RECLAMATION CRITERIA FOR WELLSITES, BATTERIES AND ASSOCIATED FACILITIES

Volume II: 2004 ASSESSMENT PROTOCOL

April 16, 2004 DRAFT

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

Alberta ENVIRONMENT

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PREFACE

As part of the new Upstream Oil and Gas Reclamation and Remediation Program, Alberta Environment, in consultation with the Alberta Research Council and the University of Alberta Department of Renewable Resources, is proposing a revision of the Reclamation Criteria for Wellsites and Associated Facilities - 1995 Update.

An updated draft criteria has been developed with input from practicing reclamation consultants.

**** Note: the Reclamation Criteria for Wellsites and Associated Facilities - 1995 Update remains in effect for current applications and will be the basis for reclamation work until further notice.****

Comments on the present draft criteria begin the evaluation and refinement process. Based on this initial input, the Department will undertake revisions and prepare plans for pilot field testing. The pilot field testing phase will be used to evaluate assessment procedures, criteria, results and costs under both the 1995 criteria and proposed new criteria. Timing of the pilot testing will depend on the nature of review comments and the scope of revision necessary. A decision on whether to proceed with the proposed reclamation criteria, will be dependent on the results of this evaluation and further consultation with stakeholders.

Comments on the present draft criteria will be accepted by mail, fax or e-mail to Alberta Environment by **June 21, 2004**.

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NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

SUMMARY

This draft assessment protocol document is the second volume in a three volume series[1] that was developed to replace the *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update*. The first document is the criteria that specify the reclamation endpoints that must be met before a reclamation certificate can be issued.

The second volume comprises the assessment protocol that requires specific field measurements and sampling and lab analysis protocols that will determine whether the site has been properly remediated and reclaimed in accordance with *Volume I: 2004 Criteria.* The assessment protocol has been developed using the experience of government, industry, landowners and other stakeholders.

The third volume provides the scientific basis for the criteria to ensure that the criteria are objective and science-based, as well as practical.

Assessment procedures have been enhanced from the *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* to include:

- Pre-construction site assessments are required for sites constructed on or after the release date of these criteria
- An increase in the number of control points for selected parameters
- Soil organic matter assessment determined through laboratory analysis of organic carbon content and bulk density
- Particle size distribution (texture) determined by laboratory analysis
- Vegetation assessment includes yield potential for annual crops
- Biomass based on dry weights for forages
- Frames used to measure cover and density of vegetation

[1] *Reclamation Criteria for Wellsites and Associated Facilities – 2004: Vol. 1 Reclamation Criteria; Vol. 2 Assessment Protocol; Vol. 3 Technical Rationale.*

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1 LAND USE CATEGORIES

The four land use categories are Cultivated Land, Grassland, Forested Land, and Peat Land. These land uses are described in *Vol. I: 2004 Criteria Update*, and in Definitions section of this document. In situations where a site is constructed on land supporting two different land uses (e.g., cultivated land and forest land), the landowner on private lands or landowner/land manager for public lands (Alberta Sustainable Resource Development) will determine the final land use for the site prior to reclamation commencing. The land use decision must be documented in the Detailed Site Assessment Report (DSA).

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2 SITE ASSESSMENTS PROTOCOL

2.1 Pre-Construction Site Assessment

A pre-construction site assessment (PCSA) can provide operators, landowners and the regulatory agencies with accurate pre-disturbance information to determine whether reclamation success has been achieved. The PCSA assessment protocol provides the basis for assessing all sites. PCSA must be employed after the release date of these criteria.

The amount of information obtained in completion of the PCSA will vary with the respective land use. The primary purpose of conducting the PCSA is to get baseline landscape, vegetation and soils information, particularly for use in construction planning and comparison to the reclamation stage assessment.

PCSA is required for all land uses and must include the following:

a) General Site Description

A sketch of the lease area and access road that includes but is not limited to:

- North arrow for reference
- Scale
- Site measurements
- Lease and access road boundary lengths (m)
- Lease and access road areas (ha)
- Topography
- Slope (percent)
- Aspect
- Drainage
- Water bodies (streams, lakes)
- Surrounding vegetation
- Adjacent land use
- Existing infrastructure (roads, pipelines, buildings, fences, power lines)
- Assessment locations (sample sites if applicable)
- Land ownership

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b) Site Imagery

Photographs are required to document lease conditions in each direction from the proposed well centre. Photographs of access road, or the proposed route required from both the start and the end points. Any anomalous areas should be photographed. The corners of the site will be flagged to identify the boundaries or corners of the site. Stakes will be placed at well centre and the four corners if they have not already been placed in cultivated and rangeland areas. In forest areas, trees at the corner locations can be flagged. An object should be included in all photographs to provide scale, and to provide location and direction information. Cameras that provide a date stamp on the photograph are recommended.

c) Soil and Vegetation Assessment

Soil and vegetation sampling must follow the sampling indicated in Tables 1, 3, 5a, 5b and 7.

For access roads, assessment points are required every 100m along the proposed access route. Where the access road is less than 100m, two assessment points are required.

Assessment points shall be located where land conditions are representative of the site.

All bulk soil samples should be a composite comprised of three sub-samples taken within a 1m radius for each location. These composites may be located in association with the assessment points for soil horizon thickness, etc. described above.

PCSA data must be compared to post-reclamation assessment information to determine if the lease has been reclaimed to pre-disturbance conditions. If farming practices have caused the surrounding land to be different from the pre-disturbance conditions, then control data may be used to determine reclamation success. Landowner consent must be obtained if control data is to be used in place of PCSA data. If landowner consent cannot be obtained, then an operator's statutory declaration must be provided documenting the attempt to obtain that landowner consent, the reasons why consent was not obtained and the reasons why control data was used.

2.2 Detailed Site Assessment Report Information Requirements

The DSA Report is an integral part of the application for a reclamation certificate. The report provides Alberta Environment with a clear understanding of the operator's site assessment and

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results. The report also provides the operator with an opportunity to justify why the site should receive a reclamation certificate even though all the criteria may not have been met.

DSA Reports must contain the following information for sites assessed on or after the release date of these criteria:

a) Pre-Construction Site Assessment Report containing the information outlined in 2.1 for sites constructed on or after the release date of these criteria

b) Site History – a brief chronological record of events and activities on an associated with the site related to soil conservation and reclamation

c) Site Map – a detailed site map showing:

- Site dimensions and grid dimensions
- Grid assessment points, access road assessment points, and control assessment points
- Well centre, sump, flare pit, soil storage area, site entrance and soil storage locations
- Landscape information such as drainage, contour, areas with gravel and rocks, bare areas, areas with stressed vegetation, and reference points (trees, posts, etc.).

d) Color photographs taken from each lease corner comparing onsite and off-site vegetation and topography characteristics. Photographs must also be taken from well centre in four directions. An object to provide scale must be included in all photographs. A record of the location and direction of each photo must be maintained.

e) Soil Information

Include the following as stipulated in Tables 1,3, 5a, 5b and 7.

- Topsoil depth
- Organic matter content
- Texture (hydrometer method)
- Aggregate size and strength
- Profile restriction rating
- Soil sample collection locations and analytical results,

f) Vegetation Data:

- Yield (annual crops)
- Biomass (hay or pasture)
- Species Composition

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- Cover or density (native landscapes)
- Plant Community Structure
- Health

2.2.1 Lease

A grid pattern of approximately 20 m by 20 m should be established across the lease, with the outside edges matched to the lease boundaries (Appendix 2). The assessment grid should be adjusted to cover the entire lease area and must account for odd sized leases. Grids should all be approximately the same size across the lease. Grid edges should be between 18 m and 22 m in length. If the lease is not square, then grid edges may be of differing lengths, or there may be a different number of grids along different lease sides.

