

DUKE UNIVERSITY

**Sustainable Development:
Producing Energy while Maintaining Ecosystems**

A Study of the Powder River Basin, Wyoming



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Ecological restoration has as its goal an ecosystem that is resilient and self-sustaining with respect to structure, species composition and function. (Gann, 2006)

1 Keywords: Adaptive Management, Energy Development, Ecosystem Reclamation

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Abstract

From the time we wake up - to the time we set the alarm clock for the next morning – we consume energy. Energy is produced from coal, oil, natural gas, uranium and renewable resources. It is transported by oil tanker, railcar, pipeline, and overhead power. Impacts on environmental systems from energy development, production, and transportation are additive (i.e. the impact from an area of extraction is added to the impact of transportation which is added from one area to the next). The only way to deduct impacts is through effective reclamation and eventual ecosystem restoration.

Twelve thousand new oil and gas wells have been permitted on federally managed minerals in Wyoming' Powder River Basin, since the last environmental impact statement in 2003. These 1,700 oil and gas wells per year plus associated pipelines, power lines and roads have been added to existing disturbance of oil well pads, coal and uranium mines. This is added to residential, recreational and industrial activities in the Powder River Basin.

Energy projects proceed through four common phases of development: planning, construction, monitoring, and adaptive management. These four phases are analyzed to identify which phase is most important to reclamation success; how actions in phases might be improved; and how improvements in phases could be coordinated so that overall reclamation success may be enhanced.

Results reveal - the most critical phases of energy development are planning and construction. To improve coordination between phases - monitoring and adaptive management must be improved. In order to improve each phase of development - areas of uncertainty need clarification. Four main areas of uncertainty were identified during the study; they lead to four recommendations of action. 1) Define to what stage an ecosystem will be reclaimed or restored. 2) Define suitable soil for reclamation, its depth and methods used to ensure it is salvaged for reclamation. 3) Establish timing and methods of measurement for monitoring. 4) Develop adaptive management strategies to incorporate results of monitoring. By incorporating these four actions and implementing clearly defined reclamation goals, objectives, and standards functioning ecosystems can be maintained during the life of energy development.

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Vertical Intrusions



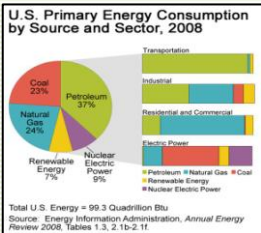
Wind Turbines



Oil Pump-jack



Transmission Lines



Energy consumption



Footprint of Energy



Wyoming's Powder River Basin

Introduction

Our generation's demand for energy production in the United States is making a physical and ecological impact on the land. People are noticing wind farms sprouting up all across the country as vertical intrusions are becoming more numerous on the skyline and development of renewable resources is added to extraction of traditional non-renewable resources such as oil and gas. The impacts of renewable energy may even rival that of the traditional pump jacks of the West. This is all part of the looming evidence of our need for energy. Energy production comes from five main sources: petroleum, natural gas, coal, nuclear and renewable energy (DOE 2008). Energy development shares similar impacts on natural systems. The affects to natural systems may not be as apparent as vertical intrusions, but the ecological footprint expands as renewable and non-renewable resources are woven together with transmission lines as energy is transferred across the Nation.

This study focuses on an area of energy development in the Powder River Basin of Wyoming. The Powder River Basin is one of five basins in the Intermountain West identified for energy development in the *Scientific Inventory of Onshore Federal Lands' Oil and Gas Resources and Reserves and the Extent and Nature of Restrictions or Impediments to their Development*. This document is the extension of the Energy Policy Conservation Act (EPCA 2000) which identifies impediments to drilling

Federal oil and gas reserves. It was initiated by Congress in response to attacks on September 11, 2001. In the executive summary, Congress on October 11, 2001 declared, " ...In light of recent attacks on the United States that have underscored the potential for disruptions to America's energy supply, the managers believe this project should be considered a top priority for the Department" (DOI 2003). Increased impacts from developing energy resources in the United State's begs the question: How can multiple-use, development, reclamation, and land management be coordinated in order to retain functioning ecological systems during the life of energy development?

A Study of the Powder River Basin

The Powder River Basin is a portion of the Great Plains located in northeastern Wyoming. It provides an excellent example of an area that is providing habitat for wildlife and open space for ranching during a time of extraordinary energy development. The grasslands of the West are situated between the Missouri River and the Rocky Mountains. They extend almost the entire length of the continental United States from Texas into Canada. The Great Plains is distinguished by a steppe ecosystem characterized by wide expanses of treeless areas made up mostly of flat prairie grasslands with occasional topographical relief created by buttes and deeply incised drainage systems. In the western portion of the Great Plains, near the base of the Rocky Mountains, subareas of higher elevation are classified as High Plains, semiarid portions of short-grass prairie which receive less than 20 inches of precipitation per year. The Powder River Basin is in a portion of this system called the Wyoming Basin shrub-steppe ecosystem. The shrub-steppe, with an average of 8-15 inches receives just enough moisture to support semi-arid shrubby vegetation such as sagebrush and bunchgrass.

The shrub-steppe system in this region has historically served many important ecological functions. The windblown landscape has sparse vegetation with a physical and biological crust that helps prevent soil erosion. Runoff from rainfall and snow melt flows through incised drainages into the Powder River which flows northward to the Yellowstone River, east to the Missouri and eventually south to the Mississippi River. Vegetation provides biogeochemical transfers sequestering carbon dioxide from air into plant material which supports an abundance of Wyoming wildlife. The wide-open grassland is utilized for ranching. The pre-historic rich natural systems also left behind an abundance of hydrocarbons; this has led to vast opportunities for energy development in the Powder River Basin.

Wyoming has a 150-year history of energy development with coal, uranium, oil, and coal-bed methane natural gas. The first coal mine in Wyoming was established in 1867. Uranium was discovered in 1918. Naval oil reserves were first leased, by the U.S. Department of Interior, in 1922. Coal-bed methane natural gas began production in the late 1980s. In addition the Powder River Basin is one of the largest coal-producing regions in the Nation, accounting for approximately 40% of all coal mined in the United States (DOE 2009)

Energy products are transported out of the state by railroad, oil tanker, and utility corridors with overhead power and buried pipelines. Wyoming coal mines have the capacity to export up to 2,000 rail cars of coal per day. Oil is transported by both pipelines and oil tankers to oil refineries in the region. Coal-bed methane gas is exported through interstate buried pipelines, which are linked together through networks of smaller buried pipelines from the well fields. In 2008 the U.S. Department of Energy established the state of Wyoming as one of the Nation's top

producers of natural gas, and declared the southeast region of Wyoming as “one of the most favorable locations for wind power development in the country”. According to the Energy Information Administration, in 2009 the Governors of four western states proposed a 1,300 mile high-capacity power line to transmit electricity from Wyoming and other Rocky Mountain States to California (DOE 2009).

Development of energy results in varying scales of disturbance. The effects on ecosystems of surface use and mineral development are additive. Some types of energy development require removal of the entire surface such as surface coal mines and constructed pads for drilling wells. Other disturbances such as railroads, pipelines, roads and transmission lines result in linear fragmentation of habitat. Finally some impacts are difficult to delineate due to the limitless boundaries and ecological services such as air quality. Maintaining functioning ecosystems becomes increasingly challenging as energy development and transmission lines are added to existing uses of wildlife, ranching and recreation. Impacts accumulate throughout environmental systems and overlap through geospatial and temporal boundaries. For example, ranching adds impacts to wildlife, energy development adds impacts to ranching and wildlife, and these impacts are in addition historical uses of the land.

- When an area is utilized for ranching, generally shrubs are considered less desirable than grasses. When shrubs are removed the system’s vegetative diversity is reduced. Many wildlife species depend on sagebrush shrub-lands and populations of wildlife suffer when habitat is reduced.

- When an area is developed for energy production both shrubs and grasses are removed. Cattle and wildlife depend on sagebrush grasslands but when vegetation is removed carrying capacities are reduced and populations may suffer.

- People in Wyoming depend on an economy based on wildlife (i.e. hunting and outfitting), ranching, and energy development. Manipulations and changes in vegetative communities can reduce the capacity of net primary production. The economy and quality of life can be reduced when cumulative effects of multiple use changes the basic structure of vegetative communities.

- The basic structure of natural systems: soil, biological crust, vegetation, wildlife and water provide ecological services such as soil stabilization, air filtration, water mitigation and various habitat functions through interactive biogeochemical processes. Primary ecological functions can be reduced when an area is overtaxed through multiple manipulations of varying components of the ecosystem. When the system is overtaxed its ability to provide ecological services to humans is reduced and human populations may suffer.

The only way to subtract impacts from the equation is to effectively reclaim and restore ecosystem functions. “Ecosystem functioning reflects the collective life activities of plants, animals, and microbes” (Naeem et al, 1999). Effective reclamation and eventual restoration is crucial to maintaining ecologically functioning systems. The terms reclamation and restoration are not explicit. The Society of Ecological Restoration states, the objectives of reclamation

include site stabilization, re-vegetation, and return of regional use; and if reclamation is more ecologically sound it may qualify as restoration (SER 2004). Reducing an area of disturbance directly reduces impacts. Therefore, minimizing surface disturbance should be the priority wherever possible. Once an area is disturbed, the most effective method to reduce impacts is to begin to reclaim the functional components (primary producers, herbivores, carnivores, decomposers, nitrogen fixers, pollinators) of the system. Due to the semi-arid conditions in the West, even with the use of the best reclamation practices, restoring pre-disturbance functionality is demanding, often taking decades for functional groups to completely reestablish. Retaining components of the ecosystem during the life of energy project is necessary to facilitate eventual ecosystem reconstruction.

Objectives

Various energy projects proceed through similar stages which can be categorized under four broad phases of development: planning, construction, monitoring and adaptive management. The objectives of this study are to determine how reclamation practices might be improved in each phase and how coordination between phases might be structured in order to maintain functioning systems throughout the life of energy development.

The study area, the Powder River Basin, is managed by the Bureau of Land Management (BLM) for Federal energy development. Prior to the last land use plan, written in 2003, there were approximately 22,000 Federal oil and gas wells in the Powder River Basin (BLM 2005). Since then approximately 12,000 new oil and gas wells have been permitted. This disturbance is in addition to 13 expanding coal mines, 2 uranium mines, and non-federal oil and gas wells. The BLM Buffalo Field Office is currently revising their land use plan. This research provides

information that should be considered in the revised land use plan and in site specific reclamation plans that accompany applications for permitting Federal related energy projects.

Methods

Two methods were used to gain information about reclamation during energy development. First, a literature review was conducted. Four interest groups were identified in the Powder River Basin: wildlife enthusiasts, ranchers, oil and gas operators, and land management agencies. Each group has published recommendations for reclamation. Wildlife is represented by the Wyoming Game and Fish Department's *Recommendations for Development of Oil and Gas Resources within Important Wildlife Habitats* (WG&F 2004). Ranching is represented by United States Department of Agriculture's *Restoring Western Ranges and Wildlands* (USDA 2004). Energy Industries are represented by the American Petroleum Institute's *Environmental Protection for Onshore Oil and Gas Production Operations and Leases* (API 2009). Federal Agencies are represented by the Bureau of Land Management's *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development, Gold Book* (BLM 2007). The recommended practices were contrasted and compared on a matrix to delineate concurrence and discord in each group's approach to reclamation.

Second, a reclamation survey questionnaire was developed to gather information about restoring ecosystems in the Powder River Basin. The survey was conducted to solicit a wide range of real world knowledge and experience in relation to reclamation during energy development. It was presented during two restoration conferences, held near the Powder River Basin, where stakeholders including wildlife enthusiasts, ranchers, energy developers, and land managers who regularly work with energy development, were present. The survey was made available in both

hard copy and posted on a survey website for 60 days. One hundred people responded to the survey. A copy of the original survey is attached as appendix 4.

