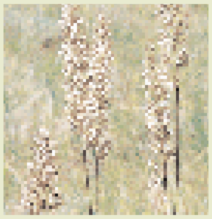
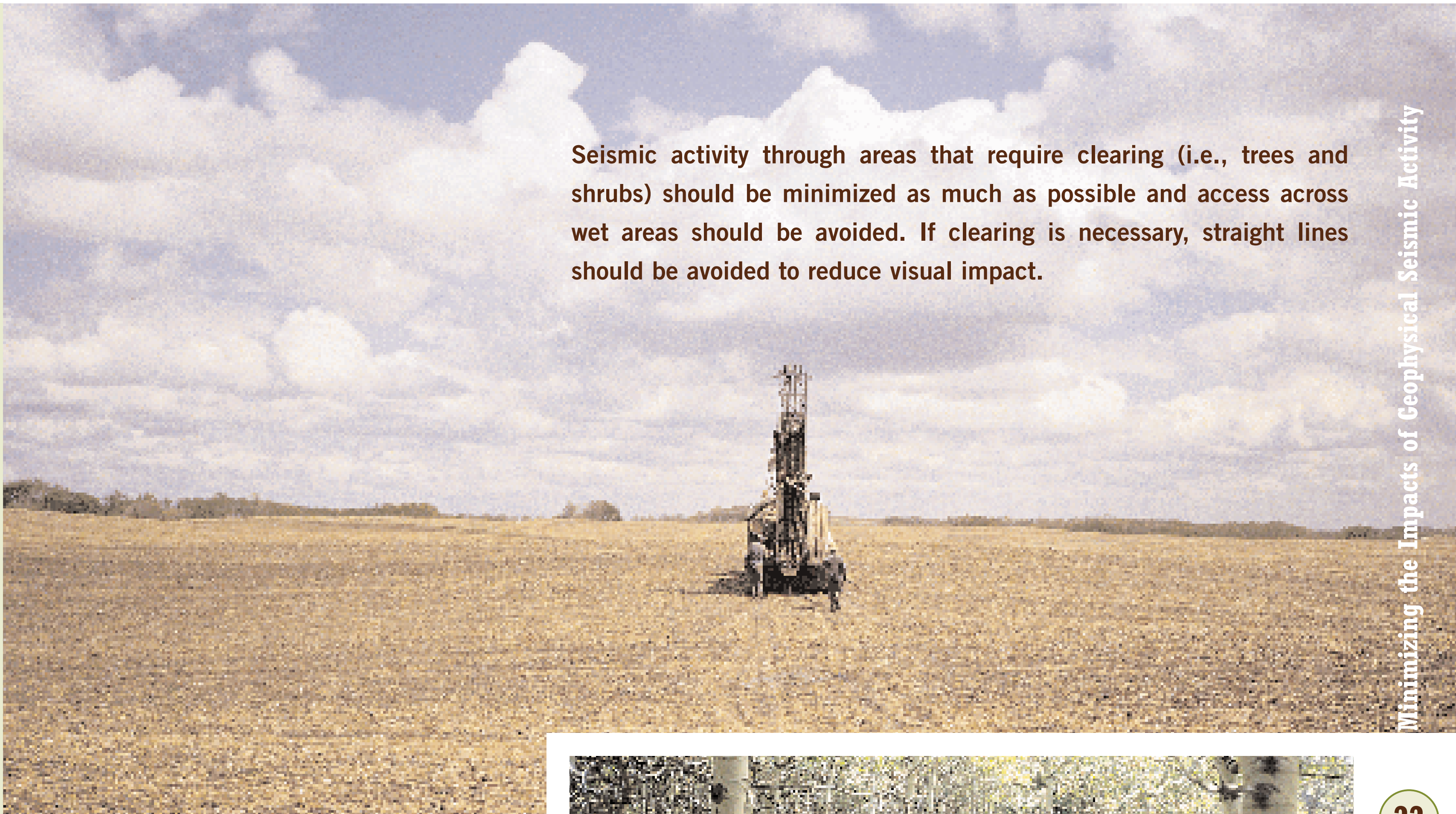
Minimizing the Impacts of Geophysical (Seismic) Activity



Minimizing the impacts of geophysical (seismic) activity on the prairie involves use of existing trails whenever possible and when ground conditions are either dry or frozen. Access routes must observe suitable setback distances (e.g., from coulees) and timing restrictions associated with sensitive wildlife and features. Vehicles and equipment with the least potential for surface disturbance should be selected.



Seismic activity through areas that require clearing (i.e., trees and shrubs) should be minimized as much as possible and access across wet areas should be avoided. If clearing is necessary, straight lines should be avoided to reduce visual impact.

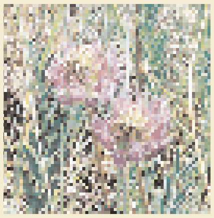
Low impact seismic

When it is necessary to conduct seismic activity through coulees or low areas with cottonwoods, the use of hand-cut lines and light-weight equipment can minimize the damage to the landscape and vegetation.

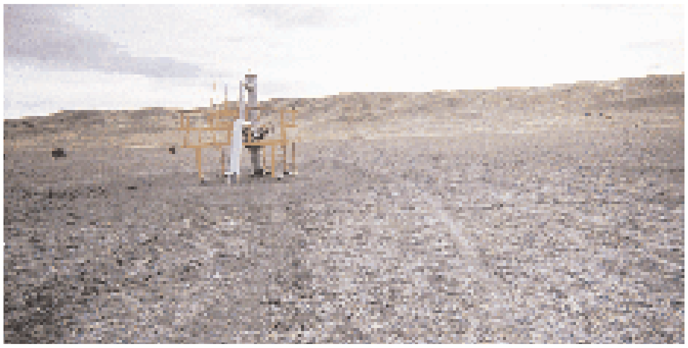
Clean up debris

Care needs to be taken to replace cuttings in shot holes and to remove any debris resulting from the activity (e.g., survey tape). Seeding following seismic activities is usually not required due to minimal soil disturbance.

Minimizing the Impacts of Drilling Activity



Careful planning, construction and reclamation techniques are key to reducing the impacts of oil and gas drilling on prairie and parkland.



Pre-planning developments to minimize environmental impact

When planning the development of an oil or gas field, it is often possible to minimize environmental impacts to prairie by directionally drilling a number of wells from one location (pad) and by placing pipelines and electric transmission lines along access roads. Any previously disturbed sites, or areas of tame pasture or cultivation should be used first.

Avoid riparian areas and dry lakebeds

More sensitive features such as riparian areas along streams or dry lakebeds should be avoided. It is often possible to locate the wellsite in a less sensitive area and directionally drill to the target zone.