As an example for a square lease:

- If the lease edge is 88 m, four 22 m grids should be used (total grids on lease = 16)
- If the lease edge is >110 m, a sixth grid should be added (total grids on lease = 36)

Larger leases may require more grids. On smaller leases (e.g. 40 m x 60 m), the 20m x 20m grid (approximate) is to be used for assessments.

Quadrant assessments entail dividing the lease into four quarters where assessment points will be located in the quadrant center.

Assessment methods for grids and quadrants must be the same.
In addition to grid and quadrant assessment points described above, key assessment points must include:

- Well centre
- Sump
- Flare pit
- Tank storage area
- Lease entrance

2.2.2 Access

Landscape, soil and vegetation data must be assessed on a paired basis (one off-site control point and one on-site control point). The control need not be immediately adjacent to the site assessment point but must be representative.

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- For roads >100 m in length, one paired assessment is to be taken at 100-m intervals
- For roads <100 m in length, one paired assessment is to be taken at a minimum of two points

The assessment points are to be adjusted to ensure the road approach and side-hill cut areas are included. If the topography is sloping, additional points should be added and the assessment points should be representative of the range in slope positions.

Assessment parameters and methods found in each land use category will apply to access roads.

2.2.3 Controls

Twelve representative control points per lease are required to provide comparisons. The following parameters should be considered when choosing control locations:

- Controls should represent pre-disturbance conditions
- Pre-construction assessments may be used in place of controls
- The operator may use relevant controls to represent portions of the site where control site characteristics vary significantly provided the controls represent all assessment parameters and indicate which portions of the DSA site those controls represent
- Controls need not be located in a regular pattern around the lease, but rather in representative locations

2.2.4 Off-Site Associated Facilities

The same sampling methodology should be used for off-site associated facilities (e.g. sumps, borrow areas, campsites) as for leases. A minimum of two grid sampling points are required, plus a minimum of two control points. Lease control points that are within 100 m of the off-site associated facilities may be used in the assessment. All facilities associated with the site should be applied for at the same time as the site.

2.2.5 Anomalies

When an anomaly appears in a grid, the operator must conduct a step-out assessment to determine if it is representative of the whole grid. A step-out assessment is made at an additional three locations, at distances of 3 m from the anomaly, in a triangular shape around it. The

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average value for the three step-outs plus the original location must be reported for all parameters assessed (e.g. soil replacement depth, vegetation yield). The information reported must be documented as a step-out assessment.

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3 CULTIVATED LAND ASSESSMENT PROTOCOL

The assessment protocol for cultivated lands is the most extensive of the four land uses. Cultivated lands comprise the intensively managed agricultural lands. Therefore, the assessment and associated criteria has been significantly enhanced from the 1995 Criteria. See *Vol. 1: 2004 Criteria***,** Table 2 for Cultivated Land criteria.

Table 1. Minimum required sampling densities for Cultivated Land

	G&R	TS	PSA*	Ag size	Db*	SOM*	Proc Restr	Pen Res	SC	Y	BioM	H
4 control	X			X	X	X	X		X		X	X
8 control		X	X					X		X		
WC				X	X	X	X		X		X	X
Grid		X					Assess where req'd by Pen Res readings	X		X		
Alt grid			X									
Quadrant	X			X	X	X	X		X		X	X

Legend

G&R	Gravel and rocks
TS	Topsoil depth
PSA	Particle size analysis
Ag size	Aggregate size distribution
Db	Bulk density
SOM	Soil organic matter
Proc Restr	Process restrictions
Pen Res	Penetrometer resistance
SC	Species composition
Y	Yield
BioM	Biomass
H	Plant health
*	Laboratory analysis required

4 control	4 control locations per wellsite assessment
8 control	8 control locations per wellsite assessment
WC	Well centre
Grid	All grids sampled
Alt grid	Alternate grids, including well centre
Quadrant	Four quarters of wellsite

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3.1 Landscape Assessment

Landscape assessments are to be completed by comparing the site against PCSA data, other pre-disturbance information or adjacent land. The landscape parameters drainage, contour, stability, and debris are to be qualitatively evaluated. Two-stage assessments should be employed:

- Stage 1 assessments are made from each lease corner over the entire lease and adjacent control areas
- Stage 2 assessments are made from a walkover of the whole lease area

3.1.1 Gravel and Rocks

Gravel and rocks are subject to qualitative and quantitative evaluations. The limitations gravel and rocks impose are related to their number, size and spacing at the surface (Agriculture Canada, 1983).

Qualitative assessment: If site appears to be non-rocky (< 2 % surface area; adapted from Agriculture Canada, 1983), the following is sufficient:

- **Visual** – A visual assessment or rock count of an area that is representative of the lease is satisfactory provided supporting photographs are included in the DSA. Photographs are to be taken vertically (not at an oblique angle) covering a surface area no less than 2m by 2m, with an identifiable object in view for scale.

Quantitative assessment: If site appears to be rocky ($\geq$ 2 % surface area; adapted from Agriculture Canada, 1983), one of the following must also be completed:

- **Frame analysis** –Delineate a 2m by 2m representative area in each quadrant. Calculate the percent cover for gravel and rock sizes. Record the change in percent as compared to the PCSA (or control, where required) calculated for each class,
- **Digital image analysis** – Photograph a representative area of known size (> 4.0 m^2) and scale (identifiable object in view) in each quadrant. Digitally analyze the image for the relative percent of surface area covered by gravel and rock classes.

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Observed data must be recorded in the DSA Report.

3.2 Soil Assessment

The Canadian System of Soil Classification (Agriculture and Agri-Food Canada, 1998) and *The Manual for Describing Soils in the Field* (Agriculture Canada, 1983) should be used to describe soil properties. Accredited laboratories are required for all laboratory analyses.

Topsoil in cultivated land is the layer of soil commonly moved in cultivation. Cultivated and non-cultivated horizons (e.g., Ap, Ah and Ahe) may be included.

If the control topsoil depth is > 15 cm, the depth of replaced topsoil, soil quality, soil profile assessment and loss of organic mater content assessments may be done after soil replacement or after cultivation in the entire replaced soil layer.

For cultivated lands, if the control topsoil is < 15 cm deep, the operator may assess depth of replaced topsoil after soil replacement but prior to cultivation to confirm that adequate soil was replaced. The Ap depth, soil quality, soil profile assessment and loss of organic matter content assessments must be done in the replaced Ap horizon after cultivation of the site has occurred.

3.2.1 Topsoil Replacement Depth

Topsoil depth is to be measured as the distance between the topsoil surface and the subsoil point of contact. On lease, assessments are required in each grid. Where there is no PCSA data, eight controls are required. The topsoil surface around the sample point must be free of furrows, etc. If the point of topsoil/subsoil contact is observed to be of a variable depth, the average topsoil depth is to be reported in the DSA. The replaced soil should be distributed uniformly across the lease. The lease must be assessed separately from the access.

Topsoil depths for access roads must be assessed in relation to representative control points on a paired basis. The control must be representative of the site assessment point. The depth requirements for access roads are the same as for the lease.

