

Visual Analysis as a Design and Decision-Making Tool in the Development of a Quarry¹

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Abstract: In order to obtain local and state government approvals, an environmental impact analysis of the mining and reclamation of a proposed hard rock quarry was required. High visibility of the proposed mining area from the adjacent community required a visual impact analysis in the planning and design of the project. The Visual Analysis defined design criteria for the mining and reclamation plans to minimize adverse environmental impacts and encourage long-term beneficial land use. Visual analysis provided an additional tool for the citizens, local government, and state government officials to evaluate the proposed mining activity.

INTRODUCTION

One application of visual analysis is as a design tool in site specific mining and reclamation plans which are responsive to the surrounding environment. Constructive use of visual analysis was an important element in the planning of a proposed mining site west of the Denver Metropolitan Area. This paper illustrates the application, on a local scale, of a visual analysis process used in planning, design and evaluation. The consultant's role was

the coordination of studies and preparation of plans and documents required for mining permits to extract and process the hard rock on the site for use as gravel in the Denver Metropolitan Area. The site was predetermined by the client. The initial mining concepts involved expansion of an existing hard rock quarry at the base of the Front Range of the Rocky Mountains.

The site is visible from a community of approximately 10,000 people and several major regional transportation corridors. As a result, the magnitude of visible change, at any time, in the natural character of the landscape of the Front Range is a critical component in the decision to allow or not allow further mining of the area. Any effort to minimize the adverse environmental effects of the proposed mining activity mandated the use of comprehensive visual resource management in both the design of the mining and reclamation plans and the local and state govern-

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ment approval processes.

The need for comprehensive analysis and planning, coupled with local and state requirements, required an environmental analysis of the proposed mining activity. The visual analysis was one part of the environmental impact analysis used to evaluate the potential impacts of alternative mining plans. As a result of the studies, specific design criteria were developed to minimize the adverse impacts on the geology, hydrology, vegetation, traffic, air quality, etc. of the site and its surrounding vicinity. The criteria were used to evaluate alternative plans and design the final mining and reclamation plans.

The principal objectives of the overall study were threefold:

- to obtain the necessary governmental approvals to extract the gravel,
- to minimize adverse environmental impacts on both the land and the adjacent community, and insure the beneficial long-term use of the land, and
- to aid in responsible government decision-making with regard to the issuance of approvals and mining permits.

The visual analysis of the site helped accomplish these goals by (1) defining on-site design criteria for incorporation in all phases of the mining and reclamation plans and (2) analyzing the off-site visual impacts on the surrounding land and community.

VISUAL IMPACT FACTORS

The surface mining process visibly changes the natural landscape in both landform (of a permanent nature) and character (which may be of a temporary nature). The change is not from a natural to urban environment. In this case, it is a modification of the existing landscape and the eventual reinstatement of similar natural conditions. Alterations in the landscape due to gravel mining occur in two ways:

- in the short-term, through constantly modified landforms resulting from ex-

traction processes of mining, and

- in the long-term, through the modification of the final landform and revegetation of the land.

Visual impacts of surface mining result from both the operation of the on-going extraction process and the short- and long-term changes in the natural landscape. The operational factors which will affect the magnitude of impacts include 1) the quantity of material to be extracted, 2) the amount of land disturbed at any one time and over the life of the project, 3) the location and visibility of the mining area, the crushing equipment, haul roads and conveyor systems, 4) the rate and phasing of reclamation, etc. Additionally, the sequential use of the land after mining will also affect the magnitude of impact.

SUMMARY OF THE PROCESS

In simplified terms, the visual analysis process determined the locations and characteristics of the most visually significant portions of the proposed mining site and then developed criteria for the mining and reclamation plans which least adversely affected those areas and the community. The process is outlined as follows:

- Define the characteristics and location of the most significant portions of the proposed mining site.
- Develop mining plans to minimize adverse effects on these areas.
- Develop a reclamation plan to maintain the character of this site with the integrity of the surrounding land of the Front Range.
- Analyze the magnitude of change from the existing conditions both during the extraction process and at the completion of the final reclamation as viewed by the adjacent communities.

To accomplish these steps the community is first divided into subareas, called Rate Areas, and the characteristics of each area are defined. The site is then divided into smaller subareas, called Site Subareas, which are analyzed individually in relation to

the adjacent land from each Rate Area. The result is the identification of the location and characteristics of the most significant areas of the site as viewed from the adjacent community. Mining and reclamation plans are then evaluated and selected. Since the visibility of each Site Subarea has been documented from each Rate Area, the magnitude of visual change resulting from the final mining and reclamation can be determined.

ANALYSIS PROCESS

To define appropriate design criteria for the mining and reclamation plans and to estimate the potential visual impacts of specific plans, the most sensitive and/or visually significant portions of the site must first be identified. The significance of each Site Subarea is determined by the natural characteristics of that portion of the site in relation to its surroundings (herein referred to as the qualifier) and characterized by how many people can see it, for how long and from how far away (herein referred to as the quantifier).

Predominance of Site Subareas

The existing conditions of the site are first evaluated as seen from the surrounding land and the adjacent community (fig. 3).

1. Both the site and the viewshed are divided into subareas. The site is divided into subareas using topographic change such as ridges and drainages as the criteria for area definition (fig. 1).

The physical boundaries of the viewshed of the site are also defined. The general land use characteristics of the viewshed are defined and form the criteria for subarea definition. In this case there are three residential areas and four transportation corridors. These areas are referred to as Rate Areas, to minimize confusion with subareas of the site (fig. 2).