Construction

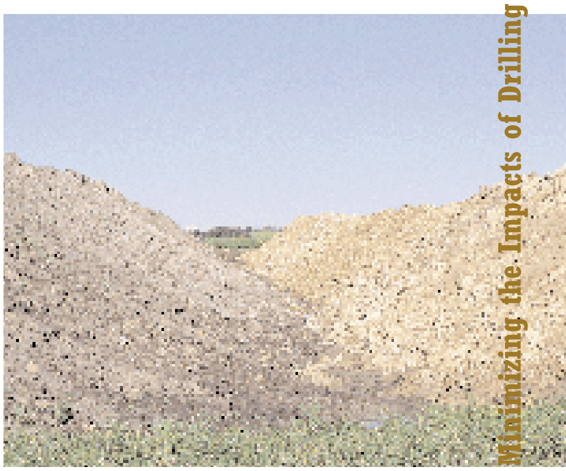
Careful construction can reap huge benefits later in terms of a reduced footprint on the landscape and a lower cost of reclamation.

Minimum disturbance wellsites

Shallow gas wells can usually be drilled within a 24 hour period. Often the small drilling rig can be placed right on the prairie vegetation, without stripping soils. Tanks are used to contain the drilling muds. The result is a very small "footprint" which heals very quickly, often without reseeding. Oil wells take longer to drill, therefore, there is a greater risk of running into bad weather. Rain or thaw conditions can result in rutting of soils. Due to this risk and the increased risk of contamination, it is often wise to strip soils back on oil well leases. It is still possible to reduce the area that has to be stripped, reducing the overall disturbance to prairie vegetation and soils.

Cut and fill

Wellsites should be sited as often as possible on level ground. The need for cut and fill at wellsites can be reduced through careful site selection, altering the size and shape of pad sites, and the use of self-levelling rigs. When cut and fill is required in hilly areas, care must be taken to stabilize slopes. Contours must be blended into the surrounding landscape during reclamation.



Drilling fluid disposal

Drilling fluids used to drill prairie wells are water-based. Companies should recycle drilling fluids to minimize water requirements in the dry prairie environment. Often disposal problems associated with drilling fluids are related to salinity or sodicity from make-up water. Testing of make-up water sources can minimize disposal problems later on.

Fluids associated with drilling systems should be managed to prevent contamination to surface water, groundwater, or soil resources. The use of portable flare pits, berms, clay pads, catchment pans under rigs, and filter fabric are options that can be considered to reduce potential impacts. Only above ground sumps (tanks) or remote sumps (off native prairie) are allowed on native prairie and parkland areas on public lands and in the Special Areas except where full site stripping has occurred. Disposal of waste by landspraying while drilling (LWD) is limited to fresh water-based gel drilling mud systems. Where allowed, LWD should be targeted for spraying on cultivated land first, then tame hay-land, and finally native prairie as a last resort.

Soil handling

Topsoil contains valuable organic matter, seeds and rhizomes and it is important to salvage it carefully and protect it from erosion and contamination during storage. Topsoil must be stripped separately from subsoil (two lift) and the piles separated. If natural recovery (no seeding) is planned for revegetation, consideration should also be given to salvaging the sod layer (seed bank) separate from the topsoil layer. Soil resources must be protected from wind and water erosion during the construction period, and throughout the production period.

Production

Access during the drilling phase should use existing trails or temporary access across the prairie.

Timing of activities (e.g., well servicing) to ensure stable or frozen ground conditions is essential. Access routes must observe suitable setback distance and timing restrictions associated with sensitive wildlife and features (e.g., coulee complex) and avoid historical resources.

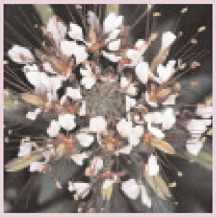
Access routes may need to be upgraded once production begins due to the impacts of regular traffic. Operators should monitor for impacts such as erosion and rutting. If impacts are noted or heavy traffic is anticipated, access can be upgraded as a means of environmental protection. Planners need to carefully consider the type of access road that is required and not over-build. Where the development of new access is required, it should be carefully planned to avoid sensitive areas. Non-permanent access to remote wells should be considered, especially in sensitive areas.

Interim reclamation

Final reclamation and seeding should be done on areas of the lease that will not be redisturbed after abandonment of the well. Topsoil held back for future reclamation should be spread to a depth of 30 to 50 centimetres and reseeded. This shallow depth keeps the seeds and microbes in the stored soil alive. The soil should be placed where it can be easily recovered and the location carefully recorded and kept on file with the wellsite history. A simple sketch on the survey drawing is effective.

“Timing of activities (e.g., well servicing) to ensure stable or frozen ground conditions is essential.”

Minimizing the Impacts of Pipelining



Environmental impacts associated with pipelines are usually confined to a short period of time during surveying, construction and reclamation, during maintenance or repair periods and again at abandonment (if the pipe is removed from the ground).

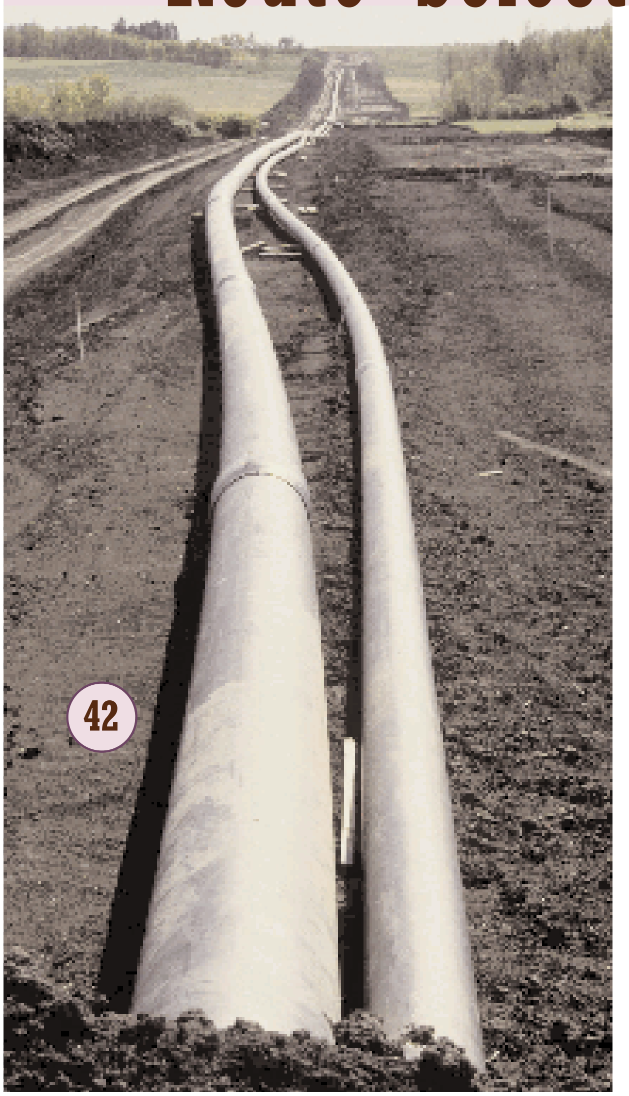
When planning pipeline construction, the least invasive procedures should always be given first consideration.