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3.2.2 Topsoil Quality

Topsoil quality must be evaluated at each assessment point for texture, structure, gravel, rocks and organic carbon.

3.2.2.1 Texture

Laboratory particle size analysis (PSA) (Gee and Bauder, 1979) must be used to confirm soil texture for a site. On-site, one non-composited PSA is required for every alternate grid. Samples from eight off-site control points (two from each side) must also be taken. The laboratory results from each of these samples may be averaged to obtain one average control PSA value that must be used to compare against every grid value. Samples should be taken as a core that represents the desired soil layer from top to bottom. Sample locations must be clearly marked on a diagram included in the DSA.

3.2.2.2 Aggregate Size

Soil aggregate size distribution is a determinant of pore-size distribution (infiltration and water holding capacity), has bearing on the soil surface erodibility of the surface (particularly by wind) and helps describe the value of a soil as a plant growth medium (tilth).

Four aggregate size classes have been assigned as:

- < 2 cm
- 2 cm to < 5cm
- 5 cm to ≤ 10cm
- > 10 cm

Qualitative aggregate size analysis must be included in the DSA. General details in the analysis must include apparent aggregate size distribution for the lease and factors that may be influencing aggregate size (e.g. cultivation, vegetation type, ground cover, soil texture, field moisture conditions)

Quantitative aggregate size analysis must be included in the DSA. This analysis must be based on representative areas within each of the quadrants and well centre compared to data from four off-site controls by one of the following:

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- **Sieve analysis** – Collected and weigh a representative composite topsoil sample (approximately 500 cm^3) from within a 1.0 m^2 area. Sieve the sample through progressively smaller screens (>10 cm; >5cm – 10 cm; >2 cm – 5 cm; ≤ 2 cm). Weigh the four size fractions sub-samples, compare to the PCSA (or control, where required) and report as a percent change calculated for each size fraction.
- **Frame analysis** –Delineate a 1.0 m^2 area. Calculate the value for soil aggregates of each size class (based on the same method above). Record the change in percent as compared to the PCSA (or control, where required) calculated for each size class.
- **Digital image analysis** – Photograph an area of known size (> 1.0 m^2) and scale (identifiable object in view). Digitally analyze the image for the relative percent of surface area covered by each of the aggregate size classes.

3.2.2.3 Bulk Density

The sample taken for bulk density should also be used for analyzing organic matter content.

Bulk density (D_b) is calculated as the dry mass of the sample of known volume (M_s), divided by that volume (V_t), such that:

$$D_b = M_s / V_t$$

Two common methods for determining bulk density are the core method and the clod method.

Core method (adapted from Agriculture Canada, 1984) described below, or McKeague (1978)

- Prepare a smooth minimally disturbed soil surface
- Press the sampler of known volume far enough into the soil to fill the sampler, but not so far as to compress the soil (do not rock the sampler, as this tends to disturb the soil)
- Core sampling is required for each soil layer extending from the surface to 20 cm below the topsoil layer (discreet samples may be taken from the plough layer, the undisturbed topsoil, and the subsoil)
- Carefully remove the sampler with soil intact.
- Carefully trim the soil sample flush with each end of the cylinder.
    - If the sample stays in the cylinder, seal both ends, label and transport carefully to lab

- Otherwise, carefully push entire sample contents from sampler into a plastic bag, seal bag and then label

- Samples are to be thoroughly dried at 105° C (72 hours for a 350 cm^3, 7.62 cm (3 in) diameter core. Less time is required for smaller cores)

Those who prefer to use the clod method are directed to refer to the technique described by Agriculture Canada (1984).

The primary horizons of concern, as well as two-lift layers, for assessment and analysis are the Ap (replaced and cultivated), A horizon below Ap (replaced and uncultivated), and upper subsoil (non-salvaged B horizon). If subsoil has been 'ripped', then bulk density core should be relocated to an unripped on-site location, or alternately delay the assessment until subsoil has settled through at least one freeze/thaw cycle.

Bulk density assessment is required for five grids associated with soil organic matter assessments (one per quadrant, plus well centre), as well as one control sample from each side of the lease. The bulk density for each analysis location will be compared against the averaged PCSA or control values.

3.2.2.4 Organic Matter Content

To obtain a true estimate of organic carbon content per unit volume, a non-composited sample taken for bulk density should be used for analyzing organic matter content.
The total organic carbon content calculated on the basis of bulk density and a 15 cm depth for each quadrant plus well center must be compared to the mean value for the four controls. Total organic carbon must be calculated as dry soil bulk density divided by percent soil organic carbon, or:

$$TOC\ (g/cm^3) = (g\ dry\ soil\ /cm^3) \times (g\ C\ /\ 100\ g\ soil)$$

For sites assessed on or after the release date of these criteria, total organic carbon content is to be assessed and compared with organic carbon content data from the PCSA or control sites.

Onsite topsoil sampling for laboratory analysis is required from all grids. Twelve off-site control points (three from each side of the lease) must be analyzed separately for organic matter and bulk

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density and the results combined to determine an average control value. Analyses should be conducted on the core from the topsoil (replaced, cultivated, and uncultivated) for on-site and off-site samples.

Total organic carbon must be determined by dry combustion (Leco induction furnace) (McKeague 1978). For samples containing carbonates, organic C is determined by subtracting carbonate C from total C. Carbonate C must be determined by the technique of Bascomb (1961).

When organic amendments have been used, a minimum three-year period without further organic matter additions is required prior to assessment.

3.3 Soil Profile Assessment

This assessment is valuable to determine the state of the site, and can be used to prescribe corrective actions for problem soil conditions. Salvaged soil (including two-lift stripping sites) to a minimum depth of 60 cm must be assessed. In the assessment depth, process restriction parameters must be documented at least as either 'restrictive' or 'non-restrictive' in the soil profile for every grid as compared to the control. Penetrometer values are valid for assessing against controls, but should not be used in comparing PCSAs to reclaimed site data because of changes in management practices and soil moisture content.

3.3.1 Process Restrictions

The following is required to determine the effects of soil conditions on plant roots, and subsequent impact on plant health (Table 2):

- A visual qualitative observation of land surface, including any evidence of ponding (size, depth, effect on plants), rutting (depth, length), different crop maturation dates and/or species
- A visual qualitative observation of the land subsurface, including root matting or flattening, dispersed lateral roots, compacted soil layers, etc.

