

CASE STUDY: POST-MINING LAND-USE PLANNING AND DESIGN: AN OVERVIEW AND MICHIGAN¹

Yun Wang², Jon Bryan Burley, and Shawn Partin

Abstract. Planners, designers, scientists, governmental authorities, non-governmental organizations, and citizens are interested in the thoughtful use and protection of the environment, including surface mined lands. Surface mining is a temporary use of the landscape, leading to a post-mining environment. In the 1960s, the late Ken Schellie was a pioneer in understanding how to create a productive and valuable post-mining environment. The creation of a successful post-mining environment begins with understanding the nature of the deposit and the extraction/processing methods, as this insight leads to opportunities to create productive land through the mining process with little additional costs. Often the post-mining landscape is more valuable than the land before mining. In addition, creating post-mining environments requires knowledge of the current regulation requirements. Being trained in the planning and design processes and having experience and knowledge across the spectrum of potential land uses from urban to wilderness are essential to professionally create post-mining environments. Today the ideas and knowledge gained from post-mining land-use planning and design is influencing other types of reclamation activities such as post-industrial reclamation and reclaiming urban areas. We illustrate the process of post-mining land-use planning and design with a case study from the Upper Peninsula of Michigan and show how portions of the design are assessed with landscape metrics.

Additional Key Words: landscape architecture, environmental design, surface mining, planning, reclamation, recreation resources.

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² Yun Wang is a masters of environmental design student in the School of Planning, Design, and Construction at Michigan State University, E. Lansing, MI 48823 USA. Dr. Jon Bryan Burley is an associate professor of landscape architecture at MSU and visiting scholar in the Département du Paysage, Agro-campus Ouest, 49045 Angers, CEDEX 01, France. Shawn Partin holds a Master of Environmental Design degree from MSU and is a practicing professional in Mamaroneck, NY 10543 USA.

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Introduction

Surface mining is an essential activity to supply the resources for many commodities and items in everyday use across the globe. This activity requires digging in the ground (Fig. 1), moving and sorting of materials, transportation of resources, and configuring the post-mining environment for use after the resources have been extracted. Surface mining can be a thoughtful activity creating useful and beneficial environments after the extraction is complete. In 1988, a project initiated by the American Society of Mining and Reclamation (ASMR) members resulted in the publication of the award winning Environmental Design for Reclaiming Surface Mines (Burley, 2001) concerning the state-of-the-art in post-mining land-use planning and design. The book featured chapters describing important aspects and guidelines to consider when reclaiming land disturbed by surface mining. The book acknowledged the late Ken Schellie for his pioneering efforts in studying post-mining land-use and design. The chapters in the book



Figure 1. Surface mining in Wyoming (copyright 2007[©] Jon Bryan Burley, all rights reserved, used by permission).

stressed the importance of having professional abilities in the planning and design creative processes. The book also emphasized the importance in understanding the character of the deposit, extraction methods, material processing, sorting, storage, transportation, the regulation setting, and environmental stabilization. In addition, the book featured insight into creating landscape from surface mining for a variety of resource types (phosphate mines, coal, hard rock, sand, and gravel) and land uses: agronomic, grazing lands, forestry, housing, recreational, visual quality, and multiple land uses. Additionally, the book presented hundreds of references on the topic of post-mining land-use planning and design.

This review article on the topic seeks to emphasize some of the major points in the book with a current case study from a post-mining land-use study in Michigan and present how the ideas initiated within the surface mining and reclamation industry are influencing other types of land reclamation activities.

The planning and design context in which surface mining and reclamation have experience over the 150 years has evolved and changed. In the 1860s and 1870s when the first university courses related to exterior design were offered (Burley and Pasquier, 2005), the focus was upon aesthetics and residential design, following the Beaux Arts educational approach of emulating Italian, French, and English landscape styles. Reclaiming the environment meant building dikes and creating new land from the seascape and eventually reclaiming arid lands in the United States (Burley, 1989a). By the 1930s, the modern landscape movement emerged where the intent of each design was considered to be original and fulfilling the functional requirements of the client. The movement also included ecological analyses and treated the environment as a client. The result was that there was a new awareness concerning the design of the environment. This meant that the post-mining conditions of abandoned surface-mined lands were being scrutinized. Ken Schellie was instrumental in bringing environmental planning and design insight into surface mine reclamation activities (Burley and Bauer, 2000). State, federal, and local laws and regulations initiated active research in understanding and building the knowledge base in surface mine reclamation. Much of this information was shared through proceedings at annual meeting of ASMR. During this time, planning and design activities entered the short-lived post-modern era that did not affect reclamation, where art and design engaged in intellectually amusing ideas, if not enduring ideas (Burley and Pasquier, 2005). By the late 1990s, planning and design began entering the post, post-modern era, where five co-dominant dimensions greatly influence projects built in

the environment. The dimensions are: 1) function (such as sustainability, efficiency and effectiveness, housing, and transportation), 2) economics (job security, and economic development), 3) culture (traditions, religious beliefs, and philosophies), 4) ecological (biological diversity and global environmental relationships), and 5) aesthetics (the beauty of life on the planet earth). This era is also known as the age of context sensitive design (which originated in the transportation sector) where design of the built environment must successfully consider a broad set of planning and design criteria (Westphal et al., 2005). It is in this context, sensitive design setting, and contemporary reclamation activities must operate. Surface mining is part of the economy providing jobs and the post-mining landscape must be productive in the economy. Mining must be functionally effective and efficient. Further, the post-mining environment must be arranged to be functionally effective. Ecological, cultural, and aesthetic issues must be successfully addressed during mining and for the post-mining environment as well. This means that surface mining and post-mining land-use planning and design can be complex and multifaceted. It is not a simple task. It requires the input and engagement of reclamation experts, mining companies, planners, designers, government officials, and citizens to make both resource extraction and creating a post-mining land-use a success.