Concerns can be largely addressed through careful pre-development planning and implementation of appropriate construction and reclamation methods.

Routing options

Pipelines should be preferentially routed through existing disturbed lands, especially rights-of-way (RoWs), or areas of tame pasture or cultivation. Locating a pipeline on native prairie should be the last resort. When it is necessary to develop a new route, the environmental sensitivities of several alternatives should be weighed, and the route causing the least impact chosen.

Route Selection



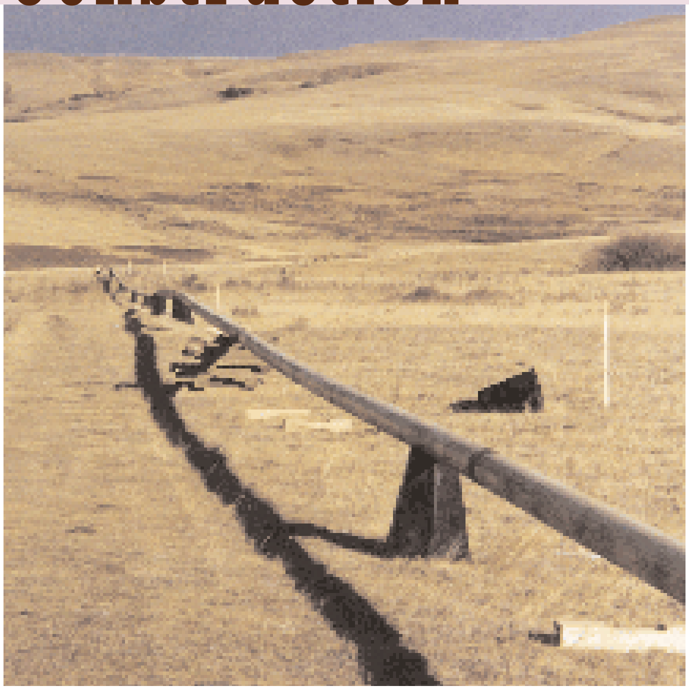
Paralleling old lines

Planning pipeline routes along existing corridors is usually preferred unless the existing pipeline or access road contains rare plant or animal species or crosses sensitive terrain that should not be re-disturbed. Overlapping of old routes seeded to invasive agronomic species like smooth brome or crested wheat grass should also be avoided unless a program to remove the undesirable plants is undertaken.

Surveys

Surveys of landscapes, soils, vegetation (including weeds and rare plants), wildlife and historical resources are usually conducted for larger or longer pipelines. The Alberta Natural Heritage Information Centre (ANHIC: www.gov.ab.ca/env/parks/anhic/anhic.html) database is a valuable source of information on rare plants (and other elements) in the province and can be used as a tool to identify areas of concern. The *Listing of Significant Historical Sites and Areas* should also be reviewed to determine if any designated historic sites or resources are situated within the proposed RoW. If sensitive features are identified (e.g., coulees, wetlands, river benches and breaks, dry lake-beds and riparian areas, significant historical resources), the route is modified to avoid these areas. If avoidance is impossible, mitigative strategies are developed in consultation with land managers.

Construction



Pipeline construction involves all construction and reclamation activities associated with the placement of pipe in the ground. Choice of appropriate techniques for a particular job should be based on an evaluation of soil (texture, depth, rocks, moisture and chemical characteristics), vegetation (type, sod thickness, range condition), weather and season, protection of other resources (wildlife, historical), available machinery, safety, project size and length. When future expansion is likely, several pipes can be installed in a common trench, eliminating the need to re-disturb the area at a later date.

The timeframe associated with pipeline construction is short. It is important that soil stripping operations are followed quickly by trenching and placement of pipe to minimize the danger of wind erosion in the dry prairie environment. Access for landowners, livestock and wildlife across the pipeline right-of-way during construction can be assisted by carefully placed trench plugs and breaks in stored topsoil, spoil materials and strung pipe. Pre-construction environmental training sessions are recommended for all personnel to identify both standard operating practice and any special issues associated with the particular project (e.g., rattlesnake protection).

Narrowing the Right-of-Way

The key to soil handling for pipeline projects is to disturb the smallest amount of area to get the pipeline in the ground.

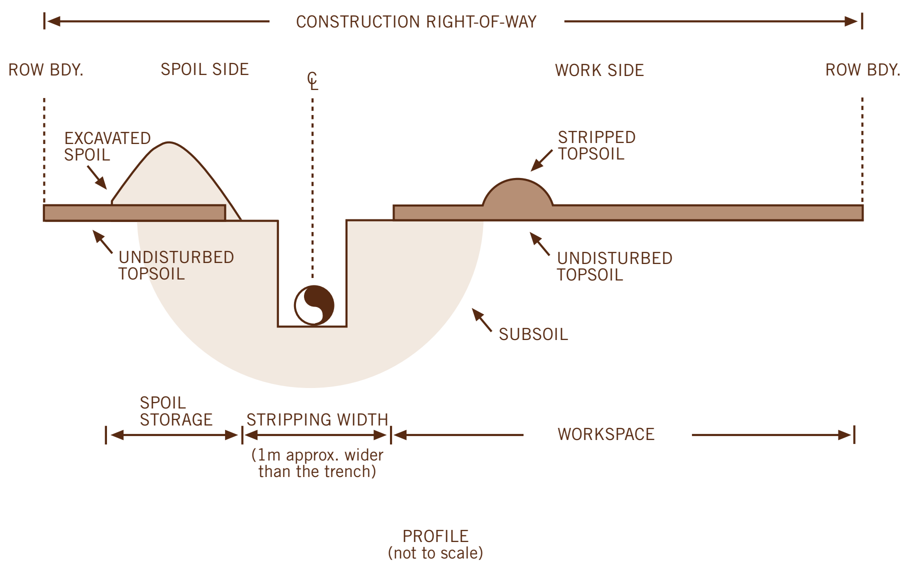
Soil stripping progressions

When constructing pipelines, a balance is needed between minimizing the area of disturbance vs. minimizing the impact of disturbance. For example, if the weather is unsettled, it may be better to strip more topsoil (which increases the area of disturbance) to prevent rutting (which would increase the impact of disturbance). Generally wider areas are stripped when topography is rough, when soils are deeper or sandier, when soil moisture is higher or the weather is poor and when special circumstances such as road, stream or railway crossings, side bends or crossings with other pipelines are encountered. Proposed methods should be discussed with the appropriate land manager. It is also extremely important to have accurate drawings of soil stripping procedures for construction personnel. Trench widths are usually slightly bigger than pipe size to allow soil to get back under the pipe. Larger trenches are required when soils are sandy because the walls tend to slough. Back-hoes are often used for trenching, however, wheel ditchers can be used to construct trenches up to 30 cm (12 inches) wide.