Table 2. Process Restriction Indicators for Cultivated Lands

Vertical Root Elongation Restriction Indicators	Water Permeability Restriction Indicators	Soil Aeration Restriction Indicators
• Presence of early maturing crop with reduced height and density • In mixed pasture or haylands, uneven distribution of species • Uneven crop height and density in cropland • Presence of root mats and bunches • Presence of flattened and highly branched roots • Presence of horizontal roots • Presence of exped roots • Absence of roots within or below reconstructed profile zones • Absence of roots within soil aggregates • Presence of soil layers or abrupt texture or structure transitions • Presence of dense and massive soil structure	• Presence of surface ponding • Presence of flooded (yellow or stunted) crop conditions • Presence of surface vehicle (equipment) ruts • Presence of dense, massive or layered structure (compaction) • Presence of stratified or abrupt moisture changes within the soil profile • Presence of abrupt texture or structure transitions	• Presence of dense, massive or layered soil structure (compaction) • Presence of reduced pore size and pore space • Presence of brownish-red ped surfaces • Presence of sour odours

3.3.2 Penetrometer Resistance

Penetrometer Resistance is a quantitative measurement of subsurface impedances. Note that soil strength is affected by soil characteristics (moisture, texture, density, etc.). These characteristics

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should be recorded in the DSA along with the penetrometer numeric results and an interpretation ('restrictive' or 'equivalent') of those results. The following procedure must be followed:

- Describe the penetrometer used (size, type, model, etc.)
- Sample (at a distance < 1 m from bulk density sampling locations) in each grid and eight off-site control locations
- Each grid result must be compared to the off-site range of control values
- Evaluate similar soil layers at all locations
- Sample to similar depths at all locations
- Pressure applied must be consistent during sampling event to depth at any location, and between locations
- Results must be included in DSA

3.4 Vegetation Assessment

The assessment protocol incorporates objective and quantifiable vegetation performance comparisons of on-site versus off-site conditions based on yield (annual crops), biomass (perennial forages), height, bare areas and weeds. Qualitative comparisons include the plant health characteristics of vigour, colour and disease.

One frame (e.g., Daubenmire frame - 20 cm x 50 cm rectangle = $0.1 m^2$) must be assessed in each of the four quadrants, well centre and in four representative control locations. If a different frame is used, the frame shape and dimensions must be defined and remain consistent for the entire assessment. For example, a 0.5 m^2 (0.71 m x 0.71 m) frame is recommended as a minimum size to accommodate measurement of forage crops that include species such as alfalfa.

Vegetation must be present at the time of the operator's assessment. Examples of how vegetation assessments should be completed are provided in following subsections. Crop data for the three years previous to application for certification must be supplied. Operators must collect their own data for the year prior to certification. Data for years two and three prior to certification application can be collected data by the operator, or operator to may opt to have the landowners collect vegetation data for them. Special ongoing management practices on the lease are not allowed if inconsistent with the controls. Fertilizer applications are considered consistent with the control only if the site has been fertilized to the same extent as controls based on laboratory

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analyses. Additional fertilizer use (above levels used on the controls) is not allowed for three years prior to certification.

Fertilizer applications are considered consistent with the control if:

- The site was fertilized by the landowner as part of his normal management practice,
- The operator fertilizes the site to equalize nutrient levels with the control soil based on laboratory analyses

Fertilizer use must be documented in the DSA report. A minimum three-year waiting period after the last fertilizer application is required prior to vegetation assessment.

A vegetation assessment is not required on access roads and pads left in place. If the roads or pads had soil replaced or have been amended and/or seeded the operator must ensure that weeds and erosion are controlled.

3.4.1 Species Composition

The vegetation on the site must be compatible with control vegetation. On cultivated land, it is preferable to have identical crops seeded at the same time, however, similar annual crops seeded within three weeks are acceptable. In perennial hay or pasture, the reclaimed area should be seeded with a similar seed mix to that on adjacent land. It is advisable to consult the landowner when choosing the mixture to achieve compatibility of species/varieties.

3.4.1.1 Weeds

Under the Alberta *Weed Control Act,* restricted weeds listed in the *Weed Regulation* or in a municipal bylaw must be destroyed and noxious weeds listed in the *Weed Regulation* or in a municipal bylaw must be controlled. The spread or scattering of nuisance weeds should be prevented. No restricted weeds are allowed on-site at the time of certification regardless of whether they are found off-site. Nuisance or noxious weeds must not exceed the degree of infestation of adjacent property.

Two stage evaluations should be employed:

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

Stage 1 observations must be made from a walk through of the reclaimed area and adjacent control areas noting all listed weeds in the *Weed Regulation* and any weeds listed by the local municipality. All weeds found should be documented in the DSA.

Stage 2 observations must describe the degree of infestation in hectares or, if linear, metres according to the levels that follow. Growth stage of the weeds should also be recorded (e.g., seedling, bolt, bud, flower, seed set, mature). A sample Weed Survey is included in Appendix 3

3.4.2 Yield - Annual Crop

Yield assessments must occur as close as possible to maturity or harvest at (or after) the following stages of growth:

- Cereal crops - hard dough stage
- Oilseed crops - firm seed or firm green seed stage
- Legume crops – after pods are filled
- Root/specialty crops – at maturity

The number of kernels or seeds per unit area can be used to estimate the yield value in bu/ac or kg/ha based on seed weights (Canada-Alberta Crop Insurance).

Measurements on representative plants will also include:

- Number of plants (and/or tillers for cereals) in an area of 1/10 m^2
- Height of 10 plants/tillers in the frame
- Number of kernels/head on 5 plants (cereal; corn)
- Number of pods/plant on 5 plants (oilseed; legumes)
- Number of seeds/pod for 5 pods on 5 plants (oilseed; legumes)
- Number of bolls (capsules)/plant, seeds/boll (flax).

Note: For tuberous crops (e.g., potatoes) tuber weight should be used in place of the yield calculation.

To determine data:

- Calculate a mean control value from yield data collected at four representative off-site control locations
- Determine yield (see below) for each wellsite quadrant

- Compare yield for each wellsite quadrant or against the mean control value
- On access roads, on-site yield for each segment is compared directly with representative controls

Calculated Yield Example

Yield (Y) (kernels/m^2) = A (plants/m^2) x B (heads/plant) x C (kernels/head)

For 6-row barley, if the following control data were collected:

A = 250 plants/m^2
B = 1 head/plant
C = 50 kernels/head (average of 5 plants), then
Y = A x B x C
250 x 1 x 50 = 12,500 kernels/m^2

To convert to kg/m^2 for 6 row barley, divide by 25,641 (Canada-Alberta Crop Insurance). In the example above, 12,500 kernels/25,641 = 0.49 kg/m^2.

3.4.3 Biomass or Density - Forage Crops

The operator must document biomass (mature forages) or density (young or overgrazed forages). Biomass is determined by clipping forages at close to ground level, drying and weighing. This can be done at any time during the growing season, but must be completed at the same time for both site and control plots. For year-to-year comparisons, assessments must be completed at the same stage of growth each year.

A step-by-step method is as follows:

- Choose a sample location that is representative of the vegetation onsite or control location
- Place a suitably sized sampling frame in the vegetation cover at the chosen location
- Clip all standing vegetation that has a stem within the frame at about one centimeter from the ground
- Ensure that the cut height is constant between all frames onsite and the controls
- Collect the entire plant, including any portions of a plant that hang outside the frame (Do not collect plants that are hanging into the frame if they do not have a stem within the frame)
- Place all clipped vegetation from the frame into a labeled paper bag (Keep all frame samples in separate, labeled bags)
- Samples should be oven-dried at 105ºC for 24 hours to determine oven-dry weight

- Record the weight
- Determine the mean value for controls and compare to onsite values

3.4.4 Sustainable Plant Community (Health)

Vegetation health assessment includes vigour, color, disease and vegetation quality. A visual assessment or diagnosis involves a comparison of the vegetation on the wellsite to the offsite or control vegetation. If deficiency symptoms or evidence of disease are present in the vegetation on site but not in the control areas, the site would fail.

Some diseases may have an appearance similar to deficiency symptoms. Deficiencies are manifested in symptoms of growth response, reproductive effects, chlorosis and necrosis. Chlorosis is a loss of chlorophyll or a "yellowing" in color. Necrosis refers to dead plant tissue or lesions in the plant. Growth response often shows up in stunting or reduced root and shoot growth. Symptoms related to reproduction stresses include suppressed, delayed or absence of flowering, and reduced viable seed production.