Pertinent Literature and Fundamental Post-mining Land-use Reclamation Concepts

Ken Schellie

The contributions of Ken Schellie, a planner and landscape architect, who began consulting with the National Sand and Gravel Association and the National Industrial Sand Association in 1948, was profiled by Burley and Bauer (2000). In cooperation with these associations and the University of Illinois, he published and directed the publication of various surface mining reclamation documents including: Schellie (1977), Baxter (1969), Pickels (1969), Shellie and Bauer (1968), Jenson (1967), Johnson (1966), Bauer (1965), and Schellie and Rogier (1963). He developed six planning and design principles, which are the foundation of any post-mining land-use planning and design project across any type of mining operation and location today.

Principle 1: Mining as a Transitional Land –use. The site of a surface mine was once the site of a previous land-use and after the mining operation are complete, the land will be used for something else. Sometimes, this long-term perspective is forgotten, especially when a mine may be in operation for generations.

Principle 2: Simultaneous Excavation and Rehabilitation. Ken Schellie promoted the thoughtful, planned, and efficient extraction of surface mined resources in an orderly fashion, disturbing only the lands necessary for current production and at the same time reclaiming those lands where resource extraction is complete. This process is the trademark of many surface mines today, including coal-mined lands in Wyoming, to phosphate-mined lands in Florida.

Principle 3: Mining Operation Creating Post-mining Land uses. Schellie realized that the movement of earth, materials processing, and the placement of overburden provided an opportunity to create land suitable for a designated post-mining land-use. In other words, if one planned ahead on the quantity of remaining materials and projected post-mining land-use, one could create reclaimed lands effectively and efficiently at minimal cost. The skills and abilities of the planner, landscape architect, and engineer are essential in this third principle.

Principle 4: The Post-mining Land can be more Valuable than the Pre-mining Landscape. Schellie observed that agricultural land near urban areas that was mined could later be developed into highly beneficial urban land. Land beyond the urban fringe that was mined land could become extraordinary wildlife habitat or recreational lands (Fig. 2). In other words, the mining process could create land with added value. Thus Schellie saw the mining process as a very positive influence in creating post-mining landscapes that were functionally beneficial.

Principle 5: Multiple Post-mining Land uses. Because of Schellie's creative educational training, he knew that the post-mining landscape could be assigned many uses. It is sometimes believed that the post-mining landscape should return to the original land-use (and sometimes by law it must), or should have only one land-use function. But as a land designer, Schellie knew how to assess a site for a diverse set of functions and could propose a variety of functions for the site according to the site's capabilities.

Principle 6: Surface Mining Planning Results in Fewer Delays, Efficient Mining, and Increased Profits. This was Schellie's major point with the industry as Schellie was just as concerned about mining operators making money as much as he was interested in creating usable land afterwards. In many ways, Schellie was a "post, post-modern" planner and designer before Tom Turner (1996) firmly established the idea.

Ken Schellie passed away before the establishment of the ASMR and as key surface mining laws and regulations were being implemented. Nevertheless, he had a tremendous influence upon the normative ideas imbedded in modern surface mine reclamation.