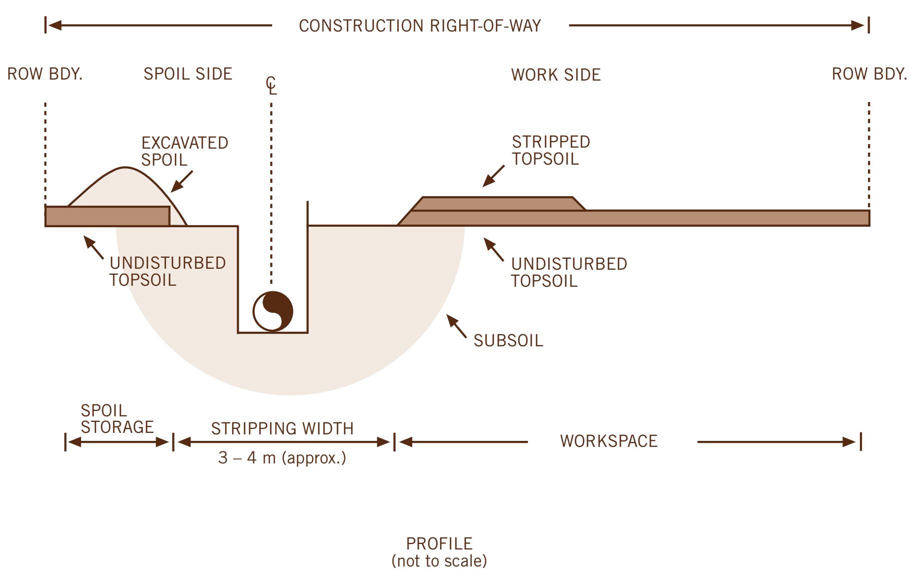
Ploughing in pipelines

Ploughing in means that there is no open excavation, just vertical soil displacement. Small diameter pipelines (<10 cm or 4 inch) can usually be ploughed in, although some bigger lines (<15 cm or 6 inch) are being installed this way. If this is done carefully in the summer, disturbance is minimal with only cracks visible in the sod layer. In a prairie environment, large rocks, wet or frozen soils and complex topography may limit the use of this procedure. In the winter, soils may need to be stripped over the ditchline with a frozen soil stripper. The technique is not suitable for installation of high pressure lines.

Trenchline Stripping



Blade Width



Topsoil Stripping

The salvage of topsoil by stripping is required for installation of most pipelines. Trenchline or blade width stripping are used to protect topsoil resources while still minimizing the surface disturbance associated with the installation of pipelines. Trenchline stripping involves removal of topsoil over the trench width only, and is most suited to low-relief terrain and stable soil conditions. As topography becomes more complex or where there is a risk of sloughing of topsoil into the trench (e.g., sandy soils), blade width stripping should be used. This involves the stripping of the trench line plus an additional width as is appropriate for the site-specific conditions. Larger stripping widths may be needed to accommodate grading in hilly areas, when safety becomes a concern or when environmental conditions deteriorate. Double blade or full width stripping may be required for pipes with a diameter larger than 60 cm (24 inches).

"No strip" construction

"No strip" construction for small pipelines (trench <30 cm) involves lifting topsoils and subsoils out together in one operation. Under the right conditions, this can result in less overall disturbance to vegetation.

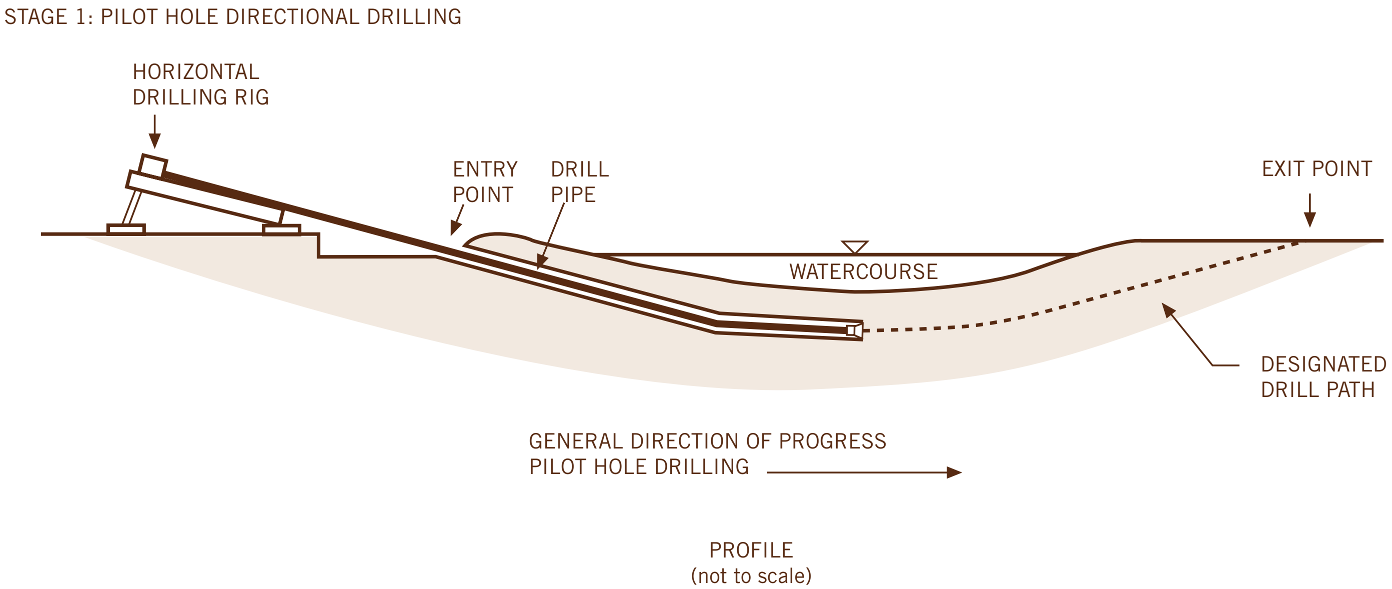
Roaches

Installed pipelines displace soil. The extra soil has to be feathered out over the pipeline right-of-way so that a raised area (roach) is not left over the pipe. Roaches shed water, producing a very dry environment, that is difficult for plants to grow in. Soil can be placed in a thin layer over adjacent undisturbed prairie sod if necessary. If this is done carefully, with the right equipment, this can result in less overall disturbance to vegetation.

