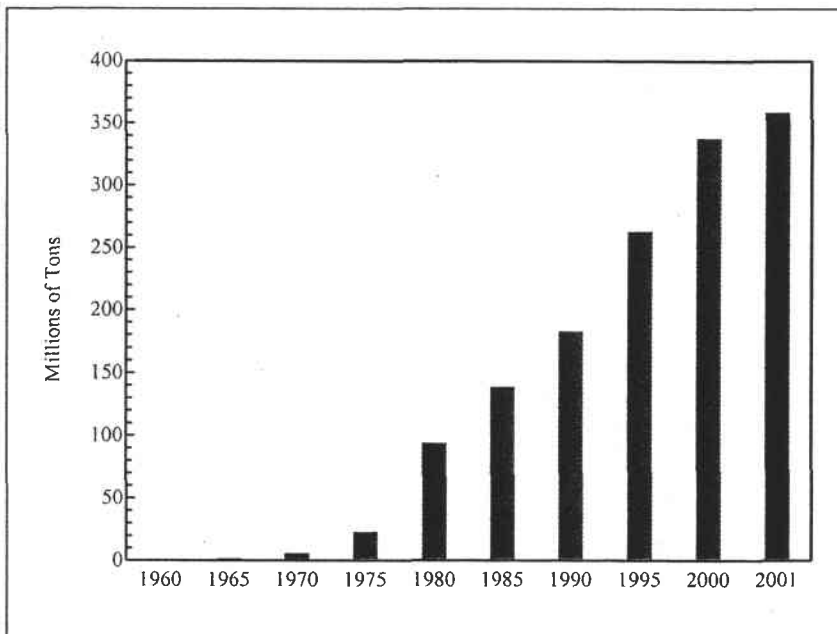


approximately 71 million tons of coal in 2000 (North Antelope/Rochelle Complex, 2000).

Wyoming has a 134-year history of coal mining. Commercial mining of coal in Wyoming started as the trans-continental railroad was being constructed across the southern border of Wyoming in the 1860's and coal was needed to power the locomotives. In 1868, the first

Figure 1. -- Coal production estimates for 2000 and 2001 for the top 15 producing states by millions of tons (source: Frame, 2000 and Lyman, 2001).

coal mine in Wyoming was opened in Carbon County under contract to the Union Pacific Railroad (Moorschlatt, 2001). By 1917, Wyoming was mining 8 million tons of coal. Examination of the last 40



years of coal production (figure 2) shows that through the 1960's and 70's the production was relatively small. However, in the 1980's and 1990's, the production increased at a rapid pace and Wyoming now produces about 360 million tons of coal annually (Lyman, 2001). There are several coal producing areas in Wyoming, but most of this production is from the Powder River Basin (figure 3).

Figure 2. -- Increase in coal production in Wyoming between 1960 and 2001 in millions of tons (Lyman, 2001).

By physical size, Wyoming is the ninth largest state with a 97 thousand square mile area. In contrast to its land size, the

population is the smallest in the United States with slightly fewer than 500,000 (Wyoming Department of

Administration and Information, 2002). The population has a strong western heritage and rural background. In 1998 the largest city, Cheyenne, had a population of 53,640. However, a significant number of people visit Wyoming on vacation or as short-stay residents. In 2000, about 3.8 million people visited Yellowstone National Park (National Park Service, 2002) in the northwestern corner of Wyoming. To give a perspective on that number, about 7 times as many people visited that one park as live in the state.

Wyoming's diverse ecosystem is part of what attracts the visitors. This diverse ecosystem also provides the framework within which mining occurs.

The terrain varies from mountains, to deserts and high plains, which are reflective of the large changes of elevation from 3,100 to 13,804 feet. The area is semi-arid with an average annual precipitation is 14.5 inches per year. However, that precipitation varies by a factor of 10 across the state from less than 6 inches per year in the Big Horn Basin to greater than 60 inches per year on the high mountains and Yellowstone Plateau (Martner, 1986).