Results

The results are presented here in three sections. First, the interest group recommendations based on the literature are presented. Second, the survey results by individual importance questions are listed. Third, the relative priority scale results are presented. In addition, the survey results and a summarization of the survey respondent comments are included as appendices 2 and 3.

Interest Group Recommendations

Seventeen “categories of concern” were identified during the literature analysis. Table 1 compares the interest group’s concerns from their corresponding published documents. The interest group findings revealed that all seventeen categories of concern were shared by at least two or more interest groups:

- Not one category of concern was listed by one group that was not also listed by at least one of the other groups
- Two categories of concern were shared by just two interest groups: comparable reference sites (for monitoring) and threatened and endangered species
- Seven categories of concern were shared by three interest groups: erosion control, reclamation standards, interim reclamation, compliance (with environmental regulations), access roads, human activities, species habitats and riparian corridors.
- Eight categories of concerns were common to all interest groups: site selection, planning, design, topsoil, weed treatment, reclamation plans, reclamation monitoring and final reclamation

Table 1 Categories of concerns in interest reclamation recommendations

	Interest Group Represented	Wildlife	Range	Oil & Gas	Federal Agencies
	<i>Recommended Reclamation Source Document</i>	<i>(WG&F 2004)</i>	<i>(USDA 2004)</i>	<i>(API 2009)</i>	<i>(BLM 2007)</i>
	Category of Concern				
1	Comparable Reference Sites	x			x
2	T & E, Special Status Species	x			x
3	Erosion control	x		x	x
4	Reclamation Standards	x		x	x
5	Interim Reclamation	x		x	x
6	Compliance	x		x	x
7	Access Roads	x		x	x
8	Human Activities	x		x	x
9	Species, Habitats and Riparian Corridors	x		x	x
10	Site Selection	x	x	x	x
11	Planning	x	x	x	x
12	Design	x	x	x	x
13	Topsoil	x	x	x	x
14	Weed Treatment	x	x	x	x
15	Reclamation Plans	x	x	x	x
16	Reclamation Monitoring	x	x	x	x
17	Final Reclamation	x	x	x	x

Finding show there is more consensus than disagreement among the groups. The interest group's concerns concur in areas of general interest such as site planning and design, topsoil salvage, reclamation, monitoring, and weed treatment. The group's depth of concern differed by the discipline they were representing. Oil and gas companies, for example, were more concerned about compliance and development; wildlife had detailed concerns for threatened and endangered species; and range was far more focused on rangeland production and seed mix selection. In areas where groups shared common concerns, the weight of concern, or intention of use of the resource differed by interest group see appendix 1 for more detail.

Importance of Individual Actions

The questionnaire for the survey addressed many of the same attributes as the interest group recommendations. Twenty four questions were developed to articulate local interpretation and implementation of reclamation methods utilized during energy development. The questions were developed based on professional experience and the guidance of those who work with reclamation in the Powder River Basin. The survey asked about individual and relative importance of actions in the four phases of development: planning, construction, monitoring, and adaptive management. Because it is not reasonable to expect successful final reclamation without concern for the measure of success in each phase, each phase of reclamation was queried independently to determine if setting standards and measures of success for each phase could provide an opportunity to improve overall reclamation success. Independent importance scale questions were developed in an attempt to decipher which phase is most critical to the success of reclamation. For example: Participants were asked, on a scale of 1-5, do you agree that X (this reclamation action) is important to the success of reclamation? Table 2 below summarizes the attributes and results for the single importance scale questions.

Table 2 Attributes Important to Reclamation

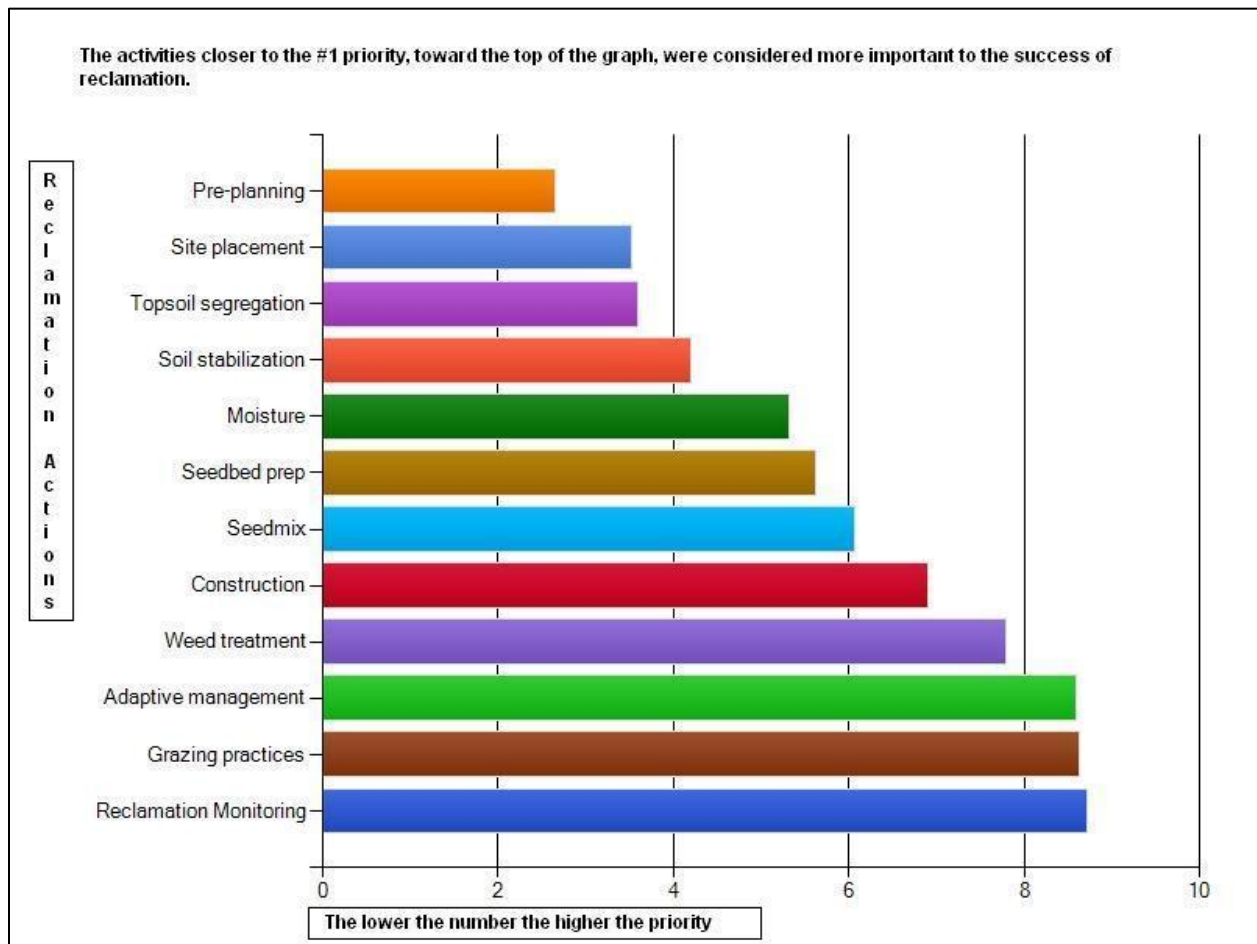
Attribute	Importance to successful reclamation
Topsoil Segregation	94% Topsoil segregation and reapplication is important to successful reclamation
Communication and planning	93.7% agreed communication between the planning and constructions crews is important to successful reclamation
Topsoil Visual	Most varied responses 40.4% agreed and 37.4% disagreed that construction crews can segregate appropriate depth of topsoil
Topsoil Depth	86.1% agreed topsoil depth is ≤ 10 "
Topsoil Horizons	73% agreed O & A horizons as topsoil
Areas surrounding disturbance	88% agreed that it important to keep area that surrounds disturbance intact, free of weeds and erosion

Reference Sites Neighboring Sites Reference Sites Ecological Sites Descriptions	86% agreed to using neighboring sites as reference sites for re-vegetation 62.9% agreed to using NRCS ecological sites description as references for baseline vegetation
Timing Soil Stabilization and Vegetation Priorities	73% agreed erosive soils priorities need to return to establishing plant communities within 2 years or less of initial disturbance
Monitoring Reclamation	50% said operators and 32.2% said federal agencies should be responsible for monitoring reclamation of disturbance due to federal energy development
Seed-mix	76.6% agreed seed-mix should contain seed of species that that mimic those growing on the site prior to disturbance
Interim and Final Reclamation Standards	55.7 % agreed and 35.1% disagree that interim reclamation should be held to same standards as final reclamation
Adaptive Management	83.8% agreed that adaptive management strategies should be pre-established in the reclamation plan

Relative Priority of Actions

If each phase of development has the potential to promote and retain environmental function independently, then how might all of the phases (planning, construction, monitoring, and adaptive management) work cohesively to provide more effective reclamation throughout the life of the project. In order to establish priority of importance on a relative scale, one question requested participants prioritize reclamation actions in reference to other actions. On a scale 1-12, one being most important, prioritize (listed) actions to the success of reclamation. Twelve is not a significant number; it just happens to be the number of potential actions normally taken during development of oil and gas in the Powder River Basin. Respondents were provided space to add additional actions in the priority list question. The results are graphed in figure 1. Priority was established on a scale of 1-12 with one being highest priority.

Figure 1 Prioritization of reclamation actions in reference to other actions. Reclamation activities are on the y-axis and the priority given for importance in on the x-axis. The activities closer to the #1 priority, toward the top of the graph, were considered more critical to the success of reclamation.



Results from figure 1 reveal participants consider:

- Pre-planning and site placement rank at the highest priority just above topsoil segregation and soil stabilization in the success of reclamation
- The next attribute selected was moisture, followed by seedbed preparation and seed mix which scored sixth and seventh place
- Construction and weed treatment scored eighth and ninth
- The last three, adaptive management, grazing, and reclamation monitoring scored almost equally distant from other critical factors of successful reclamation

Figure 1 will be reprinted in the following discussion to illustrate how the four phases of development may work cohesively to achieve successful reclamation.

Discussion

The discussion is organized around these four main questions:

1. Which phase is most important to successful reclamation?
2. How can reclamation practices be improved in each phase of development?
3. How might coordination between phases be structured in order to improve overall reclamation success?
4. How might planning, construction, monitoring and adaptive management be incorporated with multiple use, development, reclamation and land management in order to maintain functioning ecosystems during the life of energy development? Four areas of ambiguity are discussed in detail: reclamation goals, suitable soil for reclamation, methods of monitoring, and adaptive management.

The study concludes with suggestions for setting reclamation goals. Recommendations for future actions include incorporating the Wyoming BLM State reclamation goals in the Powder River Basin land use plan (BLM 2009). Wyoming BLM's short term goals are to immediately stabilize disturbed areas and provide conditions necessary to achieve long term goals. The long term goals are to facilitate eventual ecosystem reconstruction to maintain a safe and stable landscape and meet the desired outcomes of the land use plan for each field office. Therefore it is essential to define desired outcomes in each land use plan.

Phases of Development

To answer the first question, which phase is most important, results from the survey were tallied for order of importance, and the questions were categorized by the four phases of development: planning, construction, monitoring and adaptive management.

Table 3 Phases list by order of attribute rating

	Attribute	Importance to successful reclamation
Construction	Topsoil Segregation	94% agree topsoil segregation and reapplication is important to successful reclamation
Planning	Communication and Planning	93.7% agree communication between the planning and construction crews is important to successful reclamation
Monitoring	Reference Sites	86% agreed to using neighboring sites as reference sites for re-vegetation 62.9% agreed to using NRCS ecological sites description as references for baseline vegetation
Adaptive Management	Seed-mix	76.6% agree seed-mix should contain seed of species that mimic those growing on the site prior to disturbance
	Interim and Final Reclamation Standards	55.7 % agree and 35.1% disagree that interim reclamation should be held to same standards as final reclamation
	Adaptive Management	83.8% agree that adaptive management strategies should be pre-established in the reclamation plan

Construction and planning were at the top of the list. 94% of participants agreed the construction phase is the most important: salvaging and re-spreading topsoil is one of the most important steps that can be taken toward reclamation. 93.7% agreement in the planning phase highlights the importance of communication between planning and construction crews.