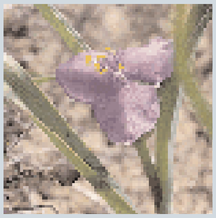
Watercourse Crossings

Boring under prairie watercourses, coulees, and riparian vegetation communities, including the adjacent slopes is preferred to an open cut.

Boring prevents siltation of water and doesn't disturb fish. A geotechnical investigation is usually necessary to determine whether a crossing is suitable for boring. If the area is unstable, an open cut may be required. Suitable erosion control practices must be implemented on steep slopes.



Reclamation



Once construction or operations cease, reclamation of the disturbed area begins. Reclamation procedures begin the healing process but the reclaimed area may not look identical to the surrounding prairie until many years later. Reclamation “sets the stage” for eventual restoration by “Mother Nature”. The ability of the reclaimed prairie area to provide multiple uses and values should be similar to the ability that existed prior to disturbance.

Getting the Site Ready

Recontouring

The first step in the reclamation process is to contour the site to fit in with the surrounding landscape. This should be done with subsoil. Topsoil should only be replaced after all contouring is done.

Drainage patterns need to be re-established and erosion control measures taken. On slopes, water bars (trenches) or rock may be placed at strategic locations to slow and direct water movement.

Alleviating compaction

Heavy equipment running repeatedly over subsoil can cause compaction. This can cause problems later when plant roots are not able to grow through such a layer. Usually compaction is relieved with ripping equipment prior to soil replacement. Paratillers can be used to remove ruts, or to relieve compaction in the subsoil after topsoil has been replaced, without mixing soil layers.

Revegetation

The goal of revegetation on prairie is to re-establish sound ecological function and eventually restore the original range of variability in biological structure and diversity.

Revegetating disturbed prairie areas can be a challenging task, particularly in dry years or on problem soils. Revegetation strategies have to consider the needs of the landowner and/or land manager as well as wildlife in the area. The revegetated area often has to fit into existing grazing management plans, for example.

When oil and gas development started on the prairies, wellsites and pipelines were not revegetated. These sites often look very similar to adjacent undisturbed prairie today. Then from the mid 1930s until the early 1990s, introduced agronomic forages such as crested wheat grass, smooth brome and timothy were used in revegetation. These plants cause difficulty as patches on the prairie landscape. Crested wheat grass, for example, matures much earlier than the surrounding native grasses. By the time cattle are turned out to graze in June, the crested wheat grass is too mature for the animals to eat. In addition, these plants are very competitive and seem to exclude native plants from reclaimed sites. Aesthetically, the crested wheat grass doesn't fit in.

Today, prairie sites are seeded to native grasses. Native species must be seeded on publicly owned prairie land disturbed after January 1, 1993, or prior to that date if required by lease conditions or in an approval issued by Alberta Environment (see Alberta Environment's Information Letter (IL) 01-6).

As more species become commercially available, revegetation mixes will be better matched to the plant species in the landscape. Alberta has over 2000 native plant species but only a handful are currently available for revegetation. The Alberta Native Plant Council has a source list of plants and suppliers on their web site: www.anpc.ab.ca.

Seed analysis

When reseeding prairie areas, it is extremely important to ensure that seed is free of persistent weeds and invasive introduced species. The best safeguard is to request a Seed Analysis Certificate from the seed supplier for each native seed lot (prior to mixing). This certificate should be examined prior to purchase to ensure that the seed lot does not contain any species of concern. Generally, annual non-native weeds are not a concern since these are already present in the seedbank on most prairie reclamation sites and do not cause serious problems. A notable exception is downy brome. Check with a local agricultural fieldman for more information about weeds of concern in the area. For a listing of problem agronomic species not allowed on public land, consult Public Lands Update IND 2000–2.

Seed mixes

The first step in designing a seed mix is to consult with a qualified vegetation specialist who has experience in designing and using native seed mixes. It is important to find out what native plants grow near the disturbed site and then to determine if they are available. A variety of plants with different growth forms should be included in a mix. *The Native Plant Revegetation Guidelines for Alberta* (www.agric.gov.ab.ca/publiclands/nprg/) can be consulted for help and for lists of commercially available seed for different areas.

It is important to consider how plants may interact with each other. Some plants are very competitive and their proportion in the mix should be reduced (e.g., native wheat grass cultivars). It is also critical to find out where seed originally came from. Seed whose genetic origin is from too far away (e.g., Europe or the southern United States) may not perform very well. To ensure the right materials arrive at the right time, give the supplier as much lead time as possible.

"The first step in designing a seed mix is to consult with a qualified vegetation specialist who has experience in designing and using native seed mixes."

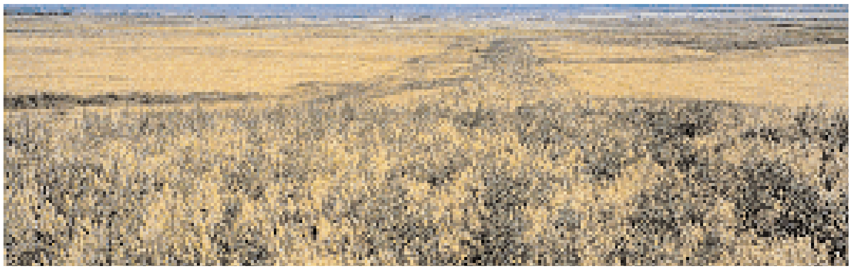
Seeding rates

Determining seeding rates (the number of seeds per unit area) is not an exact science due to the tremendous variability from species to species in seed size and shape, performance, and differences in seeding and growing conditions. It is very important to consult with experienced vegetation specialists to determine suitable seeding rates. There is a tendency to over seed resulting in stands that quickly become too thick and rank. Drill seeded rates of 10 to 12 kg/ha are more than adequate to provide an adequate vegetation cover on most sites. Lower rates (e.g., 6 to 8 kg/ha) are suitable for sites where erosion potential is low and ingress of native plants from surrounding areas is desired.