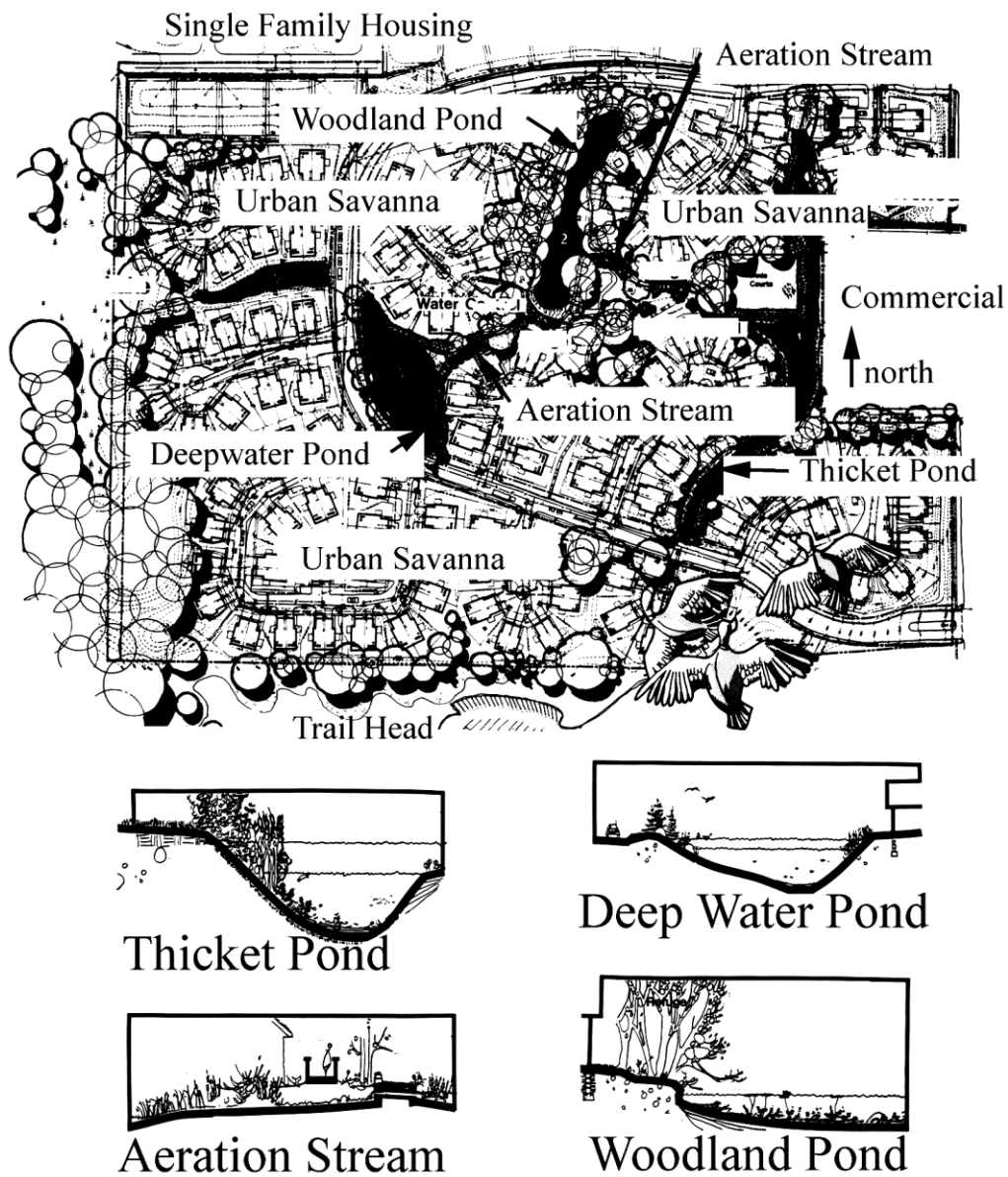


Figure 2. A drawing of the wetland features of Cimarron Ponds (described in Burley and Martin, 1988), a sand and gravel surface mine that became a housing development after mining (copyright 1981 © Jon Bryan Burley, all rights reserved, used by permission).

Mining Methods, Laws/Regulations, and Operations.

As indicated in Schellie's principle number 3, in order to understand the opportunities to reclaim a surface mine, it is extremely important to understand the mining process, methods, and materials. This does not mean that one must be a mine engineer, but one must know the limits of the mining operations, how the material is processed, and what the by-products/excess materials will be. Georgian Collins, a mining engineer and landscape architect provides an overview of the essentials related to surface mining (Burley, 2001). In addition, the late Norm Dietrich, also a mining engineer and landscape architect explores the pertinent laws and regulations at federal, state, and local levels that govern mining activities (Burley, 2001). Finally, Anthony Bauer, FASLA, a former associate of Ken Schellie describes the mine operations process and how it can be employed to create reclaimed land (Burley, 2001). These topics form the knowledge base for mining materials and extraction knowledge base that is essential to professionally understanding the opportunities for making thoughtfully reclaimed sites.

Planning and Design Process.

Another knowledge base in creating reclaimed land is the information imbedded within the planning and design professionals (Burley, 2001). This begins with a fundamental understanding of historic precedent (what has been done before). In addition, the professional planning and designers must have experience, training, and practice in the processes that leads to the implementation of a solution. They need to be trained in developing a program, conducting an inventory, generating a synthesis of the essential components, developing a concept to lead the creation of form, and the creation of implementation documents. This is something that cannot be learned overnight. Usually it takes 4 or 5 years of repeated supervised practice and guidance in a university setting, several more years of professional office practice, and then completing/passing a lengthy registration examination. Often the leading designers have practiced for 30 or more years and have gathered considerable experience in their area of expertise including construction technology and successfully working in the political context associated with projects and land-use.

Post-mining Land Uses.

Sometimes reclamation practices focus mostly on the technical aspects of revegetation. After all, surface mining disturbs the surface of the landscape and the land needs to be stabilized again. However, revegetation is just one aspect of reclamation. The late Robert Dorney (1984), an ecologist from the University of Waterloo, in Ontario, Canada, used to comment that sometimes

the “cure,” meaning the reclamation plan, was worse than the “disease,” surface mining. Instead, he thought that reclamation should focus upon creating usable land in a thoughtful manner. To accomplish creating usable land requires knowledge and skill across various land-use types including land for housing, commercial development, industrial lands, agronomic lands, grazing lands, forested lands, recreational lands, land for wildlife habitat, and knowledge in visual quality. This knowledge base is featured in Burley (2001).