Monitoring actions and making changes in response to monitoring (adaptive management) are also essential actions. It is important to record success and failures of the management strategy.

If standards are met in each phase of development, there is greater potential for success of using this strategy in future reclamation. But if standards fail, actions taken in other phases must make up for this failure. Examples are as follows:

- If a site is planned in an area with poor reclamation potential (per NRCS soil surveys), other phases of construction, monitoring, and adaptive management must be adjusted to establish higher standards in order to make up for this short coming
- If a site was placed in an area of good reclamation potential but the topsoil was not salvaged by the construction crew, more time and money must be budgeted in the adaptive management and monitoring phases
- The same scenario may be found if the monitoring phase fails to meet standards; it will cost more money and time to develop adaptive management strategies which feeds back to re-writing reclamation plans or re-constructing a site for stability

Monitoring can identify areas of success and lessons learned that can be incorporated in future actions. Recording the monitoring results and implementing change based on this information is the foundation for adaptive management. Adaptive management allows learning while avoiding repeated actions, and therefore, saving time and money.

Improvements in Phases

Respondent comments in appendix 3 provided the answer to the second question, how can reclamation practices be improved in each phase of development. They said, improvement comes through training, communication, and supervision. Continued training should provide the tools necessary to succeed, and convey the importance of success in each phase of development.

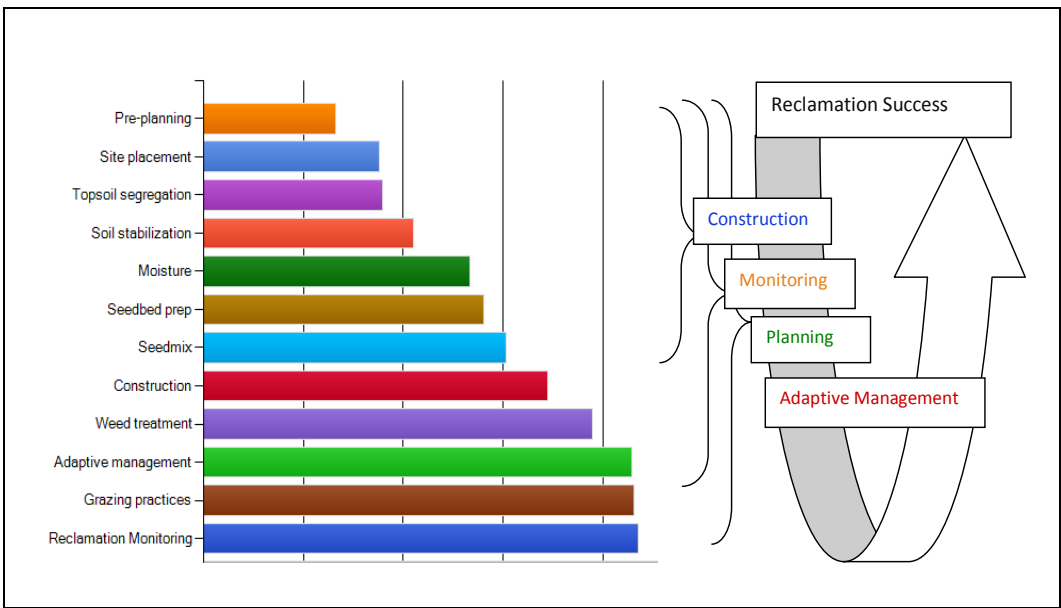
Construction supervisors and planning managers need to be on site supervising during both the planning and construction phases. Timing and standards need to be established to improve the

monitoring phase. Communication is essential to adapt reclamation strategies to changing environmental conditions and management objectives.

Coordination between Phases

Coordination can be improved by communicating and adapting to change. To answer the third question, how coordination between phases might be structured in order to improve overall reclamation, actions within phases needed to be correlated. The phases of development are actions that occur chronologically over time and they are building blocks for success of other phases. Phases and actions within phases are interdependent. For example, pre-planning, site placement, and topsoil segregation are necessary components in the construction phase (as shown in graph 2 below). But these same actions also fall under the phases of monitoring and planning.

Figure 2 Actions prioritized in reference to other actions. Survey respondents gave top priority to pre-planning and reclamation monitoring the lowest priority. Actions are classified by phases of development. On the right the graph shows that phases overlap and are not autonomous, they are mutually supporting.



Adaptive management was rated as one of the lowest priorities, number 10 out 12, to the success of reclamation, but adaptive management is the common thread of coordination and

communication between phases. Adaptive management, planning, and communication need to be structured in such a way that it prevents people from repeating unsuccessful reclamation strategies and improves overall rates of success.

Maintaining Ecosystems during Development

The fourth question, how to maintain functioning ecosystems during the life of energy development, requires further consideration; the answer is twofold. Goals and objectives need to be developed, defined, and agreed upon by stakeholders; but first there needs to be a clear understanding of the expected outcomes and objectives of reclamation.

Clear goals are necessary in order to set objectives. Objectives define expected outcomes, and standards define expectations. The survey results and comments in the survey reflected stakeholder uncertainty on four major subjects of concern:

1. The terms reclamation and restoration were controversial
2. The concept of topsoil segregation was arguable
3. Reference sites were not specific and timing and methods of measurement had not been established
4. Adaptive management was not being incorporated.

The four areas of uncertainty affect the potential to set clear standards, objectives, and goals. The following is a brief overview of each of the four subjects.

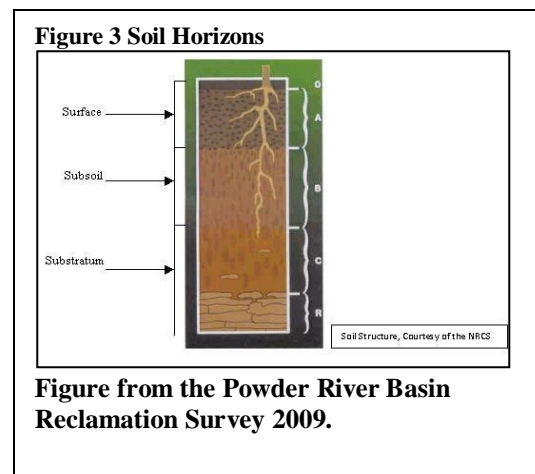
Reclamation – Restoration

In order to plan for success, it is important to define the outcome. What is the difference between reclamation and restoration? At the beginning of the survey, participants were asked if they agreed that reclamation and restoration have the same meaning; 79% claimed these two terms do

not mean the same thing (appendix 2). When asked to define reclamation - responses varied - from suggesting total ecosystem reconstruction - to reestablishing vegetation to a useable condition. Society for Ecological Restoration asserts, “The objectives of reclamation include site stabilization, re-vegetation, and return of regional use; and if reclamation is more ecologically sound it may qualify as restoration” (SER 2004). Generally speaking, successful reclamation means reclaiming a disturbed area back to nearly what it would have become without the disturbance, so that the reclaimed condition promotes restoration.

Soil Horizons

Construction begins when the first blade turns the soil. At 94%, survey respondents gave the highest consensus to the importance of salvaging and re-spreading topsoil. Yet there was less agreement on the other factors of topsoil: Figure 3 was provided in the survey; 73% said topsoil includes O&A horizons; 86% said topsoil is 10 inches or less in depth from the surface; and the most mixed responses were tallied when respondents were asked if they agreed that most



construction crews could salvage the appropriate amount of topsoil based on visual characteristics of soil, 40% agreed and 37% disagreed. The concept of topsoil, according to respondent comments: is the topmost surface layer that is biologically active; it contains the seed bank including native species; it requires proper handling; it must be spread in a timely manner and they said, re-spreading it saves money.

Topsoil is the most suitable soil for reclamation. Indeed, the top layer of soil is an accumulation of centuries of seed, organic matter, and microbes. The USDA (2004) states the depth of suitable soil is limited by a layer that has higher pH, salinity or exchangeable sodium percentages. This limits soil's potential to be utilized in reclamation. At a 2010 Wyoming Reclamation conference Soil Scientist, Pete Stahl from the University of Wyoming, said "instead of calling it topsoil, call it suitable soil". Salvage as much suitable soil as possible. Most limiting factors in Wyoming's soil will be reduced by having more soil to work with and spread back. He claimed, it is better to have a little too much, then not enough.

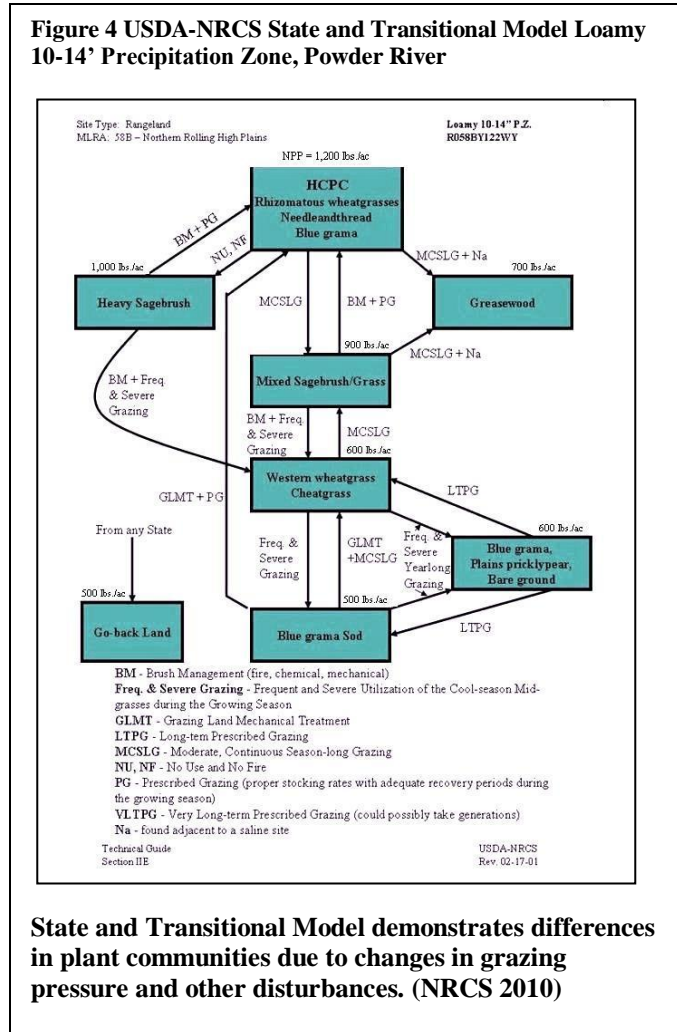
Reference Sites and Methods of Monitoring

Identifying reference sites is important in the reclamation process. Respondents called for defined objectives with standards and methods of measurement. Plant communities, functional groups, and structure need to have a reference for qualitative and quantitative results to be measured. Three common methods of establishing reference sites are listed below with their potential and uncertainties:

- Pre-disturbance site inventories – This method can provide information on exactly what was growing there prior to disturbance, but it does not account for ecosystems changes and rangeland health
- Inventorying post-disturbance neighboring sites with similar soil characteristics – This method accounts for changes over time and includes potential seed source of neighboring volunteer species, but it does not account for specific differences in ecological conditions such as isolated soil complexes or neighboring site health
- Natural Resource Conservation Service's (NRCS) ecological site descriptions (ESDs) are based on potential of the identified soil type to grow predictable plant communities, but

ESDs do not account for transitional states due environmental factors such as drought and grazing pressure

Soil type is one indicator of a number of varying plant communities that may inhabit a site. Neighboring vegetation is generally a good indicator of the current pressure on the surrounding plant community. Plant communities transition through different states in response to environmental and management pressures. Figure 4 demonstrates differences in states of plant communities due to changes in grazing pressure and other disturbances. Net primary production varies from 1,200 lbs/ac with a rhizomatous wheatgrass at the top of the chart and is reduced to 500 lbs/ac at the bottom of the chart with a blue grama sod.