4 GRASSLAND ASSESSMENT PROTOCOL

The assessment protocol for grasslands addresses the balance between landscape, soils and vegetation required to ensure that post-reclamation land use and land management are equivalent to pre-disturbance conditions. Parameters such as texture, topsoil volume, soil profile assessment, plant density or cover, weeds and others are key criteria components that require detailed investigation. See *Vol. 1: 2004 Criteria*, Table 3 for Grassland criteria.

Table 3. Minimum required sampling densities for Grasslands.

	G&R	TS	PSA*	Ag size	Db*	SOM*	Proc Restr	Pen Res	SC	PCS	LPC/LPD	H
4 control	X			X	X	X	X		X	X	X	X
8 control		X	X					X				
WC				X	X	X	X		X	X		X
Grid		X					Assess where req'd by Pen Res readings	X			X	
Alt grid			X									
Quadrant	X			X	X	X	X		X	X		X

Legend

G & R	Gravel and rocks
TS	Topsoil depth
PSA	Particle size analysis
Ag size	Aggregate size distribution
Db	Bulk density
SOM	Soil organic matter
Proc Restr	Process restrictions
Pen Res	Penetrometer resistance
SC	Species composition
PCS	Plant community structure
LPC/LPD	Live plant cover / live plant density
H	Sustainable plant community (Health)
*	Laboratory analysis required

4 control	four control locations per wellsite assessment
8 control	eight control locations per wellsite assessment
WC	Well centre
Grid	All grids sampled
Alt grid	Alternate grids, including well centre
Quadrant	Four quarters of wellsite

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

4.1 Landscape

The landscape parameters drainage, contour, stability, gravel, rocks and debris are to be evaluated. Two-stage evaluations should be employed to provide the required information.

- Stage 1 observations are to be made from each lease corner over the entire lease and adjacent control areas.
- Stage 2 observations are to be made from a walkover of the whole lease area.

4.1.1 Gravel and Rocks.

Gravel and rocks are subject to qualitative and quantitative evaluations. The limitations gravel and rocks impose are related to their number, size and spacing at the surface (Agriculture Canada, 1983).

Qualitative assessment: If site appears to be non-rocky (< 2 % surface area; adapted from Agriculture Canada, 1983), the following is sufficient:

- **Visual** – A visual assessment or rock count of an area that is representative of the lease is satisfactory provided supporting photographs are included in the DSA. Photographs are to be taken vertically (not at an oblique angle) covering a surface are no less than 2m by 2m, with an identifiable object in view for scale.

Quantitative assessment: If site appears to be rocky (> 2 % surface area; adapted from Agriculture Canada, 1983), one of the following must also be completed:

- **Frame analysis** –Delineate a 2m by 2m, representative area in each quadrant. Calculate the percent cover for gravel and rock classes. Record the change in percent as compared to the PCSA (or control, where required) calculated for each class
- **Digital image analysis** – Photograph a representative area of known size (> 4.0 m^2) and scale (identifiable object in view) in each quadrant. Digitally analyze the image for the relative percent of surface area covered by gravel and rock classes

Observed data must be recorded in the DSA Report.

4.2 Soil Assessment

Topsoil in Grasslands is the uppermost organic-enriched mineral soil (e.g. Ah and Ahe horizons).

The *Canadian System of Soil Classification* (Agriculture and Agri-Food Canada, 1998) and *The Manual for Describing Soils in the Field* (Agriculture Canada, 1983) should be used to describe soil properties. Accredited laboratories are required for all laboratory analyses.

4.2.1 Topsoil Replacement Depth

4.2.1.1 Topsoil Volume

All topsoil must be salvaged and replaced. Topsoil depth is to be measured as the distance between the topsoil surface and the subsoil point of contact. If the point of topsoil/subsoil contact is observed to be of a variable depth, the average and range of topsoil depth is to be reported in the DSA. The lease is assessed separately from the access.

Some variability in topsoil replacement depth is allowable, and even desirable on native grassland sites to enhance site stability and plant diversity. Special machinery may be required to place depressions in the surface in order to facilitate plant establishment.

Topsoil volumes for access roads must be assessed in relation to representative control points on a paired basis (Appendix 1, Figure 2). The control must be representative of the site assessment point. The measurement allowances for access roads are the same as for the lease.

4.2.2 Topsoil Quality

Topsoil quality must be evaluated at each assessment point for parameters including texture, structure, gravel, rocks and organic carbon.

4.2.2.1 Texture

Particle size analyses are required for all grids plus eight controls. Samples should be taken as a core that represents the desired soil layer from top to bottom, and should be a representation of the quadrant's average soil texture. Sample locations must be clearly marked on a diagram included in the DSA.

4.2.2.2 Aggregate Size

Four aggregate size classes have been assigned as:

- < 2 cm

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- 2 cm to < 5cm
- 5 cm to ≤ 10cm
- > 10 cm

Qualitative aggregate size analysis must be included in the DSA. General details in the analysis must include apparent aggregate size distribution for the lease and factors that may be influencing aggregate size (e.g. cultivation, vegetation type, ground cover, soil texture, field moisture conditions)

Quantitative aggregate size analysis must be included in the DSA. This analysis must be based on representative areas within each of the quadrants and well centre compared to data from four off-site controls by one of the following:

- **Frame analysis** –Delineate a 1.0m^2 area. Calculate the value for soil aggregates of each size class. Record the change in percent as compared to the PCSA (or control, where required) calculated for each size class.
- **Digital image analysis** – Photograph an area of known size (> 1.0 m^2) and scale (identifiable object in view). Digitally analyze the image for the relative percent of surface area covered by each of the aggregate size classes.

4.2.2.3 Bulk Density

The sample taken for bulk density should also be used for analyzing organic matter content.

Bulk density (D_b) is calculated as the dry mass of the sample of known volume (M_s), divided by that volume (V_t), such that:

$$D_b = M_s / V_t$$

Two common methods for determining bulk density are the core method and the clod method.

Core method (adapted from Agriculture Canada, 1984) described below, or McKeague (1978)

- Prepare a smooth minimally disturbed soil surface
- Press the sampler of known volume far enough into the soil to fill the sampler, but not so far as to compress the soil (do not rock the sampler, as this tends to disturb the soil)
- Core sampling is required for each soil layer extending from the surface to 20 cm below the topsoil layer (discreet samples may be taken from the plough layer, the undisturbed topsoil, and the subsoil)
- Carefully remove the sampler with soil intact.

- Carefully trim the soil sample flush with each end of the cylinder.
    - If the sample stays in the cylinder, seal both ends, label and transport carefully to lab
    - Otherwise, carefully push entire sample contents from sampler into a plastic bag, seal bag and then label
- Samples are to be thoroughly dried at 105° C (72 hours for a 350 cm^3, 7.62 cm (3 in) diameter core. Less time is required for smaller cores)

Those who prefer to use the clod method are directed to refer to the technique described by Agriculture Canada (1984).

The primary horizons of concern, as well as two-lift layers, for assessment and analysis are the Ap (replaced and cultivated), A horizon below Ap (replaced and uncultivated), and upper subsoil (non-salvaged B horizon). If subsoil has been 'ripped' then bulk density core should be relocated to an unripped on-site location, or alternately, delay the assessment until subsoil has settled through at least one freeze/thaw cycle.