Therefore, to develop a surface mine reclamation plan, it is helpful to know how mining is conducted, have experience in planning and design, and know about a variety of land uses.

Surface Mining Reclamation Principles Applied to Other Transitional Land uses

Just as the notion of reclamation has changed and evolved over the last 100 years, it continues to evolve. The latest trends in reclamation include reclaiming brown fields (contaminated land), industrial sites (post-industrial reclamation) (Loures, 2010) and urban areas (grayfields) (Burley et al., 2011). In many respects, any land-use may be a transition to another land-use. The spatial and content properties of any land parcel may require amendment, adjustment, and reconfiguration. Much of this knowledge base is found in surface mine reclamation journals, proceedings, and reports.

Context Sensitive Planning and Design Case Study: A Michigan Example

Surface mining companies have engaged cooperatively with university professors in educating college-aged students about planning and design opportunities concerning environmental design (Nieratko and Burley, 2003). Surface mines are interesting places to learn about planning and design because mining operations move earth and allow students to imagine new post-mining configurations in the landscape. In the Upper Peninsula of Michigan, the Cliffs Natural Resources Company has offered opportunities for students from China, Portugal, and the U.S.A. to learn about resource extraction, mining operations, and have allowed use of the site as a study area to learn about reclamation. Koski (2005) described reclamation activities at this mine. The mine is located in a relatively low population density, hilly, and forested landscape, with recreation, forestry for paper production, watershed conservation, and wildlife habitat being common local nearby land uses. The mine is extremely important in the economy and supplies a substantial portion of the nation’s iron for manufacturing. Cliffs Natural Resources Company operates in an

environmentally thoughtful and creative manner. In the past, the company worked in cooperation with a nearby paper mill in their reclamation activities (Koski, 2005).

One of the potential post-mining land uses affiliated with large hard rock iron ore mines in the Upper Midwest is affiliated with recreational opportunities such as downhill skiing. For example, near Biwabik, MN, a winter recreation ski slope has been built upon overburden/waste rock piles from a nearby iron mine, providing 500 ft of vertical drop. The Cliffs Natural Resources Company at their mine site could potentially create landscapes providing skiers and snow boarders the possibility of over 2000 ft of vertical drop for a substantial skiing experience in the Midwest. While there are currently no such plans at the mine, the site does provide opportunities for students to study these kinds of applications. To begin planning, development, and analysis of such a design, one of the key organizing features for ski areas is the placement of the ski slope (Johnson and Burley, 1990). In our study, the ski-slope site was chosen on the south side of one of the largest basins offering a north-facing slope for snow retention (Fig. 3).

Design layout

Planning and design is a process where land uses and general spatial organization are often the first visible design elements that emerge from extensive inventory, programming, analysis, and public meetings, as form and the details of the design evolve (Burley, 2001). The layout is often described as a synthesis (Fig. 3) displaying the essential land uses and spatial arrangement for the design. Fig. 3 is not yet a design, but is a precursor to a design giving the locations of the major program elements. Planning and design is a convergent process because it may take many public meetings and planning sessions to reach consensus on a basic land-use plan. In this case study, there are two major functional parts of the layout: 1) the ski slope and 2) the facilities base area. One of the unique characteristics of this skiing facility is that the facilities base area is located on the top of the ski slope. At many ski areas the base area is at the bottom the mountain or slope. A location at the top of the ski-slope provides scenic views and, in this case, is close to an existing road (Fig.4). The services at the facility base area will consist of: 1) a general service center, 2) a commercial center, and 3) hotels and chalets (Fig. 5). Figure 5 presents another step of organization of the site based upon the general spatial ideas in Fig. 4. The sequence of drawings in Figures 3 through 5 illustrate the process of design development where refinements are made eventually leading to final design details.