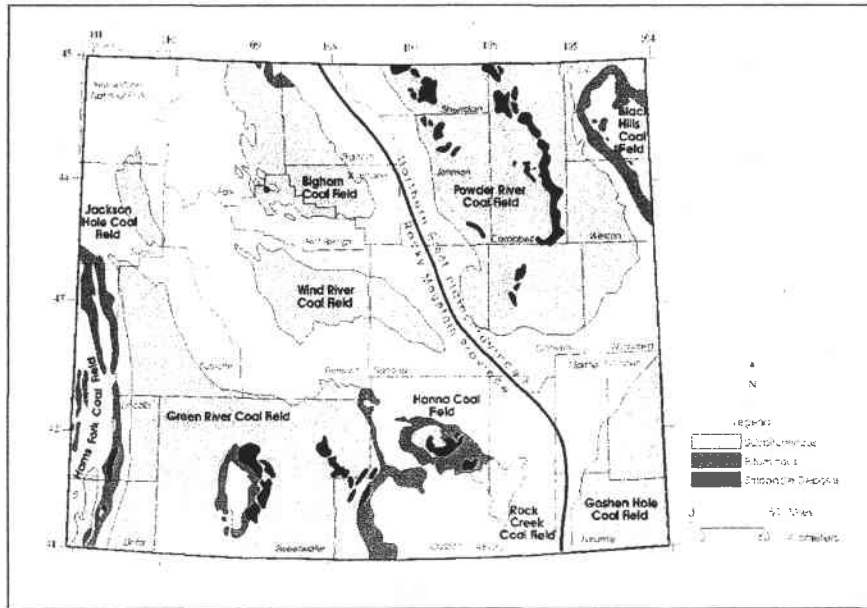


Figure 3. – Map of Wyoming with coal fields (source, Wyoming Geological Survey).

CHIA History

Wyoming's approach to CHIA's has evolved with experience. In the mid-1980's, Wyoming first CHIA effort was a Powder River Basin wide CHIA (Martin et al, 1988) that was completed as a cooperative effort between the WDEQ, the U. S. Office of Surface Mining (OSM) and the U. S. Geological Survey (USGS). It was published as Water Resources Investigations Report and included a cumulative assessment of 16 existing and 6 proposed mines. It covered the entire Powder River structural basin and three major river basins. It was a valuable document and we continue to use parts of it as a reference. However, it was broad in scale and general in assessment.

In 1992, OSM suggested to Wyoming that the 1988 CHIA was out of date and the agency should consider the need for a more current CHIA. WDEQ then participated in a second attempt to develop a large scale CHIA in cooperation with the University of Wyoming (UW), Wyoming State Engineer's Office (WSEO), Wyoming Geological Survey (WGS), Bureau of Land Management (BLM), and OSM. This effort became mired in modeling efforts and the development of coal bed methane (CBM). Although a pilot study was completed (Wyoming Water Resources Center, 1997), the agency decided that the process did not best meet the needs to assess the impact of coal mining.

Wyoming's approach to CHIAs has changed. WDEQ now prepares the CHIAs in house with