Bulk density assessment is required for five grids associated with soil organic matter assessments (one per quadrant, plus well centre), as well as one control sample from each side of the lease. The bulk density for each analysis location must be compared against the averaged PCSA, or control values.

4.2.2.4 Organic Matter Content

To obtain a true estimate of organic carbon content per unit volume, a non-composited sample taken for bulk density should be used for analyzing organic carbon content.
For sites assessed on or after the release date of these criteria, total organic carbon content is to be assessed and compared with organic carbon content data from the PCSA or control sites based on the sampling protocol used for determining texture.

On-site topsoil sampling for laboratory analysis is required from all quadrants. Four off-site representative control points must be analyzed separately before being numerically combined to determine an average control value. Analyses should be conducted on the core from the upper topsoil (replaced and cultivated) and lower topsoil (if any, replaced and uncultivated) for on-site and off-site samples.

Total organic carbon must be determined by dry combustion (Leco induction furnace) (McKeague 1978). For samples containing carbonates, organic C is determined by subtracting carbonate C from total C. Carbonate C must be determined by the technique of Bascomb (1961).

When organic amendments have occurred, a minimum three-year period without further organic matter additions is required prior to certification application.

4.3 Soil Profile Assessment

This assessment is valuable to determine the state of the site, and can be used to prescribe corrective actions for problem soil conditions. Salvaged soil (including two-lift stripping sites) and remaining subsoil to a minimum of 60 cm must be assessed. In the assessment depth, process restriction parameters and penetrometer indicators must be documented at least as either 'equivalent to', 'less restrictive' or 'more restrictive' for well centre and each grid as compared to the control values. Penetrometer values are valid for control assessments, but are not valid for PCSA assessments.

The following is required to determine the effects of soil conditions on plant roots, and subsequent impact on plant health (Table 4):

- A **visual** qualitative observation of land surface, including any evidence of ponding (size, depth, effect on plants), rutting (depth, length), different maturation dates and/or species
- A **visual** qualitative observation of the land subsurface, including root matting or flattening, dispersed lateral roots, compacted soil layers, etc.

4.3.1 Process Restrictions

Table 4. Process Restriction Indicators for Grasslands

Vertical Root Elongation Restriction Indicators	Water Permeability Restriction Indicators	Soil Aeration Restriction Indicators
• Presence of early maturing vegetation with reduced height and density • In mixed pasture or haylands, uneven distribution of species • Presence of root mats and bunches	• Presence of surface ponding • Evidence of chlorosis • Presence of surface vehicle (equipment) ruts • Presence of dense, massive or layered structure	• Presence of dense, massive or layered soil structure (compaction) • Presence of reduced pore size and pore space

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• Presence of flattened and highly branched roots • Presence of horizontal roots • Presence of exped roots • Absence of roots within or below reconstructed profile zones • Absence of roots within soil aggregates • Presence of soil layers or abrupt texture or structure transitions • Presence of dense and massive soil structure	(compaction) • Presence of stratified or abrupt moisture changes within the soil profile • Presence of abrupt texture or structure transitions	• Presence of brownish-red ped surfaces • Presence of sour odours

4.3.2 Penetrometer Resistance

Penetrometer Resistance is a quantitative measurement of subsurface impedances. The results must be a qualitative interpretation of those values. Note that soil strength is affected by soil characteristics (moisture, texture, density, etc.). These characteristics should be recorded in the DSA along with the penetrometer numeric results and an interpretation ('restrictive' or 'equivalent') of those results.

- Describe the penetrometer used (size, type, model, etc.)
- Describe on-site and off-site soil moisture conditions
- Sample (at a distance < 1 m from bulk density sampling locations) in each grid and eight off-site control locations
- Compare grid result to the off-site mean control value
- Sample to similar depths at all locations
- Ensure pressure is applied consistent during sampling event to depth at any location, and between locations
- Include results in DSA

4.4 Vegetation Assessment

Vegetation assessment must address issues of erosion control and water capture, forage productivity for livestock grazing, wildlife habitat, aesthetics (e.g. recreational areas) and maintenance of biodiversity. The operator must revegetate according to the land use defined at the time of reclamation based on consultation with the landowner.

The assessment protocol incorporates objective and quantifiable vegetation performance comparisons of on-site versus off-site conditions based on species composition (including weeds), plant cover or density and plant community structure. A vegetation assessment is not required on access roads or pads left in place. If the roads or pads have had soils replaced, or have been amended and seeded, the vegetation criteria will apply.

One frame (e.g., Daubenmire frame - 20 cm x 50 cm rectangle = 0.1m^2) must be assessed in each of the four quadrants, well centre and in four representative control locations. If a different frame is used, the frame shape and dimensions must be defined and remain consistent for the entire assessment. For example, a 1.0 m^2 frame is recommended as a minimum size to accommodate measurement of shrubs. Vegetation must be present at the time of industry assessment.

Timing of the evaluation will vary according to the type of disturbance, soil salvage procedures, revegetation procedure and precipitation. Sites that have been minimally disturbed should be ready for assessment before sites that have been fully stripped. A site in a moist environment may be ready for final assessment by the second growing season following seeding. However, natural recovery sites and sites seeded in a drought-prone environment may require several years before a final assessment is appropriate. Fertilizer and other amendment applications, including types and rates, must be documented in the DSA. Final assessment of these areas can not take place until five years following the last application of fertilizer.

4.4.1 Species Composition

The vegetation on the site must be a sustainable desired plant community (compatible with original or control species or meets end land use and land management objectives of the landowner). The use of appropriate plant materials is critical for the successful establishment of a

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native plant cover (e.g., prairie). The *Native Plant Revegetation Guidelines for Alberta* (AAFRD and AENV, 2001) should be consulted for more information.

Assessment should be made based on observations in each quadrant plus well centre and compared to four controls. In each frame, the dominant species (up to 5) in each plant layer must be recorded in the DSA. The ability of the reclaimed area to be utilized in the same manner and in conjunction with the adjacent lands (unless end land use is changed) should not be impaired. Vegetation on the site must be developing along expected successional trends (e.g., annual weeds are not significantly inhibiting native perennial establishment or growth).

Elimination of problem introduced species is required if non-native species were seeded on native prairie or parkland sites constructed after January 1, 1993 unless the landowner approved the seeding. See the Information Letter R&R/03-5 *Problem Introduced Forages on Prairie and Parkland Reclamation Sites* (AENV, 2003) for more information. Best management practices employed must be documented in the DSA.

On sites where natural recovery (no seeding) has been used, revegetation success depends on the establishment of early successional native plant species that are compatible with the surrounding landscape and protect the site from erosion. Assessment for species composition is the same as for seeded sites. The integrity of native plant communities must be maintained. See R&R /03-6: *Sites Reclaimed Using Natural Recovery Methods: Guidance on Site Assessment* for more information.

4.4.1.1 Weeds

Under the *Weed Control Act,* restricted weeds listed in the *Weed Regulation* or in a municipal bylaw must be destroyed and noxious weeds listed in the *Weed Regulation* or in a municipal bylaw must be controlled. The spread or scattering of nuisance weeds should be prevented. Two stage evaluations should be employed.

- Stage 1 observations are to be made from a walk through of the reclaimed area and adjacent control areas for all listed weeds in the *Weed Regulation* and any weeds listed by

the local municipality. All weeds found should be listed in the DSA. A sample Weed Survey is attached in Appendix 3.