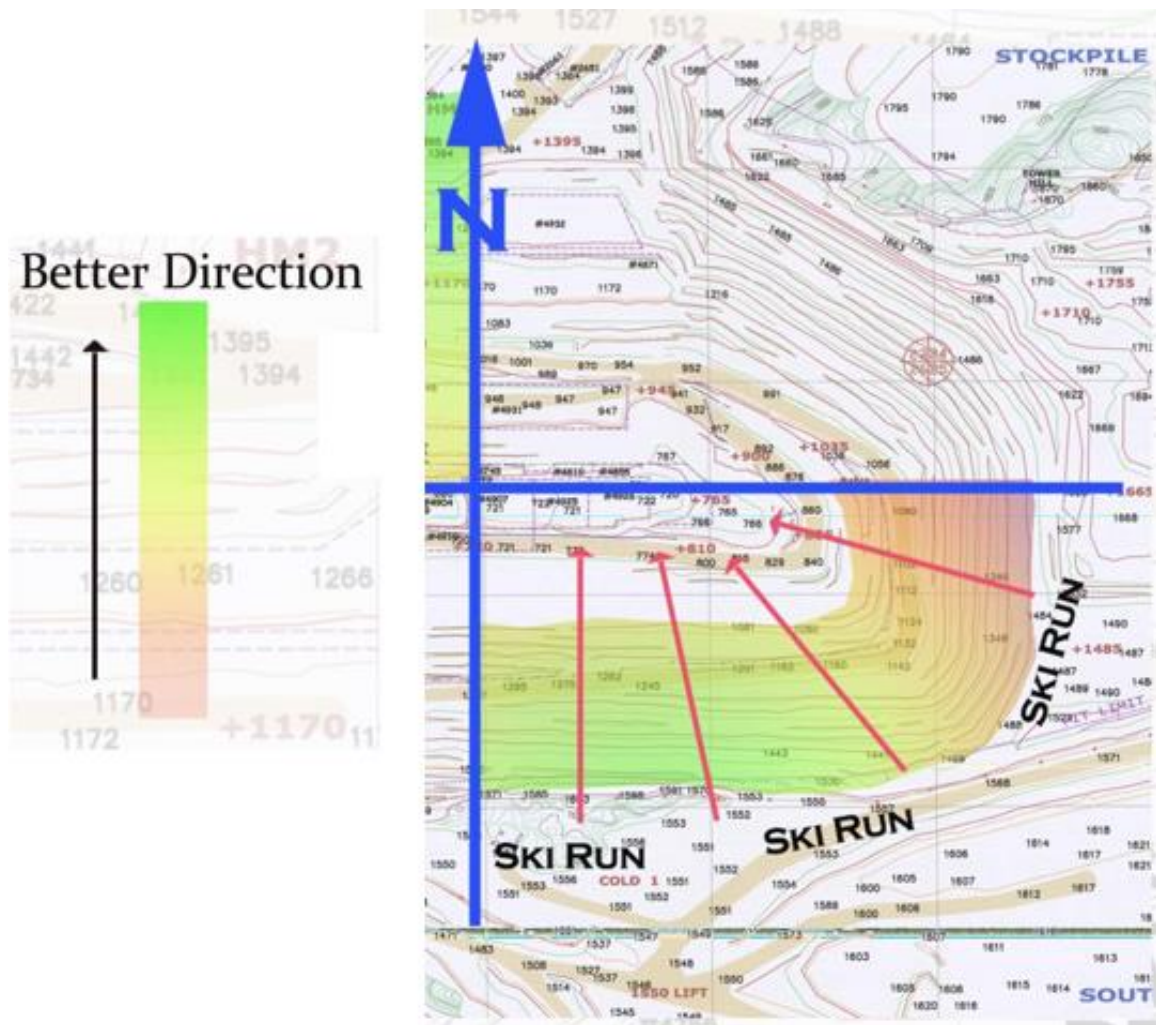


Figure 3. The green areas indicate the best orientation for a ski slope in the study area (copyright 2011[©] Yun Wang, all rights reserved, used by permission).



Figure 4. An aerial view of the study area setting and basic program features for the investigation (copyright 2011© Yun Wang, all rights reserved, used by permission).

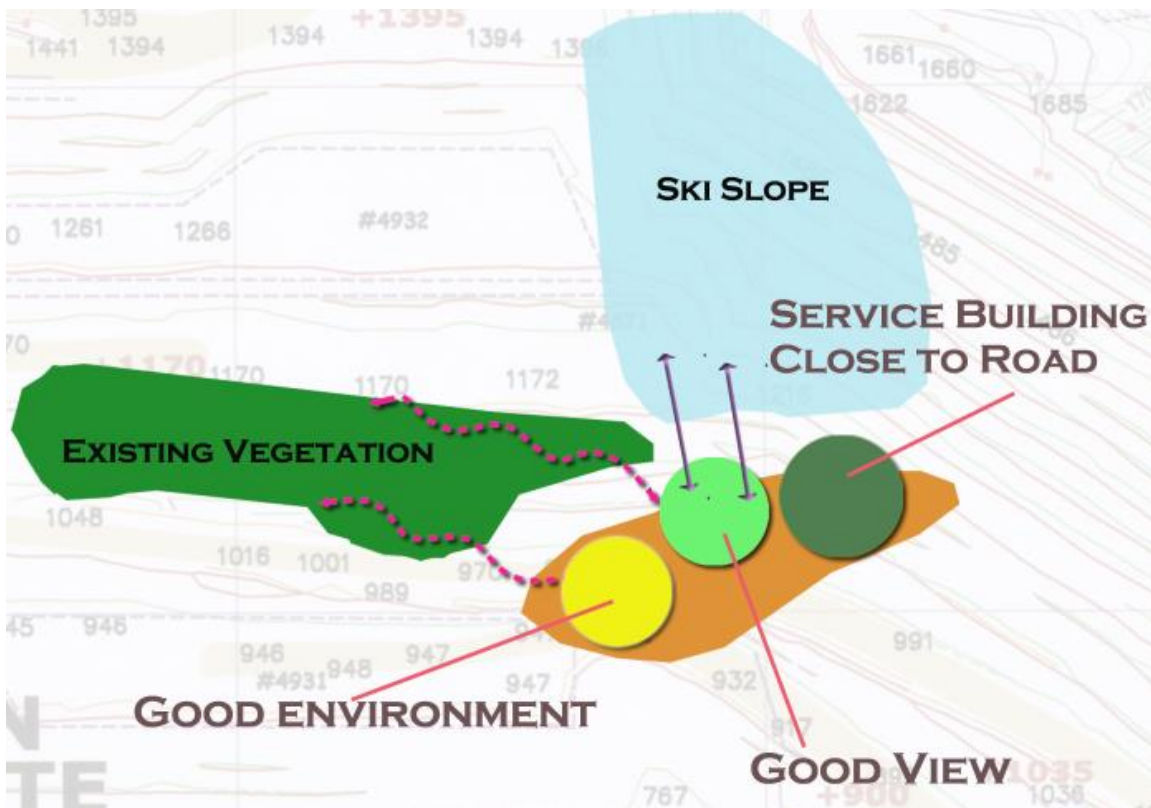


Figure 5. This drawing is a functional use diagram applied to the existing site, providing greater detail and evolving development of the design (copyright 2011© Yun Wang, all rights reserved, used by permission).