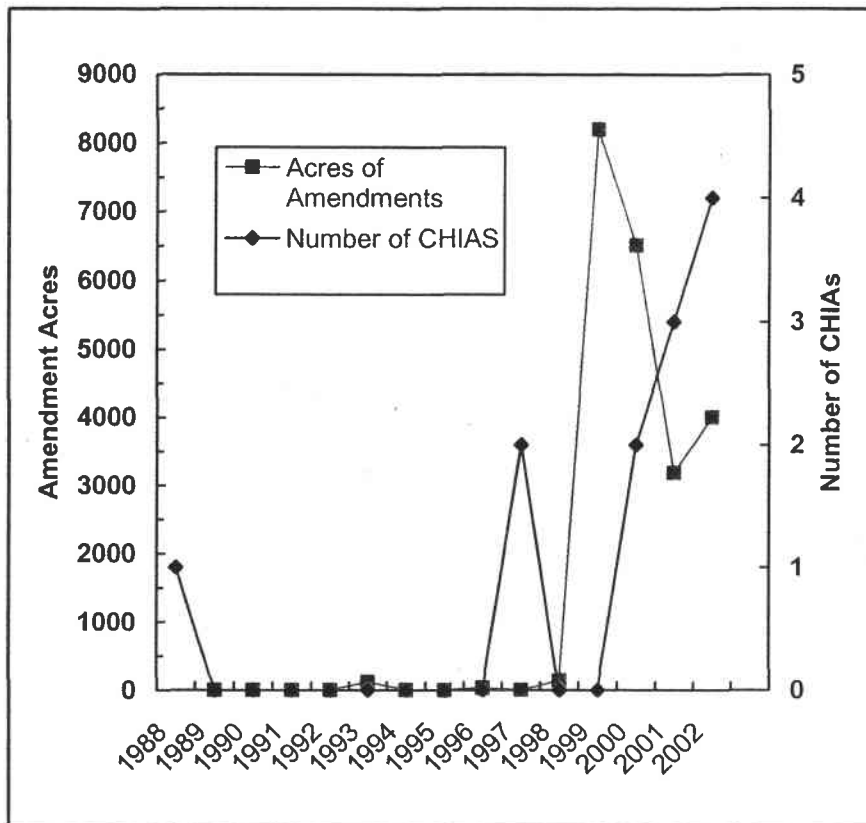


Figure 4. -- Number of amendment acres and number of CHIAs completed in Wyoming.

agency staff. The CHIAs are shorter documents with more specific analysis directed at the scale at which cumulative impacts can be measured and using current data from the permits, annual reports, and other published data sources. The agency did one CHIA in 1997, but it wasn't until 2000 that the need for the number of CHIAs began to grow. Two CHIAs were completed in 2000, three in 2001, and additional four are projected for this 2002 (figure 4). A CHIA hydrologist completes the work with assistance from a

surface-water hydrologist and additional support from district hydrologists and

permit coordinators.

The reason for the change from general to specific CHIAs was initiated both by OSM oversight suggestion and by a change in the economics of the coal market. On the economic front, Wyoming coal prices dropped from \$12.75 per ton in 1982 to \$5.30 per ton in 1999 (Wyoming Mining Association, 2001). Since companies had already made large capitol investments in Wyoming coal mines in the form of equipment, facilities, rail spurs and environmental permits, mining continued to increase during that period. After the initial permitting in the 1980's, other than a few small amendments, most of the environmental permit activity involved changes to mine plan to optimize stripping ratios, produce marketable coal quality blends, changes of ownership, and mine consolidations. Few new lands were added to the permits, so most of the cumulative impacts had been addressed in the original permit issuance. However, after 15 to 20 years of operation, the mines are submitting applications to amend new lands to increase coal reserves. This has resulted in large amendment applications, which require CHIA analysis (figure 4).

There are advantages and disadvantages to Wyoming's approach. The more specific analysis results in better-detailed examination of the data and at a scale at which an impact can be measure. One of the things learned from the basin scale CHIAs was that in highly variable hydrologic systems the basin variability might mask the impacts from mining. It was also found that the agency had the best knowledge base from which to perform this analysis. To complete general CHIAs, both the USGS and the BLM hired agency hydrologists because of the specialized knowledge and skills needed to work with mining hydrology and permits. When the general CHIAs were complete, the agency lost the knowledge base. It required staff time manage the CHIA contracts and keep the analysis focused on CHIA issues and not

diverting into research issues. By compiling the CHIA in house the agency can keep focused on the issues needed to make the CHIA findings and build on the knowledge base. A disadvantage of Wyoming's approach is that it requires agency staff time to produce the CHIA. There are also some the challenges in producing a document when publishing is not a general agency function. Wyoming's approach has the potential to create a bottleneck in the permitting process if several CHIA require completion at the same time. Wyoming is attempting to use advances in publishing technology and cross training to mitigate some of the disadvantages.

Wyoming CHIA Process

The framework for the Wyoming CHIA process is defined by the Wyoming Environmental Quality Act and the associated Rules and Regulations. These are part of Wyoming's approved program and generally mirror the Surface Mining Control and Reclamation Act (SMCRA). Wyoming Statute 35-11-406 (n) (iii) requires that "The proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area:". In WDEQ/LQD, Coal Rules and Regulations, Chapter 19, Section 2 (Required Studies), (a)(i) the requirements for specific types of groundwater and surface water information are outlined and "... This information shall be in sufficient detail to enable the Administrator to determine the probable cumulative hydrologic impacts on surface and groundwater systems including the impacts resulting from the proposed operation and their interaction with the impacts of all anticipated mining upon all affected hydrologic systems. Anticipated mining shall be projected over the life of the operation, and shall include all other existing coal-mining operations, any proposed operations required to meet diligent development requirements for leased federal coal where mine development and geological information is available. The assessment of the probably cumulative hydrologic impacts shall be sufficient to make the determinations of S. W. 35-11-406(n)(iii)."