2. To reflect objectively, the characteristics of each of the Rate Areas, their identifying factors of number of people

(refer to "a" below), degree and/or length of visual exposure to the site (refer to "b" below), and average distance from the site (refer to "c" below) was calculated.

- a. Number of people (N)
The number of people for each Rate Area was calculated for residential areas by multiplying the number of dwelling units times their average population density³, or for transportation corridors by multiplying the average daily traffic count by 1.5 people/car.
- b. Time of Exposure (T)
The degree of visual exposure was the anticipated time that the viewers within the area could see the site or a portion thereof. In the residential areas the yearly average daylight hours were found for the Golden latitude and longitude. The transportation corridors were driven at their respective speed limits and timed⁵. These calculations indicated average daily time the viewers within a rate area would be exposed to the site.
- c. Distance from the Site (D)
Average distance was found by drawing a series of ¼ mile concentric circles radiating from the site. Each Rate Area was given its distance factor according to the number of circles it fell within and their distance from the site.

The factors resulting from each of the above characteristics are multiplied to produce one "quantifier" for each of

^{3/} City of Golden Planning and Zoning Department records.

^{4/} Average vehicle occupancy rate, Denver Metropolitan Area, Denver Regional Council of Governments.

^{5/} The speed limits of the different roads varied from 40 to 55 mph.

the seven Rate Areas.

3. An evaluation of the Site Subareas was next conducted. Each of these Site Subareas was evaluated from each Rate Area. This was done through an examination of the elements that create visual prominence in a mountain landscape; visibility, orientation to observer, color and texture in relation to surrounding areas, and ridge-line dominance. "Visibility" defines whether the Site Subarea can be seen from that part of the community; "orientation" describes the degree which the Subarea faces the observer and the seasonal and/or vegetative characteristics which may affect its significance, i . e . , snow accumulation. "Texture and color" address the variation and characteristics of the vegetation and rock outcropping in relation to the adjacent areas; and "ridge-line dominance" defines the significance of the ridges based on whether they define the skyline profile of the mountain or serve to define topographic change and overall landform.

Because each Site Subarea is a different size, the acreage of each was considered another contributing factor in qualifying the significance of the subarea. Each of the subjective "qualifier" scores was multiplied by the acreage to reflect the size differential (fig. 1) and provide a "qualifier" for each area.

4. The qualifying score for each site subarea is multiplied by the rate area quantifier score, giving a prominence score. This is calculated for each rate area. Each prominence score is added together to give a Total Prominence Rating for the Site Subarea.

Design Criteria

The process has now documented the significant natural characteristics of the site to be used as important criteria for both the mining and reclamation plans. These criteria included:

Vegetative zones --

The extent, coverage, orientation, type, texture and color of areas of predominantly grass vegetation, shrub vegetation, and/or tree vegetation, interim revegetation potentials and final revegetation character.

Land forms --

The size, slope, orientation, shape, and character of the landforms, ridges, and drainages both during the extraction phases and at completion of reclamation.

Rock outcroppings --

The size, locations, shape, slope, mass texture and overall appearance of rock outcroppings and/or rock faces.

The effects of light or seasonal changes on the significance of the subarea.

As each phase of the mining process is determined the affected areas and resulting landforms are identified, and the off-site visual appearance of the site's subareas can be evaluated. Design changes and/or operational changes can then be made to minimize the adverse visual effects seen from the community and surrounding land. These design and operational guidelines consist of such things as 1) limiting the amount of land disturbed at any one time, 2) identification of areas, landforms, vegetative character to be preserved, and/or replaced, the location and design of haul roads, the character and extent of area of revegetation and rock outcropping to maintain the visual continuity of the site in relation to the Front Range vicinity, 5) revegetation and soil stabilization procedures and schedules, 6) topsoil stockpiling and redistribution, and 7) definition of areas where permanent buffering and/or screening of the operation are desirable. All of these and many other design and operational criteria are essential considerations in minimizing the potentially adverse impacts of surface mining.

Visual Impact on the Community

The visual impacts of alternative mining plans, their interim phases, and their

resulting reclamation potentials can then be evaluated. This is accomplished by determining the magnitude of increased visual impact in relation to the existing conditions. The magnitude of change consists of variations in the amount of exposed land, number of people exposed to the operation, and the nature of their exposure.

The potential viewshed for each alternative is defined to establish the variations in the area exposed to the mining project. The changes in the number of people, distance and duration of exposure to the operation are then documented. The visibility, character, and orientation of the 1) land disturbed during various phases of the project, the physical extent of the mining operation, 2) the areas of revegetation and rock outcropping, 3) all aspects of the mining operation, such as the location and type of equipment and the processing and transportation of materials, and 4) the reclamation phasing schedule in relation to the extraction schedule, etc., must all then be documented to further define the magnitude of change. This information is mapped on

the same base map or overlaid over the existing visual impact map to illustrate graphically those changes (fig. 4). The result is an analysis of the variations in the visual impact of a proposed mining plan and reclamation plan on the surrounding community.

The Value of Visual Analysis in Decision-making Processes

The citizen and/or government decision-maker is afforded an instrument to analyze the characteristics and results of a proposed action, and weigh them in relation to the overall policies and goals of their jurisdiction. Also, the authorities who govern mining operations can then issue permits based on an evaluation of a proposed action. This evaluation includes the short- and long-term visual implications of the mining activity. This information should be used by the client, planner, consultant, citizen and/or government decision-maker to develop detailed mining and reclamation plans which will benefit the community and its environment.