Energy development often involves removing and reapplying the top layer of soil, as a result reference sites should incorporate all three of the above methods to determine potential vegetative composition. Soil type should be ascertained. ESDs should be used to formulate a

baseline of potential plant communities. Neighboring sites should be used to provide current vegetative states. And the NRCS transitional states should be used to provide predictive models to establish a reference trajectory that incorporates current ecological conditions with potential for improved health and integrity. It is crucial to have goals and objectives preset to determine the detail needed in the description of the reference site (SER 2004).

Monitoring is the orderly collection, analysis, and interpretation of resource data to evaluate progress toward meeting management objectives.

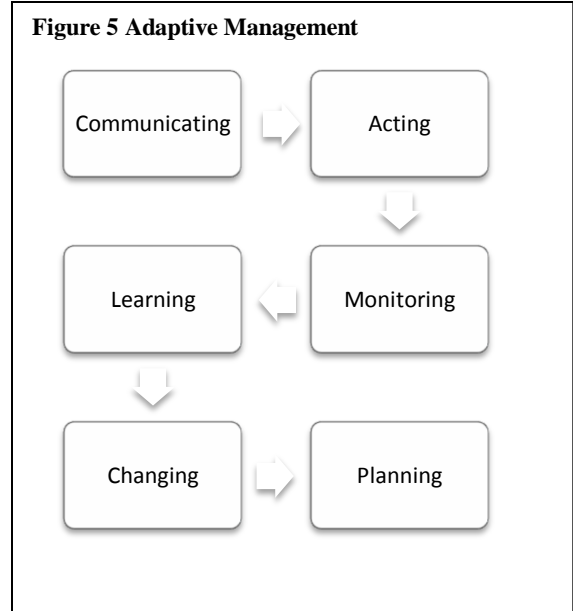
The process must be conducted over time in order to determine whether or not management objectives are being met (Pellant 2005).

Monitoring is used to track success toward reclamation goals, and to record quantitative vegetation measurements to compare to the reference site. The majority of survey participants agreed that monitoring should be conducted throughout phases of development. Recording data throughout phases of development will help determine methods, areas, and timing of success and failure.

Adaptive Management

“Adaptive management (is a decision process that) promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes of management actions... become better understood” (AMWG). Adaptive management works particularly well with ecological systems because responses of natural systems to management strategies are inherently uncertain.

According to the DOI Adaptive Management Working Group (AMWG), adaptive management is a learning process. As seen in figure 5, changing reclamation strategies can be achieved through selecting appropriate alternatives to meet objectives of the land use plan, communicating current knowledge in site specific reclamation plans, monitoring to see if actions are effective, using results to learn from success and failure, and



adjusting reclamation techniques to apply lessons learned by changing future actions. Adaptive management is not only based on making good decisions today, it relies on the process of gaining knowledge and using that experience to make better decisions in the future (AMWG 2007).

Adaptive management not only requires defining management goals and communicating expected outcomes, it also requires a reference of measurement so that you have something to compare actual results and the ability to make changes. Adaptive management is deemed successful when reclamation is trending toward management goals. If outcomes are veering from expected trends, management actions can be adjusted. Connecting management objectives with what's learned from site monitoring and adjusting the direction of trends in reclamation distinguishes adaptive management from repeated trial and error processes.

Conclusion

All four phases of energy development can be improved by setting standards and measuring success. The most critical phases are planning and construction. To improve coordination between phases, monitoring and adaptive management must also be improved. Improvement comes through training, communication, and supervision. A clear understanding of the reclamation goals, objectives, and expected outcomes is necessary in order to maintain functioning ecosystems during energy development.

Recommendations and Future Actions

Success is recognized when it is defined, measured, and accomplished. According to the Society for Ecological Restoration, all plans have one central task: the goal must be clearly stated. Incorporate results of the Powder River Basin Reclamation Survey to define objectives and goals of reclamation.

1. Define to what condition an area will be reclaimed or restored
2. Establish methods to measure and handle suitable soil for reclamation
3. Designate reference sites, specify timing intervals and methods for monitoring reclamation
4. Devise a plan for how lessons learned will be adapted into future management actions

Even the best laid plan is often obscured by limited understanding (AMWG 2007).

Communication is the key. Goals must be set, so that plans reflect clear objectives. Objectives and expected outcomes need to be communicated with planning and construction crews.

Monitoring requires setting standards and methods of measurement so that incremental steps can be measured. Results of monitoring should be used for making mid-course decisions to adapt to

varying environmental responses. Adaptive management should be employed to communicate and incorporate what is learned in future actions.

Expedient reclamation provides potential for ecosystems to continue to function during energy development. The Wyoming Reclamation goals are to stabilize disturbed areas, provide conditions necessary to facilitate eventual ecosystem reconstruction, and maintain a safe and stable landscape to meet the desired outcomes of the land use plan. Define the criteria necessary to declare an area successfully reclaimed.

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Appendix 1 Interest Group Recommendations

Interest Group Represented	Wildlife	Range	Oil & Gas	Federal Agencies
<i>Recommended Reclamation Source Document</i>	<i>Recommendations for Development of Oil and Gas Resources within Important Wildlife Habitats (WG&F 2004)</i>	<i>USDA Restoring Western Ranges and Wildlands (USDA 2004)</i>	<i>API Environmental Protection for Onshore Oil and Gas Production Operations and Leases (API 2009)</i>	<i>BLM Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development The Gold Book (BLM 2007)</i>
Site Selection	Pg 98 Consult state and federal wildlife agencies during the pre-planning phase using landscape planning principles and concepts to reduce extent of impacts.		Pg 18 Minimize adverse effects on the environment while providing an economical means of recoverable reserves	Pg 22-23 Production facilities and roads should be sited to allow for maximum interim recontouring and revegetation.
Topsoil	Pg 47 Objectives are to maintain healthy, biologically active topsoil; control erosion; and restore habitat, visual resources, and forage. Stockpiled topsoil should be reapplied to a reclaimed area while the topsoil is still viable – usually within 2-5 years	Principle 2: The terrain and soil must support the desired objectives	Pg 26 To reduce costs, salvaged topsoil should be respread over the areas of interim reclamation rather than being stockpiled.	Pg 22 Segregate, stored separate from subsurface materials Never place subsurface on top of topsoil protect from wind and water erosion.
Planning	Pg 98 Landscape planning is comprehensive, on geographic scale and in a configuration sufficient to maintain biotic communities in a properly functioning condition.	Principle 1 Changes to the plant community must be necessary and ecologically attainable.	Pg 4 The total infrastructure that may later be developed should be considered during the selection process.	Pg 43 Planning for reclamation <i>prior</i> to construction is critical to achieving successful reclamation in the future.
Design	Pg 98 Cluster drill pads, roads and facilities in specific, “low-impact” areas, if geologically feasible.	Principle 5: Plant and manage site adapted species, subspecies, and varieties.	Pg 19 Production facilities should be planned to use the smallest area possible.	Pg 15 Design should minimize surface disturbance, fit the landscape and minimize construction needs.
Species Habitats and Riparian Corridors	Pg 98 Consider lease suspensions and delays in lease sales/purchases in adjacent or off-site areas to support mitigation efforts. To the extent practicable, place infrastructure within or near previously disturbed locations.		Pg 4 Environmentally significant areas, sensitive wildlife, and critical habitats should be avoided for travel routes.	Pg 35 Wetlands should be avoided, cut slopes, fill slopes, and borrow ditches should be covered with topsoil and revegetated to restore habitat, forage, scenic resource
Erosion control	Pg 102 Employ erosion control practices and sediment retention structures to prevent sediment transport. Use dust abatement procedures including reduced speed limits and application of environmentally compatible chemical suppressants or suitable quality water.		Pg 5 Soil properties should be tested to assess erosion potential and slope stability. Length gradient, slope and vegetative cover contribute to stability. Locate roads on moderate slopes and stabilize to reduce erosion and sedimentation.	Pg 16 To reduce erosion divert storm water away from the well location. Erosion control is generally sufficient when groundcover is reestablished, water infiltrates without gulling, head cutting, slumping, and deep or excessive riling
Access Roads	Pg 101 Construct roads below ridgelines to minimize the zone of visual and auditory effect. Locate away from bottoms sources of cover and forage for wildlife. Locate overhead power along existing road rights-of-way. Seasonally restrict public vehicle traffic in important habitats. Use shuttle buses to transport drilling rig workers and field service personnel.		Pg 4 Environmentally sensitive areas should be avoided to the maximum extent practical including sensitive and critical habitats, areas of T&E species, areas of (federal state and local) concern and wetlands.	Pg 24 When used and maintained appropriately, non-constructed roads and routes have the advantage of reducing construction, maintenance, and reclamation costs and reducing resource impacts.

Interest Group Represented	Wildlife	Range	Oil & Gas	Federal Agencies
Weed Treatment	Pg 104 Use portable washing stations for equipment, request employees clean mud from boots/work and include provisions in subcontractor agreements requiring procedures to prevent spread of noxious weeds.	Principle 4. Competitive species must be controlled to ensure species planted establish and persist.	Pg 27 The degree of weed control should be compatible with the local environment. Cut, mow or spray to improve the appearance and control fire.	Pg 43-44 The site must be free of state or county listed noxious weeds.
Reclamation Plan	Pg 105 A well field reclamation plan should be developed with site specific inventories of vegetation (plant life forms, species composition, cover, height, and production) and soil types within the site(s) to be disturbed, or within a nearby reference area that is ecologically similar.	Principle 6: A multispecies seed mixture should be planted. Principle 7: Sufficient seed of acceptable purity and viability should be planted.	Pg 5 Interim reclamation plans and final restoration plans should be developed and incorporated into the planning process. Pg 32 Revegetation alone does not constitute successful reclamation. Restoration of the original landform is a key element in ensuring that the effects of oil and gas are not permanent.	Pg 43 The reclamation process involves restoring the original landform, revegetating disturbed areas to native species, controlling erosion, controlling invasive non-native plants and noxious weeds, and monitoring results. Pg 44 A reclamation plan is included in the Surface Use Plan of Operations and should discuss plans for both interim and final reclamation
Human Activities	Pg 101 All employees should receive environmental awareness training during orientation. Consider non-crucial upland sites for employee housing to relieve pressure to develop new housing subdivisions within more valuable habitats, also consider acquiring easements to protect important habitat.		Pg 5 Construction crews should be given training on safety and environmental requirements in a project area.	Pg 9 The onsite inspection team will include a BLM, operator, permitting agent, planning team dirt work contractor, agency resource specialists, surveyors, and pipeline or utility company representatives. and private surface owner. pg 10 Operators are responsible for their contractor's and subcontractor's compliance with the approved APD.
Interim Reclamation	Pg 103 To maintain as much effective habitat as possible throughout the production phase; establish effective, interim reclamation throughout the production phase, monitor until self-sustaining plant cover is established.. All disturbances exceeding the minimum area required should be reclaimed, as soon as the construction or other activity has ended.		Pg 26 Minimize where possible, reclaim areas not needed for production, operations and safety. Respread topsoil and revegetate up to production facilities	Pg 47 Interim reclamation consists of reclaiming portions wherever possible, revegetate to restore habitat, forage, scenic resources, and to reduce soil erosion and maintenance costs.
Reference Sites	Pg 105 Reclamation standards should be based on vegetation cover and species composition measured within the plant community prior to disturbance, or within an undisturbed reference area on an ecologically similar site near the operation.			
Reclamation Monitoring	Pg 102 Monitor conditions or events that may indicate environmental problems. Report potential wildlife problems to state and federal resource agencies.	Principle 10: Newly seeded areas must be managed properly	Pg 25 Inspections should be conducted and qualifications of people working on the construction site should be evaluated in order to ensure designs specifications are met and work is properly performed.	Pg 45 It is the operator's responsibility to monitor the site, take the necessary steps to ensure reclamation success, and to notify the surface management agency when success is achieved.