For clarification and supplemental guidance, Wyoming consults several other sources. SMCRA, primarily sections 507 and 510, and the federal register of September 26, 1983, which provided additional clarification, are used for references. The OSM (2002) online and OSM (1985) printed guidance on CHIA and PHC provide some of the framework for the CHIA documents. The LQD developed agreements with two other State agencies, the WDEQ/Water Quality Division (WQD) and the WSEO to define material damage. To give a broader perspective on cumulative analysis, the cumulative impact guidance for other laws have been reviewed. Many laws require broader scope cumulative impact analysis including subjects of wildlife, air quality and others, in addition to hydrology. NEPA guidance contains a process for deciding when a CHIA is needed. The Department of Transportation has a succinct 11-point process on how to analyze cumulative impacts.

The Wyoming CHIA process involves six steps – 1.) Determination of when a CHIA is required, 2.) Defining the type of CHIA needed, 3.) Defining the cumulative impact area (CIA), 4.) Defining pre-mining conditions, 5.) Analyzing the impacts, and 6.) Determining the potential for material damage. Except for step two, Wyoming proceeds linearly through each step.

1.) Determination of when a CHIA is required.

Either a new mine application, any change to an permitted operation that results in a significant revision to the probably hydrologic consequences (PHC) section of the permit, or a change in hydrologic

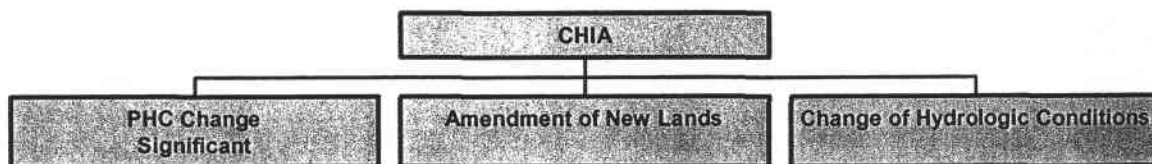


Figure 5. -- Diagram of when a CHIA is needed.

conditions will trigger the agency to complete a new CHIA. Types of activities that generally result in significant revisions to the PHC are amendment of new lands, a significant revision that affects the hydrology, or an unforeseen change in hydrologic conditions.

2.) Defining the type of CHIA needed.

The second step is to classify the type of a CHIA will be required based on the hydrology. There is some overlap with defining the CIA, but for clarity purposes the type of CHIA is discussed first. If the mine is hydrological isolated from other mines, a simpler CHIA is developed based on the PHC in the mine permit. If there will be additive effects from other mines or anticipated mining, then a regular CHIA is merited. To be hydrological isolated, the impact from that mine must not overlap with the impacts from other mines. For example, the drawdowns in impacted aquifers would not overlap with impacts from another mine and the surface water impacts are far enough away from any other mine as to not be measurable as a cumulative effect. If a mine is in close enough proximity to other mines or anticipated mining to contribute to cumulative impacts, then a regular CHIA is prepared. It is that regular CHIA process that will be discussed in the remainder of this paper.

3.) Defining the cumulative impact area.

Three factors play a part in defining the CIA; coal mining, time of impact and spatial area over which the impact will occur. Although the physical area is often emphasized, it is important to consider the other two factors first since they will help defined the physical area to consider.

Wyoming's CHIA's are limited to coal mining. Four types of coal mines – the operation that is proposed, the operations with existing permits, the operations with permit applications submitted, and the operations with due diligence requirements for Federal coal for which actual mine information is available – are considered. Data and analysis is available on the first three types of operations through Wyoming's permit processing. For the fourth type of operation, available data is obtained from published sources and from any planning documents available from the BLM or U. S. Forest Service.

The time over which the impacts are considered is controlled by two factors. First, the life of the mining operations is considered. The time frame on large operations may be in the 20 to 30 years range. The time may be extended as amendment areas are added and technology advances and price changes allow economic stripping of larger overburden to coal ratios. This time frame coincides with the bonding period for the life of the operation. The second is the time frame considered is that over which hydrology functions such as recovery of water levels, recharge to the backfill aquifer, and major geochemical changes to occur. Hydrologic time frames may be on the order of hundreds of years.