Seeding equipment

Special equipment is required for seeding native species due to tremendous variability in seed size and shape. No till rangeland drills such as Truax or Great Plains are often used, and should be calibrated several times a day to ensure proper delivery of seed. The Kinsella accuroller is another useful piece of equipment that broadcasts the seed and then rolls it into the ground in a waffle-like pattern. This has the added advantage of creating better conditions at ground level for seed germination. It also places smaller seeds (e.g., June grass) closer to the soil surface where they have more chance of germinating.

Revegetation continued...



Natural recovery

Natural recovery (no seeding) is an appropriate option in some situations. It can be used where the disturbance is small and located away from problem weed sources. The condition of the prairie around the site should be good (lots of seed) and potential for erosion low. Annual weeds are dominant on natural recovery sites for the first several years, which often provides erosion control. These can be mowed if they are too thick. Weeds will start to disappear as the native perennial plants re-establish. Annual crops (e.g., durum wheat, flax) can be seeded at half the normal rate to provide interim erosion control.

Sod salvage

Prairie sod has to be in good condition and thick enough to stay intact when it is cut. If sod salvage is done during the spring or summer, the construction phase has to be short (i.e., a few days), otherwise the sod dries out and the plants die. In the fall, the storage time can be longer (e.g., a few weeks), since the plants are dormant. Salvaged sod should be protected with filter cloth (preferably white to reflect heat). Although the sod salvage technique is time consuming and expensive, it can be useful in specific situations where keeping the original vegetation is very important and the construction schedule allows for it.

Livestock Management

Livestock access to newly reclaimed areas may result in overgrazing of vegetation and damage to soils. Reclaimed areas should be protected from grazing during the first year of vegetation establishment.

Good communication with land managers is needed to develop an appropriate livestock management strategy. Wellsites on the prairie are usually fenced to keep cattle out. Cattle management along pipelines is variable. Sometimes it is possible to change cattle rotations so that cattle do not graze the fields that the pipeline runs through the first year following revegetation. In other cases, temporary electric fencing keeps animals out.

Location of salt and water well away from reclamation sites also helps to minimize cattle impacts once they are allowed access. It is important not to leave fences up too long. In particular, areas seeded to native grasses need to be lightly to moderately grazed to keep the stands healthy and productive. Reclamation is considered successful only if the site can withstand normal grazing pressure.

Record Keeping

Record keeping is critical to the success of any reclamation/revegetation program. It helps to manage the specific site and assists with the planning and preparation for future disturbances. The following information should be collected:

- **topsoils –** where they came from, storage times, stockpiling methods (including whether they were planted in storage and with what) and replacement depths.
- **site preparation –** what was done, what equipment was used and when each task was carried out.
- **plants and seeds –** type of plant material (scientific names), suppliers, genetic sources, seed analysis certificates, seeding rates and planting densities.
- **other techniques used –** ripping, paratilling, mulching, fertilizing and fencing.
- **management and mitigation activities** and whether they were successful (e.g., rare plants).
- **dates** when each activity was done.
- **maps** indicating where each activity was carried out.

"Record keeping is critical to the success of any reclamation/revegetation program."

Measuring Success

Reclamation requirements are not identical for all reclamation sites in Alberta. Site age determines the level that should be used. Newer sites must meet more rigorous standards than older sites.

The criteria for reclamation vary geographically within the province, and with land use. Generally, to determine reclamation success, the condition of landscape, soils and vegetation of the reclaimed area is compared to the condition of the site before construction (where this information is available) or to the condition of similar sites in the immediate area. The reclaimed site must be able to sustain plant growth similar to pre-disturbance growth, controls or agreed upon (in writing) targets.

The revegetated area must be able to prevent wind and water erosion, unless erosion is a normal part of the landscape (e.g., sand dunes). The minimum level of acceptable ground cover is site specific and varies according to soil type/texture, plant community, wind, precipitation and slope. Plants on revegetated areas should be healthy, both above and below ground and be able to sustain grazing pressure. There should not be any restricted or noxious weeds on the site.

On sites seeded after January 1, 1993 it is expected that the integrity of native plant communities be maintained and meet land use objectives. Invasive agronomic species (e.g., crested wheat grass, smooth brome, timothy) should not be present. If the reclaimed area is part of a grazing operation, plants should be compatible with plant species offsite, (i.e., be able to be grazed at the same time).

Case Study:

Oil and Gas Development on Providence Ranche

Information for this case study was provided by Marilyn Neville, AXYS Environmental Consulting Ltd., with the permission of the landowner, Hamish Kerfoot, and the company, Olympia Energy Inc.

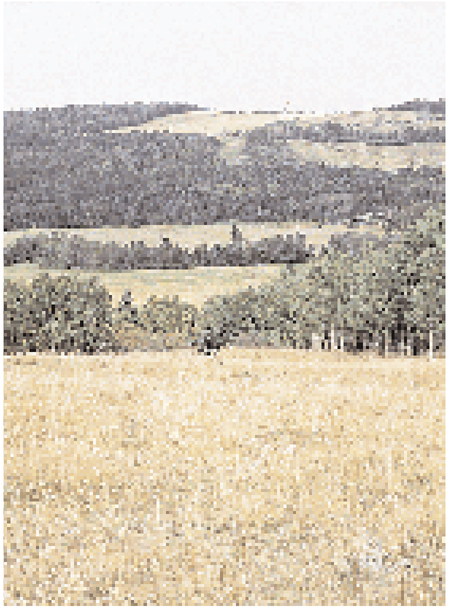
Industry, government agencies and landowners are working together more than ever to try to conserve remaining prairie landscapes. What follows is an example of what can be accomplished when cooperation is at its best. Providence Ranche is located in the Wildcat Hills, approximately 12 kilometres north and west of the town of Cochrane Alberta. Providence Ranche is private land, owned and operated by the Kerfoot family of Cochrane, as a sustainable ranching operation for over 100 years.

In October of 1997, the Kerfoot family decided to protect the ecological integrity of the ranch against increasing pressure from acreage developments by signing a conservation agreement with the Nature Conservancy of Canada. The agreement with the Nature Conservancy allows land uses that ensure the protection, conservation and enhancement of the environment and of natural scenic values. The agreement allows for the continued use of the land for ranching purposes. Oil and gas development is only allowed under very stringent conditions. Other acceptable uses include recreation, environmental education and use for scientific studies.