Interest Group Represented	Wildlife	Range	Oil & Gas	Federal Agencies
Final Reclamation	Pg 48 Final reclamation should be conducted by first stabilizing the site, then reapplying salvaged topsoil and seeding locally adapted species/varieties of native grasses, forbs, and shrubs in the spring and/or fall as appropriate.	Principle 9: Plant during the season that provides the most favorable conditions for establishment	Pg 28 If flat ground. Strip enough topsoil for the wellhead, stockpile and seed to prevent erosion. If on slope and a pad is constructed, interim vegetation and topsoil is restripped from areas that will be recontoured, the pad is contoured and "topsoil respread over the entire disturbed area to ensure successful revegetation."	Pgs 46-47 All topsoil and vegetation must be restripped from all portions of the old well site that were not previously reshaped to blend with the surrounding contour. Gravel materials are to be removed from the well location or buried deep in the recontoured cut to prevent possible surface exposure. Disturbed areas are then recontoured back to the original contour or a contour that blends with the surrounding landform, topsoil is redistributed, and the site revegetated. The site should be prepared to provide a seedbed for reestablishment of desirable vegetation. Site preparation may include gouging, scarifying, dozer track-walking, mulching, fertilizing, seeding, and planting. Water breaks and wattles should only be installed only when absolutely necessary to prevent erosion of fill material and should be removed when the site is successfully revegetated and stabilized.
Reclamation Standards	Pg 48 Interim and final reclamation standards for wildlife habitat should be developed by BLM in consultation with WGFD. Reclamation should be done as concurrently as possible with the progression of development. The BLM should develop quantitative criteria for evaluating reclamation success, including species similarity standards, on permanently reclaimed sites.		Pg 32 After completion of all activities all disturbed areas will be restored to conditions similar to the adjacent land or to landowner requirements	Pg 43 Reclamation generally can be judged successful when a self-sustaining, vigorous, diverse, native (or otherwise approved) plant community is established on the site, with a density sufficient to control erosion and non-native plant invasion and to re-establish wildlife habitat or forage production.
Compliance	Pg 48 Compliance with reclamation standards should be enforced and companies required to correct reclamation that does not meet established standards. Future permitting should be based on past performance.			

Appendix 2 Powder River Basin Reclamation Survey Results

A survey of restoration professionals was conducted during two restoration conferences in the Powder River Basin of northeastern Wyoming. The survey was available in hard copy and via a survey host's website. One hundred people participated including wildlife enthusiasts, land owners, oil and gas operators, and land managers. The results are summarized by category. Each question provided space for respondents to write additional comments. Respondent comments are summarized as bullet point with the survey results below.

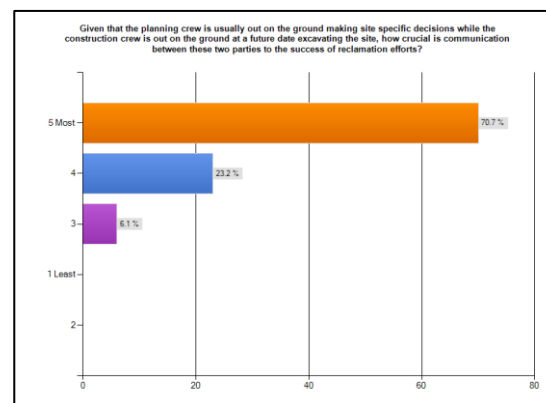
Communication and planning

Communication received 93.7% agreement. In figure 6 the graph illustrates 70.7% of respondents fully agreed that communication is the most critical action to the success of reclamation, an additional 23.2% somewhat agreed, and 6.1% were neutral.

Respondent Comments

- Frequent and clear communication between planning and construction crew is essential
- Regular training is important along with reminders as to why the construction work is important
- The construction crew should have a supervisor present who was part of the planning crew
- A federal agent who took part in the planning should be present during construction

Figure 6 Importance of Communication



The x-axis lists the percentage of responses. Importance is listed on the y-axis 1-Disagree this is most important; 2-Somewhat disagree; 3-Neutral neither agree nor disagree this is most important; 4-Somewhat agree this is most important; 5-Agree this is most important.

Topsoil Salvage

Respondents gave the highest consensus to the importance of salvaging and re-spreading topsoil.

Figure 7 reveals 66.7 agreed and 27.3% somewhat agreed, making topsoil segregation the highest total consensus of agreement at 94% (5% were neutral and 1% somewhat disagreed).

Respondent Comments

- Topsoil is biologically active
- Topsoil has a seed bank of native species
- Salvaging and re-spreading topsoil speeds reclamation and saves money
- Topsoil requires proper handling and must be re-spread in a timely manner

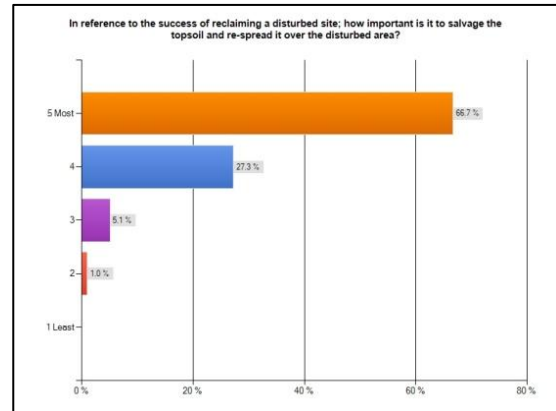
Areas surrounding disturbance

The third highest consensus to the importance of reclamation was given to the care of an area surrounding the disturbance. Figure 8 shows 59% agreed and 29% somewhat agreed, for a total 88% agreement that keeping an area that surrounds disturbance intact, free of weeds and erosion is important to success of reclaiming the disturbed site.

Respondent Comments:

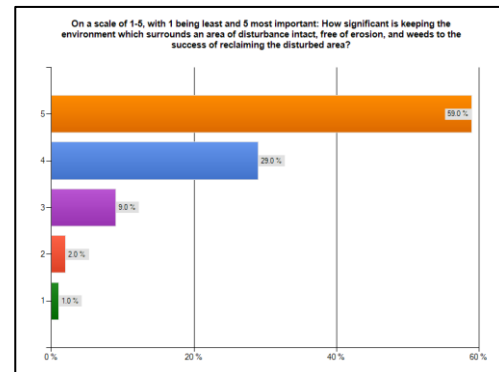
- The operator should be a good steward, control dust and treat weeds

Figure 7 Importance of Topsoil Salvage & Re-spread



The x-axis lists the percentage of responses. Importance is listed on the y-axis 1-Disagree this is most important; 2-Somewhat disagree; 3-Neutral neither agree nor disagree this is most important; 4-Somewhat agree this is most important; 5-Agree this is most important

Figure 8 Keeping Surrounding Areas Intact



The x-axis lists the percentage of responses. The y-axis is the level of agreement.

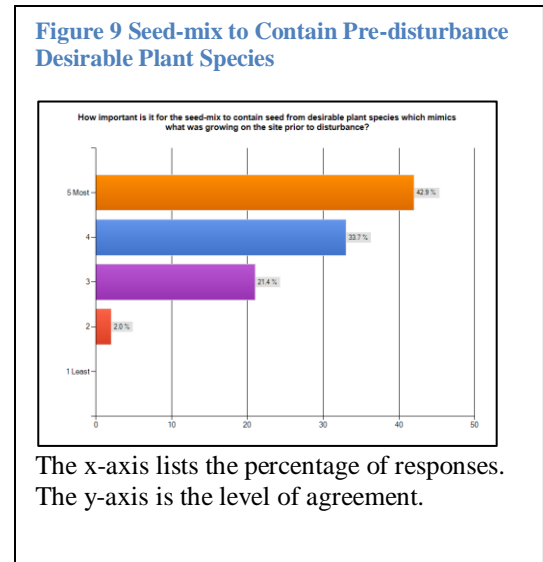
- Reclamation is not just at the site of disturbance it involves a landscape approach, ultimately it will reflect surrounding ecological integrity, and it should be treated as whole
- The federal agency needs to set standards and goals for reclamation

Seed-mix

Fourth in single importance to reclamation was given to seed-mix containing seed of species that that mimic those growing on the site prior to disturbance. Figure 9 shows 42.9% agreed and 33.7% somewhat agreed for a total of 76.6% agreement.

Respondent Comments

- Site specific species will be adapted to local conditions and competitors
- Seed mix should contain seed that it adaptive and will stabilize the site
- The local natives will migrate in with time
- Selection of species in the seed mix should be left up to the landowner

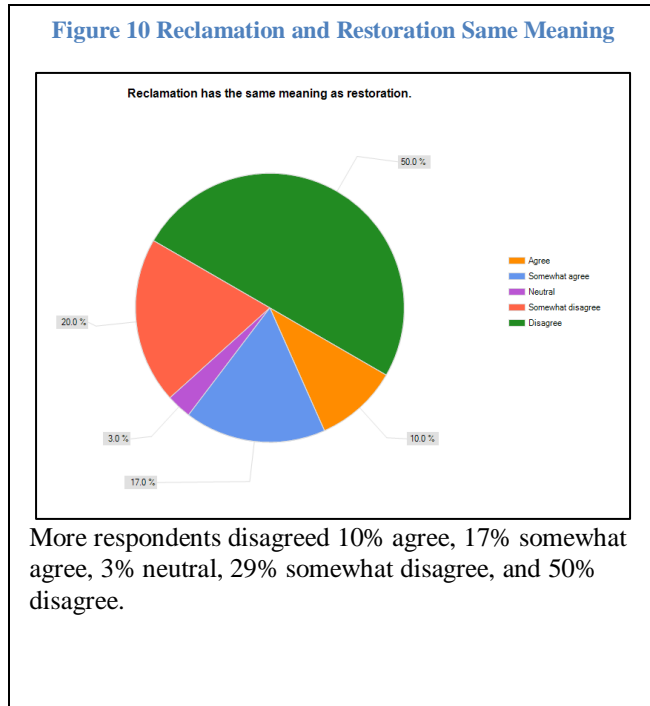


Reclamation

Six questions were asked to measure levels of agreement surrounding actions which affect the success of reclamation. These questions included defining reclamation as restoration; should interim and final reclamation held to same standards; are construction crews able to salvage appropriate the amount of topsoil; should nearby sites be used as reference sites; or should the Natural Resources Conservation Services Ecological Site Descriptions be used as reference sites and should adaptive management strategies be set up front.

Reclamation and Restoration

Two questions specifically inquired about the similarity and differences of reclamation and restoration. The first question of the survey asked if respondents agreed that reclamation and restoration have the same meaning. More respondents disagreed with the statement that reclamation and restoration have the same meaning. As can be seen in figure 10, total agreement is 27% while total disagreement is 79%.