- Stage 2 observations must describe the degree of infestation in hectares or, if linear, metres according to the levels that follow. Growth stage of the weeds should also be recorded (e.g., seedling, bolt, bud, flower, seed set, mature). No restricted weeds are allowed onsite at the time of certification. Nuisance or noxious weeds on-site must exceed the degree of infestation found offsite.

Sites left to recover naturally often get a flush of non-persistent annual weeds (such as *Descurainia sp.* flixweed) in the first few years. This is not usually a concern since they provide early erosion control. Sites should be assessed after this phase is past, when native plants are well established.

Degree of Weed Infestation:

- Trace (Rare): <1 percent cover
- Low (Occasional plants): ≥ 1 percent and <5 percent cover
- Moderate (Scattered plants): ≥ 5 percent and <25 percent cover
- High (Dense infestation of plants): ≥ 25% cover
- Linear (access road): length of infestation in metres

4.4.2 Plant Community Structure

Diversity in plant community structure is important for erosion control, ecosystem functioning and wildlife habitat. Plant layers in grassland usually include:

- Moss
- Lichen
- sedge layer
- mid-grass/forb layer
- tall grass/forb/shrub layer.

One frame (e.g., Daubenmire frame - 20 cm x 50 cm rectangle = 0.1m^2) must be assessed in each of the four quadrants, well centre and in four representative control locations. For sites constructed prior to the release date of the criteria, one plant layer is acceptable. Sites constructed after this date must have a minimum of two plant layers. The distribution of plants in

the community in either case does not have to be even but should simulate off-site plant distribution as much as possible and ensure site stability.

4.4.3 Live Plant Cover or Plant Density and Litter Cover

Live plant cover/litter and live plant density/litter assess different plant communities or situations. Live plant cover/litter assessment is appropriate for mature grassland sites where it is often difficult to distinguish individual plants. Live plant density plus litter cover is appropriate for assessing younger sites planted to grasses, grassland/forb sites in a drought year or overgrazed sites. The reason for using one assessment method over the other must be included in the DSA.

The amount of litter and bare ground must be assessed. Other erosion control products applied on-site (e.g., straw crimping) must be documented in the DSA.

Plant Density/Litter Cover: In each frame, the following information shall be recorded if sampling plant density:

- The number of individual plants or groups of stems of each species (for rhizomatous species)
- The percent cover of litter, erosion control products and bare ground.

Live Plant/Litter Cover: In each frame, the following information shall be recorded:

- The plant layers that are present
- The amount of live aerial cover provided by the various layers
- The amount of cover at ground level provided by lichens, mosses, and litter (defined as dead plant material that is produced naturally on a site, expressed as a percent of the total area)
- The percent bare ground in the frame.

Use of permanent erosion control practices or materials must be documented in the DSA and photos must be provided.

Plant Community Structure

Two or more plant layers (overstory / understory) must be established on-site. If only one plant layer is found at the controls, then one layer is acceptable on-site. The assessment parameters above will be used to determine the appropriate number of plant layers required.

4.4.4 Sustainable Plant Community (Health)

Vegetation health assessment includes: vigour, color, disease, vegetation quality and reproductive potential. A visual assessment or diagnosis involves a comparison of the vegetation on the wellsite to the offsite or control vegetation.

Some diseases may have an appearance similar to deficiency symptoms. Deficiencies are manifested in symptoms of growth response, reproductive effects, chlorosis, and necrosis. Chlorosis is a loss of chlorophyll or a "yellowing" in color. Necrosis refers to dead plant tissue or lesions in the plant. Growth response often shows up in stunting or reduced root and shoot growth. Symptoms related to reproduction stresses include suppressed, delayed or absence of flowering, and reduced viable seed production. Plants have healthy root systems. Where perennial plants are established, there should be evidence of successful reproduction (e.g., seeds, rhizomes).

5 FORESTED LAND ASSESSMENT PROTOCOL

Forested lands include a mixture of private and public land. Some of these lands have potential for cultivation. Land that has been converted to continuous cropping or hayland should be assessed under the Cultivated Land criteria. Land that has been converted to permanent grassland should be assessed under the Grassland criteria. Where a site is constructed on land supporting two different land uses (e.g. Cultivated Land and Forested Land), the landowner will determine the final land use for the site.

Forested Public Land Criteria requires a Landscape Assessment for all sites and provides for two options when assessing soils and vegetation. Option A requires that all soils criteria be met as well as a rudimentary vegetation assessment. Option B requires that a more stringent vegetation criteria be achieved in lieu of the soils criteria. Where sites have been abandoned for an excess of 10 years, treed vegetation criteria have an additional minimum growth criteria.

The following information must be provided in the DSA in support of chosen assessment criteria:

- Current and proposed land uses
- Adjacent land use (e.g. cultivated land, grassland)
- Access restrictions (e.g. distance, topography, water issues)
- Current forest type
- Topography relative to adjacent developed land
- Soil (e.g. type, depth, horizonation (CSSC, 1998), texture, stoniness)

Forested topsoil is referred to as surface soil in the criteria as it may also include upper portions of the B horizon. Surface soil is important as an organic matter source and for propagule preservation. This material aids successful reclamation and therefore has been included in the criteria update. Landscape, surface soil quantity, soil profile and vegetation are the key parameters that must be assessed. See *Vol. 1: 2004 Criteria*, Table 4 for forested lands criteria.

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

Two site assessment options are available. Sites constructed prior to the release date of these criteria may be assessed with either Option A or Option B. All sites constructed on or after the release date of these criteria must be evaluated with Option A.

Option A focuses on the soil characteristics as indicators of forest potential where tree establishment has had limited time since reclamation. Vegetation characteristics are assessed but to less an extent than Option B. Option A is available to all sites regardless of construction date.

Option B focuses on the vegetation characteristics where tree establishment has had extended time since reclamation. The only soil criteria addressed with this option is for surface soil replacement. Option B is available only to those sites constructed prior to the release date of these criteria.

Table 5a. Minimum required sampling densities for Forested Lands
Option A, soil and vegetation focus

	G&R	SS	PSA*	SOM*	Proc Restr	Pen Res	SC	PCS	LPC/ LPD	H
4 control	X	X	X	X	X		X	X	X	X
8 Control						X				
WC				X	X		X			X
Grid					Assess where req'd by Pen Res readings	X		X	X	
Alt grid		X	X							
Quadrant	X			X	X		X			X

Table 5b. Minimum required sampling densities for Forested Lands
Option B, vegetation focus

	G&R	SS	SC	PCS	LPC / LPD	H
4 control	X	X	X	X	X	X
8 Control						
WC			X			X
Grid				X	X	
Alt grid		X				
Quadrant	X		X			X

Legend

G&R	Gravel and rocks
SS	Surface soil depth
PSA	Particle size analysis (soil texture)
SOM	Soil organic matter
Proc Restr	Process restrictions
Pen Res	Penetrometer resistance
4 control	four control locations per wellsite
8 control	eight control locations per wellsite
SC	Species composition
PCS	Plant community structure
LPC/LPD	Live plant cover / live plant density
H	Sustainable community (Health)
*	Laboratory analysis required
WC	Well centre
Grid	All grids assessed
Alt grid	Alternate grids assessed

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

Quadrant Four quarters of wellsite assessed

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

5.1 Landscape

The landscape parameters drainage, contour, stability, gravel and rocks, debris and weeds are to be evaluated. Two-stage evaluations should be employed. Stage 1 observations are to be made from each lease corner over the entire lease and adjacent control areas. Stage 2 observations are to be made from a walkover of the whole lease area. These staged observations must provide information required for the landscape parameters.