The manner in which the various land uses become connected via circulation design is often considered during these initial planning phases. There are still many choices and options available. In this study, the program suggested a pedestrian-oriented facility center. The commercial center, service center, and hotel area will only be accessed by pedestrians; no cars will be allowed. There will be vehicle access outside this zone. The main entrance will be located at the east end, the exit is on the opposite side; and there will be a minor entrance next to the main entrance for service staff. Two large parking lots will be located beside the main and minor entrance for public and staff as well as several smaller parking areas along the road for the commercial center, chalets, and hotel (Fig. 6). The described plan evolved from the program of the site and is reflected in the circulation design. Sometimes various versions or alternatives are explored with the client and public.



Figure 6. A drawing of the circulation plan (copyright 2011© Yun Wang, all rights reserved, used by permission).

The skiing area is also developed, providing more detail concerning the land uses associated with the ski slope, comprised of downhill ski trails and a base to queue returning skiers to the top (Fig. 7). Ski trails are rated according to difficulty, so every skier can choose an appropriate route.

Different trail ratings have different slope angle: easiest, intermediate, and advanced. For novices, the slope angle should be between about 5° and 14°, with an average of 10°. For intermediate level skiers, the angle should be between about 14° and 22°. For advanced levels, the angle should be greater than 22°. Slopes around 60° require snow avalanche management. The length of the run is important too, with shorter trails for novices around 200m (656 ft.) and longer for intermediate skiers around 400m (1312 ft.) as well as for advanced levels 600-800m (1968- 3280 ft.)

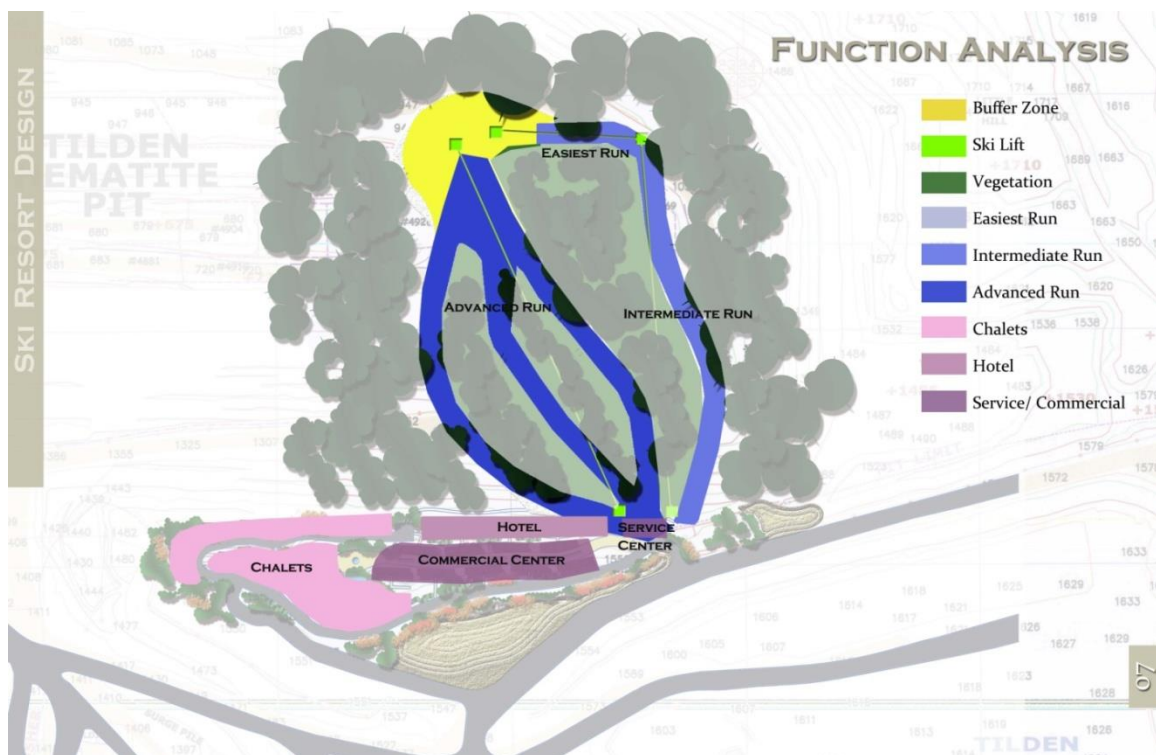


Figure 7. This drawing illustrates the organization of the ski slopes and land uses at the base facility (copyright 2011© Yun Wang, all rights reserved, used by permission).