Respondent Comments

<i>Reclamation means</i>	<i>Restoration means</i>
<ul style="list-style-type: none"> Reclaiming to nearly the original condition that prevents erosion, is environmentally stable with established vegetation usable by inhabitants 	<ul style="list-style-type: none"> Returning the land to exactly the way it was before disturbance, same contours, same vegetative community and same successional stage
<ul style="list-style-type: none"> The site is cleaned up and stabilized but it is a lower standard than restoration 	<ul style="list-style-type: none"> Restoring the same successional stage as the surrounding undisturbed area
<ul style="list-style-type: none"> Creating an environment that promotes restoration 	<ul style="list-style-type: none"> Restoration could take a long time or may never recover pre-disturbance condition
<ul style="list-style-type: none"> Returning land to productivity for grazing 	<ul style="list-style-type: none"> Pre-disturbance condition could be positive or could negative

Interim and Final Reclamation

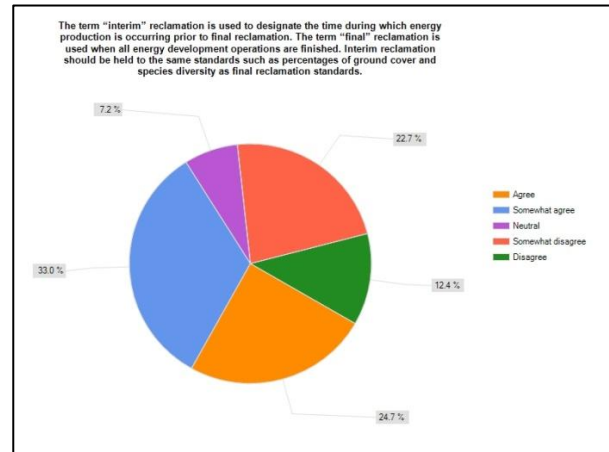
In order to further define reclamation standards, respondents were asked if interim reclamation should be held to the same standards as final reclamation in terms of species diversity and percentage of ground cover. Most respondents agreed with the statement that reclamation and

restoration should be held to the same standards. Figure 11 reveals agreement as 55.7 % while total disagreement is 35.1%.

Respondent Comments

- Interim reclamation should lead to final reclamation
- Whether you use interim or final reclamation standards depends on the amount of time before soil is re-disturbed
- During interim reclamation the focus should be on site stability and weed control
- You may use temporary non-native grasses

Figure 11 Same Standards for Interim and Final Reclamation



More respondents agreed (22.7% agree, 33% somewhat agree, 7.2% neutral, 22.7% somewhat disagree and 12.4% disagree) that interim should be held to the same standards as final reclamation.

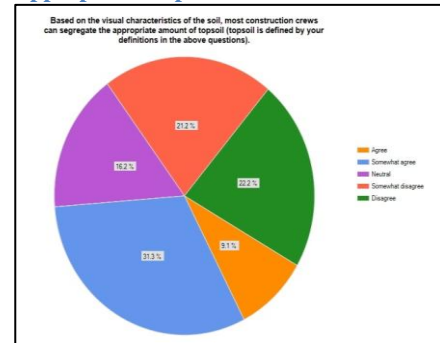
Topsoil

Three questions considered the treatment of topsoil during construction. The most mixed responses were tallied when respondents were asked if they agreed that most construction crews could salvage the appropriate amount of topsoil based on visual characteristics of soil. Figure 12 is a pie chart that looks like a beach ball with a total agreement was 40.4% and total disagreement was 37.4%.

Respondent Comments

- Construction crews need training
- Depends on crews experience
- Depth of topsoil needs testing by soil experts

Figure 12 Construction Crews Salvage Appropriate Topsoil



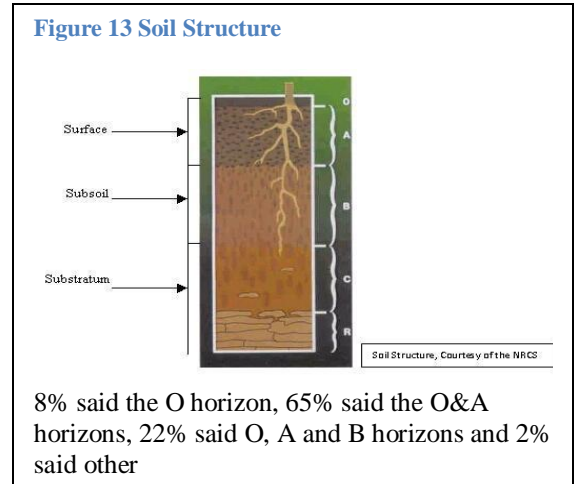
Most varied response in the survey: 9.1% agreed, 31.3% somewhat agreed, 16.2% neutral, 21.2% somewhat disagreed and 22.2% disagreed.

- Money gets the job done

The following two related questions were asked to query how many respondents would agree on topsoil depth and which soil horizons would be included in topsoil salvage.

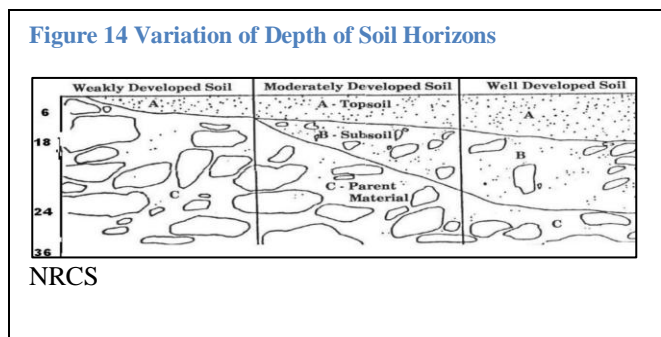
Soil Structure

One question provided the picture in figure13 of soil horizons. Participants were asked which layer(s) would be considered to be salvaged with topsoil; if the upper layer of soil 'O' is the organic layer, 'A' is the surface layer, 'B' is the subsoil, 'C' is the substratum (with parent material), and 'R' in the bedrock. A total of 73% included the O and the O&A horizons



Soil Depth

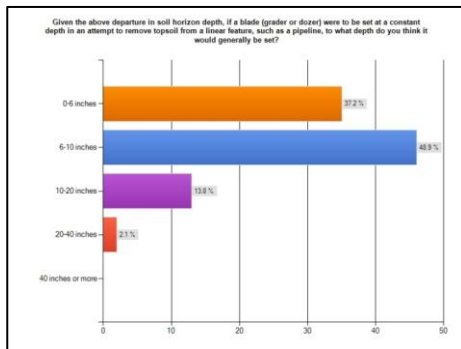
The other question provided figure14 and asked if a blade operator were set a blade at a constant depth to salvage topsoil across a liner feature such as a pipeline or road to what depth would it be set? 86.1%



responded that it would set at 10 inches or less.

The graphs 15 and 16 below illustrate results from the soil depth and structure questions above. Notice that there is some consensus; according to the survey suitable topsoil would include the O&A horizons and it is usually 6-10 inches in depth.

Figure 15 Blade Set at a Constant Depth

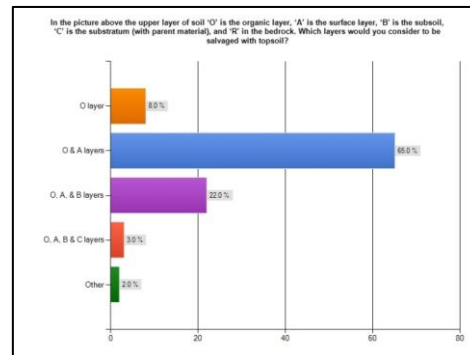


37.2% said 0-6“, 48.9% said 6-10”, 13.8% said 12-20” and 2.1% said 20-40”

Respondent comments

- Too much parent material is bad
- Would not set a blade at a constant depth
- Need to establish topsoil depth during the onsite field review
- Contractors move faster if the blade is set at a constant depth
- Equipment operators are not in re-vegetation field

Figure 16 Which Horizons are Salvaged with Topsoil



8% O horizon, 65% O&A horizons, 22% O, A and B horizons and 2% said other

Respondent comments

- More topsoil is better
- The root support, water and food transport functions are in the topsoil
- This does not apply to all situations.
- BLM standards dictate otherwise.
- Varies with eco-site, normally limit topsoil to primary root zone with organic matter
- Segregation of O and A could be a viable alternative, depends on depth to bedrock, and soil testing for salts/sodium
- Construction is done quickly the contractors take whatever they can get for topsoil

Monitoring Reclamation

When asked who should be responsible for monitoring reclamation of disturbance due to federal energy development; 50% said operators, 32.2% Federal Agencies, 5.2% contractors, and 3.1% said landowners.

Respondent Comments

- Operators leased the land they should be responsible for monitoring reclamation
- BLM has responsibility to monitor operators by field verifying operator reports
- Operators, BLM, Landowners and Contractors working in the area should have their eyes on the ground

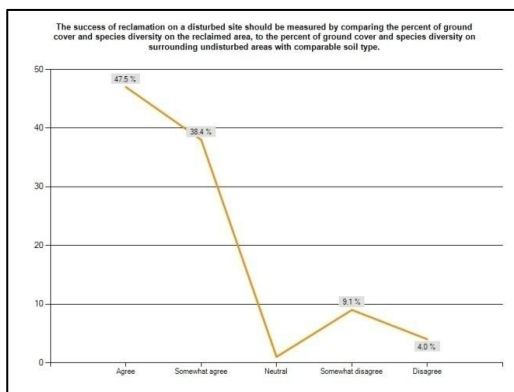
Measuring Reclamation Success

In reference to monitoring, participants were asked two questions. One asked if neighboring sites should be used to measure percent cover and species diversity; 85.9% agreed with using neighboring sites for comparison. The other asked about using the Natural Resource Conservation Service's (NRCS) ecological site descriptions (ESD): 62.9% agreed with using the NRCS ESDs by soil type as baseline data for determining percent cover and species diversity on a disturbed site.

Respondent Comments

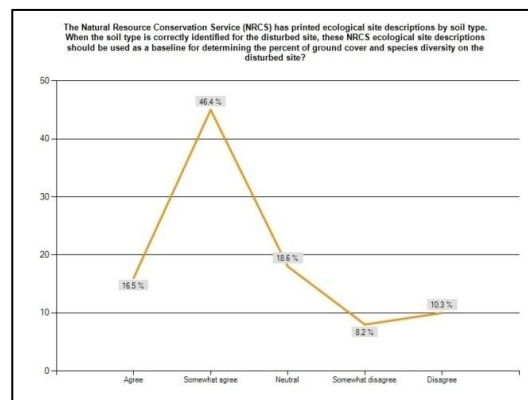
- The soil is a different composition than the neighboring site after mixing
- Don't use the neighboring reference site if it is not healthy
- Instead of matching the neighboring site, should try to improve what is there
- Need field site verification for ESDs
- ESDs could be used as baseline data or as a guideline

Figure 18 Neighboring Sites as Reference Sites



85.9% agreed with using neighboring sites would be good for comparing sites

Figure 17 NRCS ESD as Reference Sites



62.9% agreed with using the NRCS ESDs by soil type as baseline data for determining percent cover and species diversity on the disturbed site

- ESDs need to consider the climax community or serial stage
- Need to define the goal, desired plant community, and representatives of functional groups and structure

Adaptive Management

One question asked if adaptive management strategies should be pre-established in the reclamation plan. There was a total agreement of 83.8%. Total disagreement percentage was 7.1%, 6.1% somewhat disagreed and 1% disagreed (figure 19).

Respondent Comments

- Need to write out the adaptive strategy options or steps to be taken in the reclamation plan
- Adaptations should depend on monitoring results
- The reclamation plan needs allow for adaptively and not be all inclusive

Timing

Three questions addressed timing of reclamation monitoring; how much time should be given to stabilize topsoil before priority returns to desired plant community, how often should seeded sites be monitored, and how frequently should reclamation plans be revised.

Timing Soil Stabilization to Vegetative Community

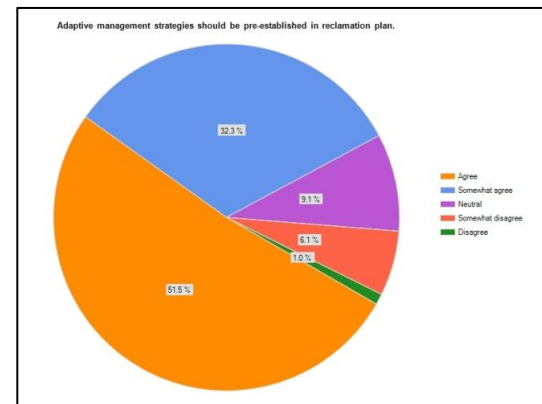
How long after initial disturbance should priority turn back from soil stabilization to establishing plant community?