Identified coal mining operations and the time frames are used to delineate in space the areas of aquifers and surface water drainages that will be affected. This physical area then becomes the CIA. From a practicable point of view, for surface water a point is selected below a natural group of mines where there is a measuring point, but not so far downstream that any impacts will be masked. In groundwater, the general area is usually defined by the cumulative 5-foot drawdown contour in the coal. This works well from a practical application since the drawdown in the confined coal aquifer extends quite some distance and includes all areas of surface/groundwater interaction, groundwater water quality impacts, and impacts in the unconfined leaky overburden. Determining the CIA requires thought and professional hydrologic judgment.

The groundwater and surface water CIA's generally have not been the same areas in Wyoming's CHIA's because much of the cumulative analysis takes place in the Powder River Basin where the geological structural basin, which controls the groundwater flow, does not coincide with the surface water drainage basins. Powder River Basin coal aquifer outcrops at the edges of the structural basin and dips inward towards the center of the basin. Groundwater flow in the coal aquifers is generally from the outcrop towards the center of the basin with a regional component to the north. The surface water drainage is primarily into three different drainages; the Powder River/Tongue River system, the Cheyenne River,

and the Belle Fouché River. A very small amount of the North Platte River and the Little Missouri River drainages also come from the Powder River Structural Basin.

4.) Defining pre-mining conditions.

The pre-mining conditions are defined in the CIA for groundwater, surface water and areas of groundwater/surface water interaction. The sources of data for this analysis are primarily from the mining permits, but are supplemented by data available from the USGS, Gillette Area Groundwater Monitoring Organization (GAGMO), Wyoming Water Resources Data System (WRDS) Coal Permitting and Reclamation (CPR) database, WSEO, BLM, WQD, Wyoming Oil and Gas Commission (WO&GC) and coal bed methane (CBM) operators.

For water quality, generally a year's data are available and sometimes several years of data has been collected before mining is initiated. The data recommendations are detailed in WDEQ/LQD Guideline No. 8. Water quality samples generally include field measurements for; pH, temperature, conductivity, (and for groundwater; water level, casing volumes purged before sampling), (and for surface water; instantaneous discharge), lab measurements for nutrients, major ions, a suite of metals (and for surface water: dissolved oxygen, total suspended solids and turbidity).

Other data and analysis generally includes precipitation, evapotranspiration, infiltration, and runoff estimates, watershed and stream channel descriptions, water rights, design of diversion and containment structures, monitor well construction information, reclaimed topography and channels, geologic information, aquifer hydrologic characteristics, potentiometric surfaces for aquifers, monitoring networks, drawdown due to mining by aquifer, predicted post mine water quality, predicted post-mine runoff and surface water flow characteristics, predicted post mining recharge rates and groundwater flow. Individual descriptions of the hydrologic systems are extracted from the permits and merged with additional data and analysis as needed to develop a description of the water resources of the CIA area

5.) Analyzing the impacts.

It is important to develop a perspective on the water resources in the area so that the analysis time and resources can be focused on the significant resources. It is worthwhile to know that Wyoming law does not use the term significant resources, so Wyoming uses this concept from a hydrologic rather than a legal point of view. The primary factors that make a resource significant in a CHIA are either use of the resource or the extent of the resource aurally. If the aquifer or the stream is supplying water for identified uses such as drinking water, irrigation, municipal, or livestock, it becomes significant. Also, if the aquifer or stream has water that has the potential to be developed for uses, based on its quantity and quality characteristics, it also becomes significant. Some the characteristics that are important in analyzing significant aquifers are their hydrologic proprieties such as water quality, water levels, yields, hydraulic conductivity, storativity and water rights. The significant characteristics associated with the streams are the flow characteristics such as perennial, intermittent or ephemeral. Other items considered are the water quality, hydrograph characteristics, sediment yield, size of drainage, and water rights. Groundwater and surface water interaction areas where base flow is maintained by groundwater, where springs discharge, or where surface water recharges the groundwater are examined in more detail.

The purpose of the analysis portion of the CHIAs is to examine significant issues and resources that may be impacted. Wyoming has large permit volumes with extensive data. Mines may have 50 to 100 monitor wells, several surface water monitoring sites, and sometimes a weather station. In the CHIA analysis from the individual permits is cumulated to the CIA scale and verification or additional analysis is completed as needed. Published research on both general disturbed hydrology and on specific reclamation issues is consulted and integrated. The results of the CHIA are peer reviewed by other hydrologists and management in the agency. On specific topics, such as backfill water quality, peer review of experts in the field may be requested. Analysis considers for groundwater – quality, flow, hydraulic conductivity, storage, yield and head – and for surface water – flow, sediment yields, water quality. Monitoring by the

mines, as well as by the BLM, USGS, WSEO, continues and verification checks can be made on the CHIA findings.