Predominantly xeric vegetation species such as red pine (*Pinus resinosa* Sol. ex Aiton) and jack pine (*Pinus banksiana* Lamb.) form the major plants around the ski slope. Other native plants are included in the design for the lower ground plane in the forest and around the base facilities.

Assessment Methods

As the design evolves, various features of the design can be assessed, evaluated, and re-designed. The late Paul Strauch (1994) illustrates how various design approaches can be examined across numerous variables to assess the merits of each design and statistically determine which

design might be better. In this case study, portions assessment of the design are examined: visual quality, bird habitat, vegetation diversity, and water runoff. The assessment is based upon equations and landscape metrics. They give insight into the properties of the design.

Investigators had developed measureable and reliable indicators of visual and environmental quality, such as the equation developed by Burley (1997). Burley et al, (2011) provide an updated review of the models, theories, and equations associated with this form of landscape assessment. Essentially, one can measure the properties of the image and get a numerical indication of respondent preferences for the environment depicted in the image. Fig. 8 illustrates

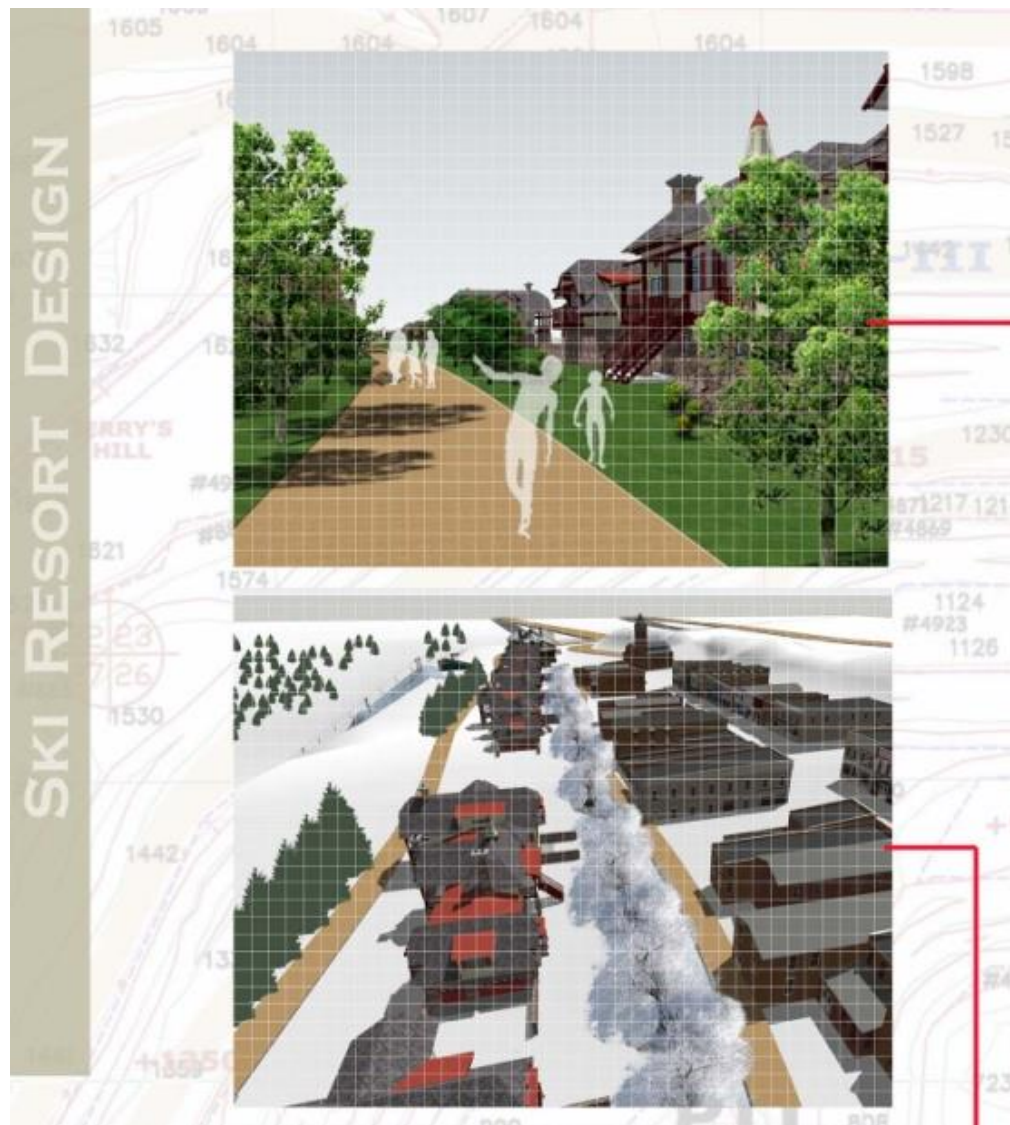


Figure 8. Images developed illustrating the design of the base facility (copyright 2011[©] Yun Wang, all rights reserved, used by permission).

two of the images examined in the proposed design. Fig. 9 shows measurements of various variables used in the calculation of the visual/environmental quality. High scores in the 80s and above (largely caused by the presence of large buildings, extensive industrial sites, utility structures, and vast parking lots) indicate low preference and low scores in the 30s and 40s (typically containing greater amounts of mountains, flowers, and wildlife) indicate high preference. Scores in the 50s and 60s are often of a landscape with numerous trees and natural features. The streetscape image (Image 1, Fig. 8) scored 52.23 and the aerial image (Image 2, Fig. 8) scored 56.28. For comparison purposes an image from the current mine (not shown, but scores listed in Fig. 9) was also evaluated with a score of 61.77. This means both the design (Images 1 and 2, Fig 8) and the current mine site are considered neither unsightly nor extremely beautiful. Although, applying the methods of Burley (1997) statistically, the streetscape image scores significantly better than the present site conditions. In other words, after reclamation, respondents would consider the post-mine land-use environmentally better and thus more acceptable.