Figure 20 shows a total of 73% agree that the goal needs to return to establishing a desirable plant community within 2 years.

Respondent Comments

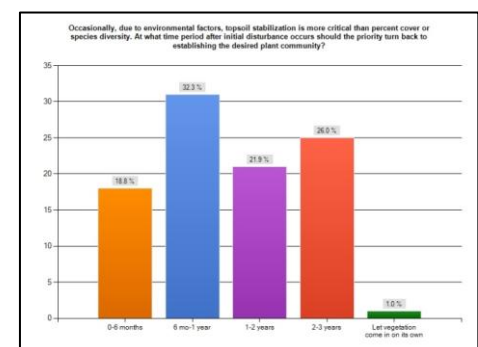
- Depends on site specific conditions

Figure 19 Adaptive Management Strategies



51.5% of the respondents agreed and 32.3% somewhat agreed, 9.1% neutral, 6.1% somewhat disagreed and 1% disagreed

Figure 20 Priority turns back from soil stabilization to establishing plant community



0-6 months, 18.8%; 6 months to 1 year 32.3%; 1-2 years 21.9%; 26% 2-3 years

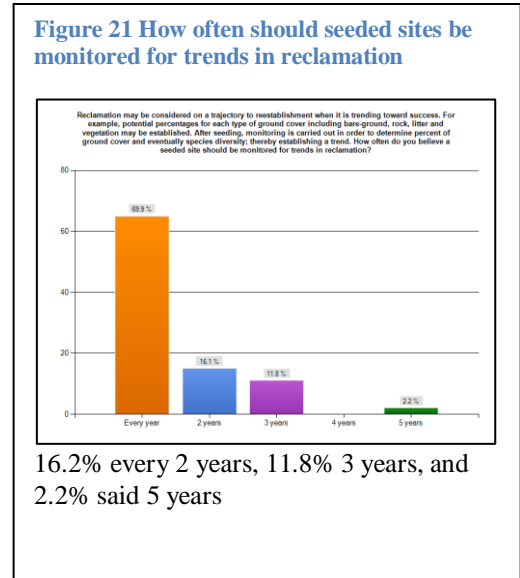
- Need to use something to hold topsoil such as hydro mulch and mats
- Topsoil health is at stake, need vegetation to retain soil organisms

Timing to Show Trends toward Reclamation

Figure 21 shows that 69.9% agree that sites should be monitored every year for trends in reclamation; A total of 96.9% said less sites should be monitored for trends in reclamation every 3 years or less.

Respondent Comments

- Success needs to be defined
- Monitoring should be conducted more in the beginning and less often once established
- Monitoring regime should restart if reclamation is unsuccessful

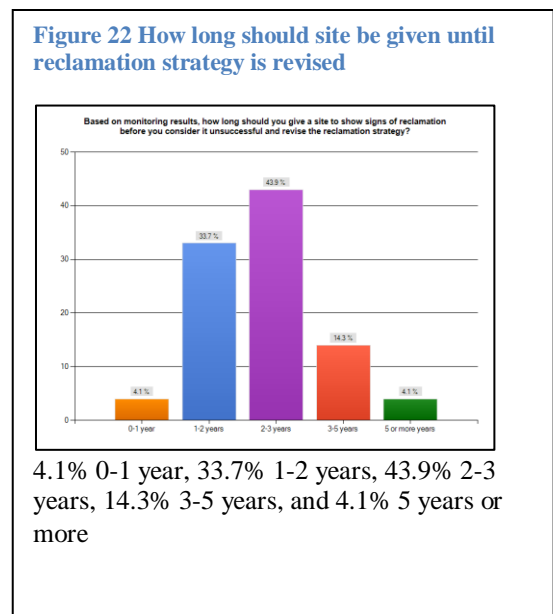


Timing before Reclamation is Revised

When asked how long a site should be given until the reclamation strategy is revised, 81.7% thought the reclamation strategy should be given 3 years or less before being revised.

Respondent Comments

- Depends on native vegetation, soil type and other site specific conditions
- Depends on moisture
- Need to focus on stability and treating weeds

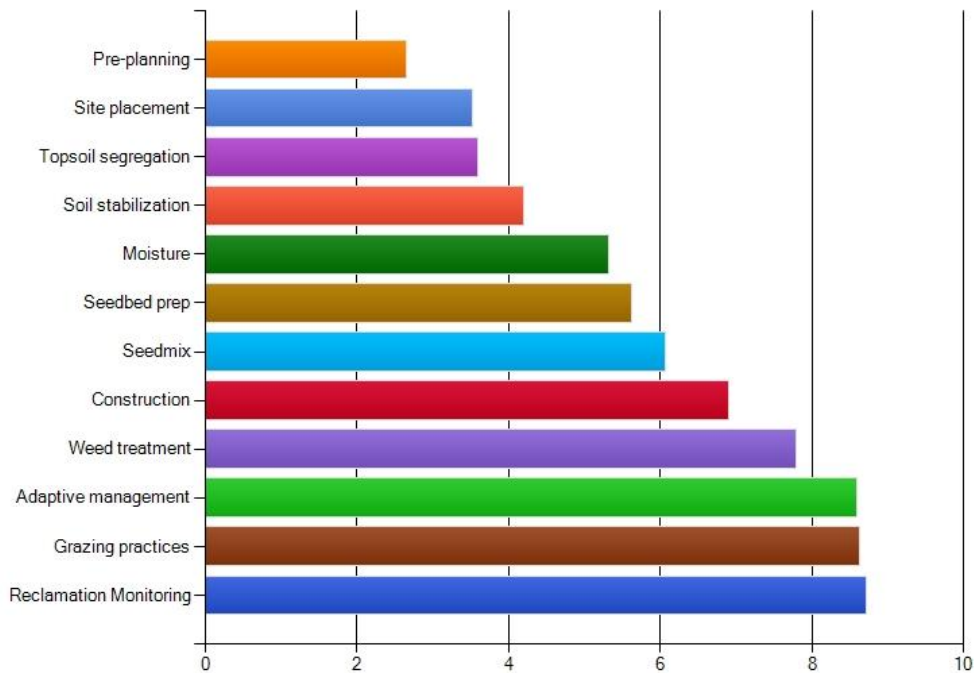


Prioritization of reclamation actions in reference to other actions

Figure 23 is from the seventeenth question in the survey. Participants were asked to prioritize reclamation actions in reference to other actions. Results reveal participants consider pre-planning and site placement as a slightly higher priority than topsoil segregation and soil stabilization in the success of reclamation. The next factor selected was moisture, followed by seedbed preparation and seed mix which scored sixth and seventh of the twelve choices. Construction and weed treatment scored eighth and ninth place. The last three adaptive management, grazing and reclamation monitoring scored almost equally distant from other critical factors of successful reclamation.

Figure 23 Prioritization of reclamation actions in reference to other actions

In your opinion, what are the most important factors for attaining successful reclamation? Please prioritize in the order of importance with 1 being the most important.



Reclamation actions are on the y-axis and priority is on the x-axis. According to this graph, pre-planning is the most important factor in attaining successful reclamation.

Open Ended Questions

Three open ended questions were asked in the survey inquiring on the respondent's 1) definition of reclamation, 2) what can be done to aid reclamation during drought, and 3) additional comments. Respondent's comments (as above) are categorized for repetitiveness of subject matter and are summarized as bullet points. The definitions are listed in order of repetitiveness from most common to least common response.

1) Definition of reclamation

85% of the survey participants presented their own definitions of reclamation success such as:

- Ecosystem reconstruction
- When a set percentage of vegetative cover is established
- Original plant community and topography is established
- Establish native or desirable plant species
- When goals and objectives are met
- Trending toward long-term goals
- Brought back to useable condition
- Species diversity is established

2) What can be done to aid reclamation during drought

82% provided suggestions of what reclamation practices would be most helpful during drought periods.

- Prevent moisture loss with mulch, straw or snow catchments
- Plant drought tolerant seed
- Water, irrigate or snow fences
- Ensure surface roughness
- Protect topsoil with a cover crop
- Factor in the effects of grazing

3) Additional comments

37% of the participants provided additional comments or suggestions on subjects they felt important to reclamation due to energy development

- Pre-planning follow through, and communication will improve reclamation
- Corridor and co-locate disturbance to reduce the footprint
- Improve construction, timing, topsoil, erosion control and seeding
- Ensure operators are accountable with bonds and enforcement
- Account for grazing impacts on reclamation
- Set goals and standards

Appendix 2 Summary of Respondent Comments Powder River Reclamation Survey

Attribute	Responder Comments
Communication and planning	<ul style="list-style-type: none"> • Frequent and clear communication between planning and construction crew is essential • Regular training is important along with reminders as to why the construction work is important • The construction crew should have a supervisor present who was part of the planning crew • A federal agent who took part in the planning should be present during construction
Topsoil Segregation	<ul style="list-style-type: none"> • Topsoil is biologically active • Topsoil has a seed bank of native species • Salvaging and re-spreading topsoil speeds reclamation and saves money • Topsoil requires proper handling and must be re-spread in a timely manner
Topsoil Visual	<ul style="list-style-type: none"> • Construction crews need training • Depends on crews experience • Depth of topsoil needs to be tested by soil experts • Money gets the job done
Topsoil Depth	<ul style="list-style-type: none"> • Too much parent material is bad • Would not set a blade at a constant depth • Need to establish topsoil depth during the onsite field review • Contractors move faster if the blade is set at a constant depth • Equipment operators are not in re-vegetation field
Topsoil Horizons	<ul style="list-style-type: none"> • The root support, water and food transport functions are in the topsoil • This does not apply to all situations. • BLM standards dictate otherwise. • Varies with eco-site, normally limit topsoil to primary root zone with organic matter • Segregation of O and A could be a viable alternative, depends on depth to bedrock, and soil testing for salts/sodium • Construction is done quickly the contractors take whatever they can get for topsoil • More topsoil is better
Interim and Final Reclamation Standards	<ul style="list-style-type: none"> • Interim reclamation should lead to final reclamation • Whether you use interim or final reclamation standards depends on the amount of time before soil is re-disturbed • During interim reclamation the focus should be on site stability and weed control • You may use temporary non-native grasses

Attribute	Responder Comments
Seed-mix	<ul style="list-style-type: none"> • Site specific species will be adapted to local conditions and competitors • Seed mix should contain seed that is adaptive and will stabilize the site • The local natives will migrate in with time • Selection of species in the seed mix should be left up to the landowner
Areas surrounding disturbance	<ul style="list-style-type: none"> • The operator should be a good steward, control dust and treat weeds. • Reclamation is not just at the site of disturbance it involves a landscape approach, ultimately it will reflect surrounding ecological integrity, and it should be treated as whole. • The federal agency needs to set standards and goals for reclamation
Reference Sites	<ul style="list-style-type: none"> • The soil is a different composition then the neighboring site after mixing • Don't use the neighboring reference site if it is not healthy • Instead of matching the neighboring site, should try to improve what is there • Need field site verification for ESDs • ESDs could be used as baseline data or as a guideline • ESDs need to consider the climax community or serial stage • Need to define the goal, desired plant community, and representatives of functional groups and structure
Monitoring Reclamation	<ul style="list-style-type: none"> • Operators leased the land they should be responsible for monitoring reclamation • BLM has responsibility to monitor operators by field verifying operator reports • Operators, BLM, Landowners and Contractors working in the area should have their eyes on the ground
Adaptive Management	<ul style="list-style-type: none"> • Need to write out the adaptive strategy options or steps to be taken in the reclamation plan • Adaptations should depend on monitoring results • The reclamation plan needs allow for adaptively and not be all inclusive
Timing Soil Stabilization and Vegetation Priorities	<ul style="list-style-type: none"> • Depends on site specific conditions • Need to use something to hold topsoil mulch, mats, ect • Topsoil health is at stake, need vegetation to retain soil organisms
Timing Monitoring for Trends	<ul style="list-style-type: none"> • Success needs to be defined • Monitoring should be conducted more in the beginning and less often once established • Monitoring regime should restart if reclamation is unsuccessful
Time Between Changing Strategies	<ul style="list-style-type: none"> • Depends on native vegetation, soil type and other site specific conditions • Depends on moisture • Need to focus on stability and treating weeds