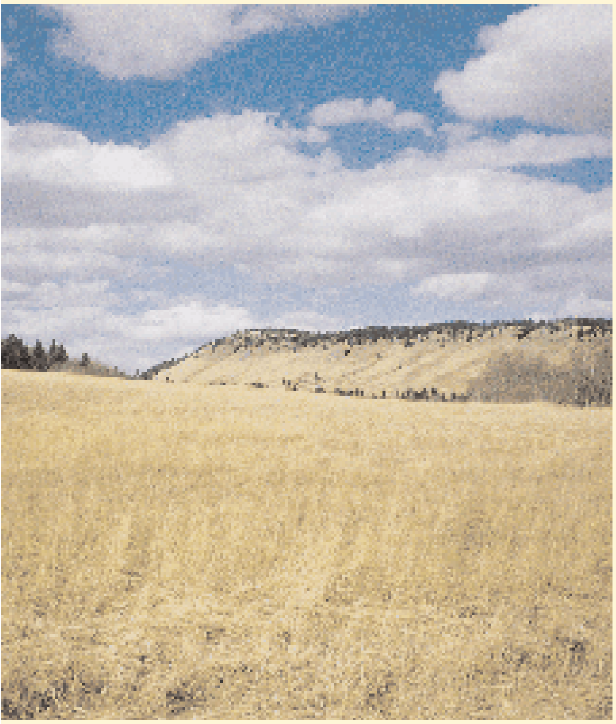
The Nature Conservancy has set out Property Management Principles for these land uses. Olympia Energy Inc., (Olympia), has used the Property Management Principles throughout the development design. At the request of Mr. Hamish Kerfoot, AXYS Environmental Consulting Ltd., (AXYS), was contracted by Olympia to provide environmental assessment and design, and onsite inspection throughout each phase of the development. Joint field visits were also conducted with Alberta Environment staff.

Vegetation

The Kerfoot property is situated where the Foothills Natural Region meets the Parkland Natural Region. The portion of the ranch affected by the Olympia Energy development is primarily a valley bottom, surrounded by steep slopes covered with mature Douglas fir and white spruce forest to the west. To the east, the steep slopes are covered with native rough fescue grasslands and aspen, with limber pine growing in the rocky ridge tops.



The range is in good to excellent range condition. Dominant plant species in undisturbed grasslands are Kentucky bluegrass, rough fescue, and Parry's oat grass. In previously disturbed grasslands, there is a larger amount of Kentucky bluegrass in the stand. Timothy and smooth brome, introduced grasses, are also dominant species.



Development Description

In November of 1998, Olympia reached an agreement with the Kerfoot family to drill an exploratory sweet natural gas well. At the completion of drilling, well test results showed substantial reserves. Olympia then negotiated with the Kerfoot family to expand drilling activity. In February of 1999, AXYS was contracted to assist Olympia with environmental assessment and design for two additional well sites, access trails and associated pipelines.

Minimizing the disturbance to the native plant communities and to the overall integrity of the ranch were the primary goals in locating suitable wellsites, access trails and pipelines. Some of the measures taken to achieve this goal include:

- Horizontal directional drilling techniques were used by Olympia to access gas reserves located under steep, naturally vegetated terrain, from well-sites located in the valley bottom.
- Existing access trails were used to get to the wellsites and for pipeline routing. Where necessary, trails were upgraded within a ten metre or less roadway with a minimum grade.
- Detailed pre-construction environmental assessments and environmental protection planning were completed prior to entry.
- There was onsite environmental inspection through all phases of the development. Pat Trautman (Olympia energy) closely supervised all construction activity.

During 1999 two wells were drilled from surface lease locations, located on previously disturbed, improved pasture located in the valley bottom. At the end of 1999, the development was completed. The wellsites were reclaimed for the production phase, the access trail upgraded and reclaimed, and the pipelines reclaimed and revegetated.

In February of 2000, Olympia entered into negotiations with the landowner to drill additional downhole locations from the existing surface lease locations, and to construct a compressor station to improve the drawdown from the reserve. The existing surface leases were used for the construction, with small extensions to accommodate the drilling rig. The site for the compressor station was chosen to minimize impacts on affected neighbouring properties and the visual impact to the ranch. A central separator unit was installed at the main compressor station located several kilometres south of the Kerfoot property. This eliminated the unpleasant odour that had surrounded each of the wellsites. Again Mr. Kerfoot worked with Olympia and AXYS to ensure the environmental design was consistent with the high standards previously set. By December of 2000, the next phase of development was complete.

Specific Construction and Reclamation Strategies

Several strategies were employed to minimize the impact of the development on vegetation in the project area:

- Minimal width stripping techniques were used for construction,
- Clearing of old conifers was minimized and special pipeline installation measures used to narrow the RoW through these areas,
- Soils were stored on top of unstripped vegetation,
- Traffic on vegetated areas was closely supervised and limited,
- Where stripping was required, soil layers (horizons) were carefully separated.

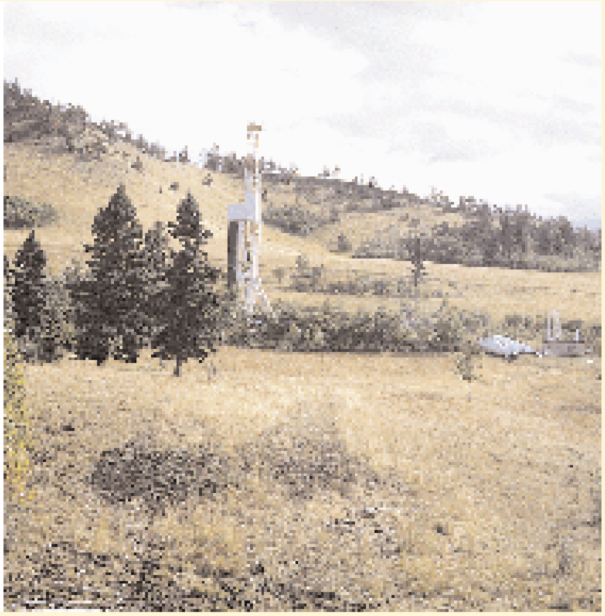
The goals of the revegetation program are to provide sufficient ground cover and distribution of plants to provide erosion control and to allow natural plant community development to take place. Two seed mixes were designed; one for use in primarily native fescue grassland, a second for previously disturbed grasslands, where Kentucky bluegrass and timothy were prominent. One portion of a pipeline right-of-way was also reclaimed as a natural recovery area, with no reclamation seed being applied.