One approach that may be changing in the future is the use of worst-case analysis. When the coal mines were relatively isolated from any other effects, it was reasonable and logical to use worst-case analysis. If it was found that the worst-case analysis of impacts did not cause material damage, then there was not a need to define the analysis more discretely. However, with CBM becoming an increasing impact to the coal aquifer and to the overburden, it may become necessary to separate the two impacts. In that case more precisely definition of the impact due to coal mining may be needed.

6.) Determining the potential for material damage.

A Statement of Material Damage was developed between the LQD and the WSEO and the WQD. The

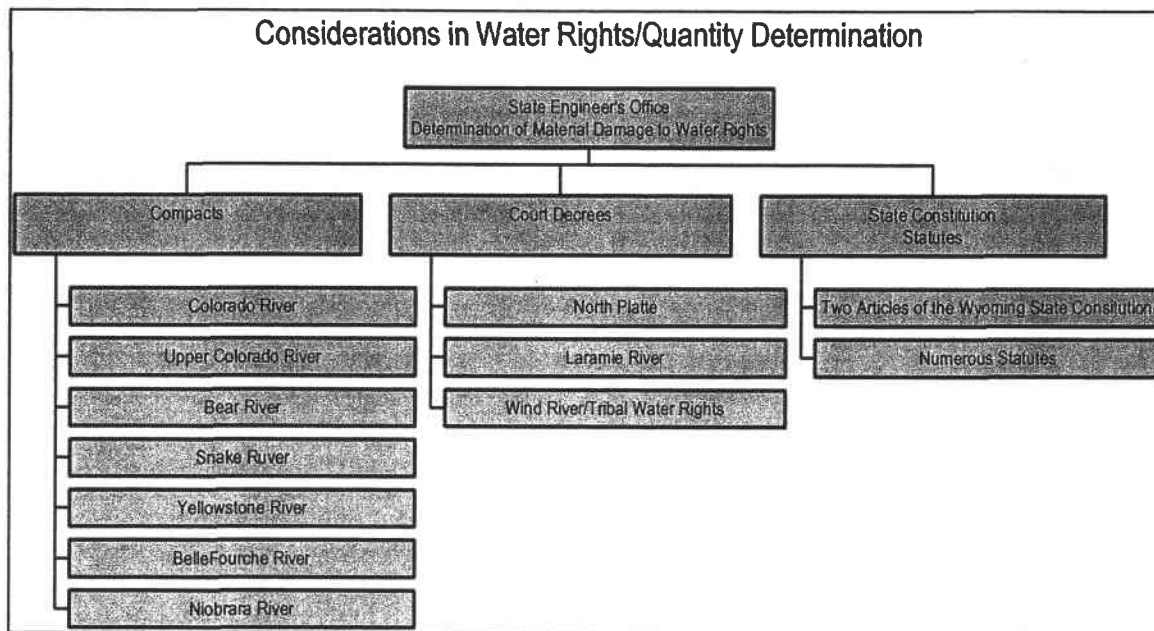


Figure 6. -- Considerations by the Wyoming State Engineers Office in the material damage agreement.

items in these flow charts were identified as being relevant laws, regulations and other governing documents related to material damage (figures 6 and 7). The document was the signed by the Director of the WDEQ and the State Engineer, WSEO. As a result of this process, all Wyoming's CHIA are reviewed by those two agencies, concurrences is obtained, and they are signed by the Director of the WDEQ and the State Engineer, WSEO. There are numeric standards in the WQD Rules and Regulations for each class of use in groundwater. The surface water classification is based on use or potential use and the level of degrading allowed under the WQD Rules and Regulations.

The projected impacts are compared to baseline or to the quality of use standards, as applicable. Based on the comparison to those standards, a recommended finding is made of potential for material damage. If the recommended finding of material damage is made, the permit application or change is denied. If the recommended finding of no material damage is made, the CHIA is sent to other agencies for review. If concurrence is received, then the document is signed by the Director of WDEQ and the State Engineer of WSEO and is final. The permit or permit change is issued and a copy of the final CHIA is placed in the permit with additional copies sent to OSM and the company.