Wildlife habitat can be examined in the same manner with metrics as with visual quality. Burley (2003) and Burley et al, (1988) illustrate these fundamental procedures and methods to quantitatively assess wildlife habitat in a surface mine reclamation study. Burley (2011) reviewed the current status of employing and validating these models. In this case study, two bird species were examined Hairy Woodpecker (*Picoides villosus* L. 1766) and Pine Warbler (*Dendroica pinus* Wilson 1811), with models by Sousa (1987) and Schroeder (1982). Scores that approach 1.0 are considered good habitat and scores near 0.0 are considered poor habitat. Initial applications of the model revealed scores of around 0.6 for the Harry Woodpecker and scores around 0.17 for the Pine Warbler. By examining which landscape features are deficient and then revising the design, the habitat score can be improved for each species.

In the design, the Simpson's Diversity Index was employed to evaluate the composition of vegetation. Burley (1989b) illustrates how the metric is calculated for planning and design applications examining vegetation and wildlife. Landscape designs are often criticized for being simplistic and not being diverse. In this case study, the score was 0.14, indicating a low level of diversity. The design can be evaluated and revised to increase the diversity score.

	Environmental quality index	Image 1	Image2	Image3
	Health	10	9	1
X1	perimeter of immediate vegetation	72	0	0
X2	perimeter of immediate non-vegetation	27	0	0
X3	perimeter of distant vegetation	4	25	86
X4	area of intermediate vegetation	296	202	15
X5	area of any kind of water	0	0	0
X6	area of distant non-vegetation	9	47	54
X7	area of pavement	188	58	0
X8	area of building	104	389	0
X9	area of vehicle	0	0	6
X10	area of humans	37	0	0
X11	area of smoke	0	0	0
X12	area of fire	0	0	0
X13	area of herbaceous foreground material	0	0	0
X14	area of wildflowers in foreground	0	0	0
X15	area of utilities	0	0	0
X16	area of boats	0	0	0
X17	area of dead foreground vegetation	0	0	0
X18	area of exposed foreground substrate	0	0	0
X19	area of wildlife	0	0	0
X20	smoothness: scale 1 to 5			
X30	open landscapes= $X2+X4+[2*(X3+X6)]$	331	509	295
X31	closed landscapes= $X2+X4+[2*(X1+X17)]$	405	417	15
X32	openness $X30-X31$	-74	92	280
X34	mystery= $X30*X1*X7/1140$	3930	0	0
X44	complexity			
X46	sum			
X51	wetness			
X52	noosphericness= $X7+X8+X9+X15+X16$	292	447	6
X53	greenness			
X63	Shafer Index			
X80	$X63*X52$			
Y		52.22928	56.28027	61.77188

Figure 9. Calculations of the scores for three images. The first two scores are for the proposed design and the third is a score from an image of the existing mine site (copyright 2011© Yun Wang, all rights reserved, used by permission).

The rate of water discharge from the site can also be a metric to indicate the environmental suitability of the design (Landphair and Klatt 1988). The more rapid the rate of water runoff, the less environmentally responsible is the design. Slower rates of runoff facilitate water infiltration and reduce flooding downstream. Post-mining landscapes usually must have peak run-off rates

that are equal to or less than pre-mining run-off rates. In this case study, the Rational equation was employed to determine peak discharge from the site, with values of 8.4 cubic feet per second for the forested area and 6.12 cubic feet per second for the urban area.

These metrics described above illustrate how designs can be evaluated. The metrics can include many other variables including social and economic assessments. This case study demonstrates how a few of the applied metrics can be used to gain insight into the design solution. These metrics are guides to understanding the design, but are not the final criteria by which designs are evaluated and selected, as the client, citizen groups, and governmental agencies also have input and decision making/influencing authority. In addition, the design would have to be carefully integrated with the operations process to optimize the site with the appropriate substrates and slopes to facilitate the design for minimal earth moving costs and efficiency.

Conclusion

Post-mining land-use planning and design is a complex activity that requires knowledge about mining, skill and ability in planning and design, experience, and collective input. Ken Schellie was a pioneer in this field of study and made important contributions that are very applicable today for a variety of surface-mine activities and post-mining land uses. Planning and design has entered the post, post-modern era-- the age of context sensitive design where projects such as post-mining planning and design must be equally ecologically sensitive, economically thoughtful, culturally aware, functionally capable, and aesthetically minded. The case study from the Upper Peninsula of Michigan illustrates this general approach.

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