Monitoring

The goal at the time of final reclamation is to restore the disturbances to the original natural ecosystem function and structure over time. To accomplish this goal it must be remembered that climate and time play major roles in achieving reclamation success. As well, reclamation science is constantly evolving. During the last ten years, new construction methods have been

developed to minimize the impact of developments. The process of revegetation using native plant material has evolved to a level where it is practical and cost effective. Studies funded and conducted by the oil and gas industry are largely responsible for the advancement of reclamation science. Monitoring has been key to evaluating new procedures.
Hamish Kerfoot requested, and Olympia agreed to, the commitment for environmental monitoring to be specifically included in all Environmental Protection Plans. The monitoring program is conducted for three full growing seasons following each stage of the Olympia development. The program designed for Olympia is simple and comprehensive. There are two main components:

- **Qualitative monitoring** in which the assessor is looking for evidence of erosion, contamination, soil and water quality issues, and the presence of weeds. All these factors can affect reclamation success, if remedial action is not taken.
- **Quantitative monitoring** in which the assessor is recording the actual plant species composition at permanently marked locations to ensure a positive trend toward establishment of the original plant community.

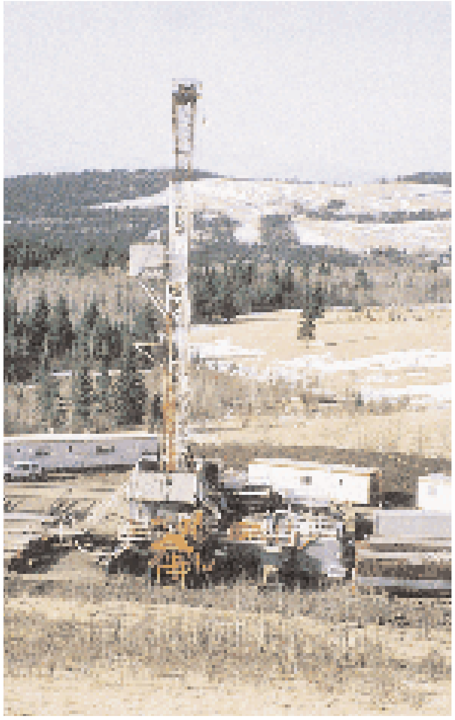


The monitoring program has established permanent plots on both wellsites and pipeline rights-of-way (RoWs). Plots have been established to represent both seed mixes, the natural recovery area and an area where soil was stored directly on vegetation during construction. A checklist for the qualitative monitoring is used to identify environmental concerns. The following environmental concerns were identified as important to this project:

- Wind erosion
- Erosion due to surface runoff
- Downslope erosion on cut and fill slopes
- Erosion causing mass movement
- Health of unstripped vegetation
- Soil compaction
- Presence of soil contaminants
- Blocked surface drainage
- Weeds and undesirable vegetation

- Qualitative revegetation success
- Visible siltation of drainages or wetlands
- Impact of grazing livestock on revegetation success
- Subsidence over pipeline trench or access trail

Vegetation species composition and percent plant cover are used as the key indicators of reclamation progress. Over several years they will show whether seeded native species are allowing recolonization by other species from replaced soils and from the surrounding area. These measurements will also show how much of the plant material is weedy and whether weeds are persisting.



Early Monitoring Results (2000)

■ Qualitative Monitoring

Very few problems were noted following the qualitative monitoring inspection. There was little or no erosion noted. There was no evidence of soil compaction or soil contaminants. A few areas with blocked surface drainage were noted, and were remedied in the spring of 2001. Gravel was added along access roads in areas where soft spots were noted. Annual nuisance weeds were controlled with mowing prior to seed set. Minor amounts of noxious weeds, Canada thistle and toadflax, were controlled with repeated hand picking or mowing.

■ Vegetation Monitoring

All eight species represented in the two seed mixes were observed growing in the disturbance with the exception of mountain brome and streambank wheatgrass. The wheatgrass may be present but misidentified as slender wheatgrass in its non-flowering state.

The natural recovery site has an average percent cover value of 50%, arising entirely from the existing seed and propagules bank. The most prominent species on the right-of-way are Kentucky bluegrass and dandelion. Dandelions (non-native) are present in the undisturbed areas as well, forming 4% of the ground cover. Rough fescue (native) and awned wheatgrass (native) are also re-establishing on the natural recovery site.

Areas with lighter grazing pressure and less timothy in the off RoW vegetation have more species from the seed mix visible. Wellsite areas, which are all fenced, also have a greater variety of grass species re-establishing on the disturbance. However, they also have more weed establishment. Mowing has been undertaken as a control measure on two wellsites. Canada thistle is establishing on the disturbance in many areas. Thistles are plentiful off site in many areas on the property. Other weeds are not generally a problem.

- **Wildlife Monitoring**

Providence Ranche provides rich and diverse habitat for a wide variety of montane, parkland and grassland wildlife species. Wildlife surveys were conducted for each phase of the Olympia development. Fine-tuning of well site locations, access trails, pipeline rights-of-way and the location of the compressor station were made to minimize the impact to wildlife habitat. Construction and drilling activities were scheduled to minimize the impact during sensitive breeding seasons.

Olympia production personnel have had the opportunity to observe considerable wildlife activity during the development and production phase. AXYS has encouraged the documentation of wildlife sightings around the facilities. These wildlife observations are valuable to monitor the response of wildlife to the facilities and to the increased activity in the area. Other interested people, such as the members of the Kerfoot family, and the Calgary Field Naturalists who conduct annual educational field trips to the area, are also encouraged to record their wildlife observations in the development area.

This case study shows how industry, landowners and regulators can effectively cooperate to ensure that oil and gas development happens in a manner that protects sensitive landscapes and minimizes impacts to humans, wildlife, soils and vegetation. In time, the footprint of this activity on the landscape should be invisible.

Photo Credits

Thanks to the following individuals who provided photos:

Nancy Boutilier
Barry Cole
D. R. Collicut
Ross Dahl
Barb Darroch
Suzanne Gill
Andrew Hammermeister
Ian Hancock
Arnold Janz
Don James
Alan Loose
Brad Lowrie
John Morgan
Marilyn Neville
Christine Pitchford
Patrick Porter
Dave Scobie
Heather Sinton
Brad Stelfox
David Walker
Cliff Wallis

Thanks to the following organizations or companies for providing photos/drawings:

20/20 Seed Labs Inc.
Alberta Agriculture, Food and Rural Development
Alberta Energy Company Ltd.
Alberta Environment
Alberta Community Development, Natural Areas Program
Alberta Sustainable Resource Development, Public Lands
AXYS Environmental Consulting Ltd.
Olympia Energy Inc.
Prairie Seeds Inc.
Tera Environmental Consultants (Alberta) Ltd.
TransCanada Pipelines Ltd.

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