Attribute	Responder Comments
Definition of Reclamation	<ul style="list-style-type: none"> • Ecosystem reconstruction • When a set percentage of vegetative cover is established • Original plant community and topography is established • Establish native or desirable plant species • When goals and objectives are met • Trending toward long-term goals • Brought back to useable condition • Species diversity is established
Reclamation means	<ul style="list-style-type: none"> • Reclaiming to nearly the original condition that prevents erosion, is environmentally stable with established vegetation usable by inhabitants • The site is cleaned up and stabilized but it is a lower standard than restoration • Creating an environment that promotes restoration • Returning land to productivity for grazing
Restoration means	<ul style="list-style-type: none"> • Returning the land to exactly the way it was before disturbance, same contours, same vegetative community and same successional stage • Restoring the same successional stage as the surrounding undisturbed area • Restoration could take a long time or may never recover pre-disturbance condition • Pre-disturbance condition could be positive or could negative
Others Important to Reclamation	<ul style="list-style-type: none"> • Pre-planning follow through, and communication • Construction, timing, topsoil, erosion control and seeding • Ensure operators are accountable with bonds and enforcement • Need to set goals and standards • Account for grazing impacts of reclamation • Corridor and co-locate disturbance to reduce the footprint

Appendix 4 Powder River Basin Reclamation Survey

QUESTIONNAIRE

This survey focuses on your professional opinion of development and implementation of reclamation techniques and strategies. You will be asked about key elements of reclamation during phases of energy development such as planning, construction, production, and monitoring. This survey is being conducted as part of a graduate project by Jennifer Spagon from Buffalo, Wyoming. Jennifer is working for the BLM as she continues her educational pursuits in Environmental Management with the Nicholas School of the Environment.

The survey results will be used by the researcher to summarize opinions of reclamation and restoration professionals. The study is funded exclusively by the researcher. A summary of the survey results will be presented as a final report in May 2010 as part of the researcher's educational program. The final report will be available to federal agencies, industry and private parties upon request.

Thank you in advance for completing this survey. It is completely anonymous and will not ask you for your name, workplace, or contact information in any of the survey responses. You may skip any question, be as brief or in-depth as you like. Any information you wish to provide is appreciated. Please contact Jennifer Spagon phone at 307-620-1286, if you seek follow-up information.

Instructions: Choose the answer that best suits your professional opinion for each of the questions below. Your observations are fundamental in portraying your opinion; therefore, please take a few extra minutes to write in comments and further explanations. After you complete the survey place it in the drop box designated by the conference host.

Please provide an explanation for the first question below. The term reclamation will be used throughout the remainder of this questionnaire. I will refer to your answer in question 1 to determine your personal interpretation of the difference between the terms reclamation and restoration.

1) Reclamation and restoration have the same meaning.

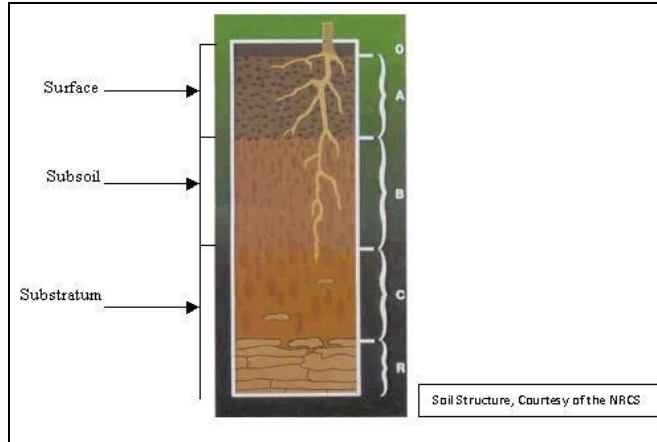
- Agree Somewhat agree Neutral Somewhat disagree Disagree
 Other/Comments

2) On a scale of 1-5, with 1 being least and 5 most important: How significant is keeping the environment which surrounds an area of disturbance intact, free of erosion, and weeds to the success of reclaiming the disturbed area?

- 1 2 3 4 5
 Other/Comments

3) In reference to the success of reclaiming a disturbed site; how important is it to salvage the topsoil and re-spread it over the disturbed area?

- 1 Least 2 3 4 5 Most
 Other/Comments



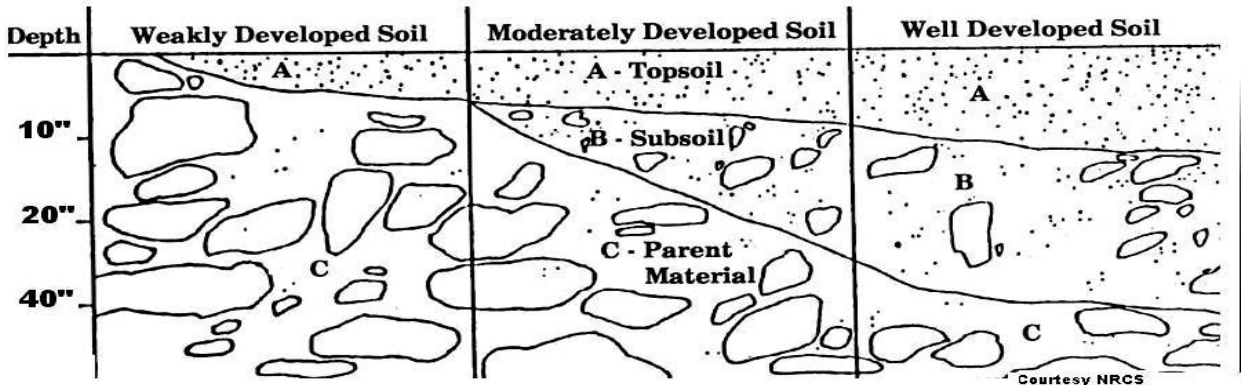
4) In the picture above the upper layer of soil 'O' is the organic layer, 'A' is the surface layer, 'B' is the subsoil, 'C' is the substratum (with parent material), and 'R' in the bedrock. Which layers would you consider to be salvaged with topsoil?

- O layer
 O & A layers
 O, A, & B layers
 O, A, B & C layers
 Other/Comments

5) Based on the visual characteristics of the soil, most construction crews can segregate the appropriate amount of topsoil (topsoil is defined by your definitions in the above questions).

- Agree
 Somewhat agree
 Neutral
 Somewhat disagree
 Disagree
 Other/Comments

Changes in Depth of Soil



6) Given the above departure in soil horizon depth, if a blade (grader or dozer) were to be set at a constant depth in an attempt to remove topsoil from a linear feature, such as a pipeline, to what depth do you think it would generally be set?

- 0-6 inches
- 6-10 inches
- 10-20 inches
- 20-40 inches
- 40 inches or more
- Other/Comments

7) Given that the planning crew is usually out on the ground making site specific decisions while the construction crew is out on the ground at a future date excavating the site, how crucial is communication between these two parties to the success of reclamation efforts?

- 1 Least
- 2
- 3
- 4
- 5 Most
- Other/Comments

8) How important is it for the seed-mix to contain seed from a desirable plant species that mimics what was growing on the site prior to disturbance?

- 1 Least
- 2
- 3
- 4
- 5 Most
- Other/Comments

9) **Reclamation may be considered on a trajectory to reestablishment when it is trending toward success.** For example, potential percentages for each type of ground cover including bare-ground, rock, litter and vegetation may be established. After seeding, monitoring is carried out in order to determine percent of ground cover and eventually species diversity; thereby establishing a trend. **How often do you believe a seeded site should be monitored for trends in reclamation?**

- Every year 2 years 3 years 4 years 5 years
 Other/Comments

10) **The success of reclamation on a disturbed site should be measured by comparing the percent of ground cover and species diversity on the reclaimed area, to the percent of ground cover and species diversity on surrounding undisturbed areas with comparable soil type.**

- Agree Somewhat agree Neutral Somewhat disagree Disagree
 Other/Comments

11) **The Natural Resource Conservation Service (NRCS) has printed ecological site descriptions by soil type. When the soil type is correctly identified for the disturbed site, these NRCS ecological site descriptions should be used as a baseline for determining the percent of ground cover and species diversity on the disturbed site?**

- Agree Somewhat agree Neutral Somewhat disagree Disagree
 Other/Comments

12) Alternative/adaptive management strategies are necessary when reclamation is not successful. The following is an example with a generic adaptive management plan: The disturbed area was seeded; two growing seasons pass; the site grows only weeds. The predetermined adaptive management plan states; if after two growing seasons, a site grows predominately weeds (1) the underlying problem will be determined (2) weeds will be removed or treated (depending on species) (3) stubble will be left to catch snow (4) site will be replanted with specific seed mix to address the problem (such as drought/salt tolerant, weed competitive, cover crop, nurse crop, or more diverse species in the seed mix). **Adaptive management strategies should be pre-established in the reclamation plan.**

- Agree Somewhat agree Neutral Somewhat disagree Disagree

Other/Comments

13) Based on monitoring results, how long should you give a site to show signs of reclamation before you consider it unsuccessful and revise the reclamation strategy?

- 0-1 year 1-2 years 2-3 years 3-5 years 5 or more years

Other/Comments

14) The term “interim” reclamation is used to designate the time during which energy production is occurring prior to final reclamation. The term “final” reclamation is used when all energy development operations are finished. Interim reclamation should be held to the same standards such as percentages of ground cover and species diversity as final reclamation standards.

- Agree Somewhat agree Neutral Somewhat disagree Disagree

Other/Comments

15) In reference to disturbance from federal energy development, in your opinion, who should be primarily responsible for monitoring reclamation progress? Please comment on why you think this entity should be responsible for reclamation monitoring.

- Operators
- Federal Agencies
- Not Sure
- Land Owners
- Contractor
- Other/Comments

16) Occasionally, due to environmental factors, topsoil stabilization is more critical than percent cover or species diversity. At what time period after initial disturbance occurs should the priority turn back to establishing the desired plant community?

- 0-6 mo
- 6 mo-1 year
- 1-2 years
- 2-3 years
- Let vegetation come in on its own
- Other/Comments

17) In your opinion, what are the most important factors for attaining successful reclamation? Please prioritize in the order of importance with 1 being the most important.

- ___ Pre-planning
- ___ Site placement
- ___ Construction
- ___ Topsoil segregation
- ___ Soil stabilization
- ___ Seedmix
- ___ Seedbed prep
- ___ Moisture
- ___ Weed treatment
- ___ Reclamation Monitoring
- ___ Adaptive management
- ___ Grazing practices
- ___ Other/Comments

18) What reclamation practices are most helpful during drought periods and other extreme weather affecting one or more growing seasons? Should monitoring efforts be modified during these times?

19) What is your definition of successful reclamation?

20) Please provide any additional comments or suggestions on subjects you believe are important to reclamation of disturbance due to energy development.

Demographics

What is your occupation?

- Operator Env. Consultant Construction Land Owner Gov.
 Other/Comments

What level of education did you complete?

- High School Some College Bachelors Masters PhD
 Other/Comments

How many years have you worked in Wyoming or other Western States?

- < 2 years 2-4 years 4-6 years 6-10 years > 10 years
 Other/Comments

How many years have you worked in the field of reclamation or related field?

- < 2 years 2-4 years 4-6 years 6-10 years > 10 years
 Other/Comments

Thank you for participating, your input is appreciated.