Observed data must be recorded in the DSA Report.

5.2 Soil Assessment

The Canadian System of Soil Classification (Agriculture and Agri-Food Canada, 1998) and *The Manual for Describing Soils in the Field* (Agriculture Canada, 1983) must be used to describe soil properties. Accredited laboratories are required for all laboratory analyses.

Topsoil in cultivated land is the layer of soil commonly moved in cultivation. Cultivated and non-cultivated horizons (e.g., Ap, Ah and Ahe) may be included.

If the control topsoil depth is > 15 cm, the depth of replaced topsoil, soil quality, soil profile assessment and loss of organic mater content assessments may be done after soil replacement or after cultivation in the entire replaced soil layer.

For cultivated lands, if the control topsoil is < 15 cm deep the operator may assess depth of replaced topsoil after soil replacement but prior to cultivation to confirm that adequate soil was replaced. The Ap depth, soil quality soil profile assessment and loss of organic matter content assessments must be done in the replaced Ap horizon after cultivation of the site has occurred.

5.2.1 Surface Soil Replacement Depth

Surface soil depth must be measured as the distance between the topsoil surface and the subsoil point of contact. On lease, assessments are required in each grid. Where there is no PCSA data, eight controls are required. The soil surface around the sample point must be free of furrows, etc. If the point of surface soil/subsoil contact is observed to be of a variable depth, the average surface soil depth must be reported in the DSA. The replaced soil should be distributed uniformly across the lease. The lease is assessed separately from the access.

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

Soil depths for access roads are assessed in relation to representative control points on a paired basis. The control must be representative of the site assessment point. The depth requirements for access roads are the same as for the lease.

5.2.2 Surface Soil Quality

Surface soil quality will be evaluated at each assessment point for texture, structure, gravel, rocks and organic carbon.

5.2.2.1 Texture

Laboratory particle size analysis (PSA) (Gee and Bauder, 1979) shall be used to confirm soil texture for a site. On-site, one non-composited PSA is required for every alternate grid. Samples from eight off-site control points (two from each side) will be taken. The laboratory results from each of these samples may be averaged to obtain one average control PSA value that will be used to compare against every grid value. Samples must be taken as a core that represents the desired soil layer from top to bottom. Sample locations must be clearly marked on a diagram included in the DSA.

5.2.2.2 Aggregate Size

- n/a

5.2.2.3 Bulk Density

The sample taken for bulk density should also be used for analyzing organic matter content.

Bulk density (D_b) is calculated as the dry mass of the sample of known volume (M_s), divided by that volume (V_t), such that:

$$D_b = M_s / V_t$$

Two common methods for determining bulk density are the core method and the clod method.

Core method (adapted from Agriculture Canada, 1984) described below, or McKeague (1978)

- Prepare a smooth minimally disturbed soil surface
- Press the sampler of known volume far enough into the soil to fill the sampler, but not so far as to compress the soil. Do not rock the sampler, as this tends to disturb the soil

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

- Core sampling is required for each soil layer extending from the surface to 20 cm below the topsoil layer. Discreet samples may be taken from the plough layer, the undisturbed topsoil and the subsoil
- Carefully remove the sampler with soil intact
- Carefully trim the soil sample flush with each end of the cylinder
    - If the sample is kept in the cylinder, seal both ends, label and transport carefully to lab
    - Otherwise, carefully push entire sample contents from sampler into a plastic bag, seal bag and then label
- Samples are to be thoroughly dried at 105° C (72 hours for a 350 cm^3, 7.62 cm (3 in) diameter core. Less time is required for smaller cores)

Those who prefer to use the clod method are directed to refer to the technique described by Agriculture Canada (1984).

The primary horizons of concern, as well as two-lift layers, for assessment and analysis are the Ap (replaced and cultivated), A horizon below Ap (replaced and uncultivated), upper subsoil (non-salvaged B horizon). If subsoil has been 'ripped' then the bulk density core must be relocated to an unripped on-site location, or delay the assessment until subsoil has settled through at least one freeze/thaw cycle.

Bulk density assessment is required for five grids associated with soil organic matter assessments (one per quadrant, plus well centre), as well as one control sample from each side of the lease. The bulk density for each analysis location will be compared against the averaged PCSA or control values.

5.2.2.4 Organic Matter Content

To obtain a true estimate of organic carbon content per unit volume, a non-composited sample taken for bulk density must be used for analyzing organic matter content.
The total organic carbon content calculated on the basis of bulk density and a 15 cm depth for each quadrant plus well center will be compared to the mean value for the four controls. Total organic carbon must be calculated as dry soil bulk density divided by percent soil organic carbon, or:

$$TOC\ (g/cm^3) = (g\ dry\ soil\ /cm^3) \times (g\ C\ /\ 100\ g\ soil)$$

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

For sites assessed on or after the release date of these criteria, total organic carbon content is to be assessed and compared with organic carbon content data from the PCSA or control sites.

On-site topsoil sampling for laboratory analysis is required from all grids. Twelve off-site control points (three from each side of the lease) must be analyzed separately for organic matter and bulk density, and the results combined to determine an average control value. Analyses should be conducted on the core from the topsoil (replaced, cultivated, and uncultivated) for on-site and off-site samples.

Total organic carbon shall be determined by dry combustion (Leco induction furnace) (McKeague 1978). For samples containing carbonates, organic C is determined by subtracting carbonate C from total C. Carbonate C must be determined by the technique of Bascomb (1961).

When organic amendments have been used, a minimum three-year period without further organic matter additions is required prior to assessment.

5.3 Soil Profile Assessment

This assessment is valuable to determine the state of the site and can be used to prescribe corrective actions for problem soil conditions. Salvaged soil (including two-lift stripping sites) and remaining subsoil to a minimum of 60 cm must be assessed. In the assessment depth, process restriction parameters and penetrometer indicators are documented at least as either 'equivalent to', 'less restrictive', or 'more restrictive' for every grid as compared to the control. Penetrometer values are valid for control assessments but are not valid for PCSA assessments.

The following is required to determine the effects of soil conditions on plant roots, and subsequent impact on plant health (Table 6):

- A visual qualitative observation of land surface, including any evidence of ponding (size, depth, effect on plants), rutting (depth, length), different maturation dates and/or species
- A visual qualitative observation of the land subsurface, including root matting or flattening, dispersed lateral roots, compacted soil layers, etc.

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

5.3.1 Process Restrictions

The following is required to determine the effects of soil conditions on plant roots, and subsequent impact on plant health (Table 6):

- A visual qualitative observation of land surface, including any evidence of ponding (size, depth, effect on plants), rutting (depth, length), different crop maturation dates and/or species
- A visual qualitative observation of the land subsurface, including root matting or flattening, dispersed lateral roots, compacted soil layers, etc.

Table 6 Process Restriction Indicators for Forested Land

Vertical Root Elongation Restriction Indicators	Water Permeability Restriction Indicators	Soil Aeration Restriction Indicators
• Presence of vegetation with reduced height and density • Uneven distribution of species • Presence of root mats and bunches • Presence of flattened and highly branched roots • Presence of horizontal roots • Presence of exped roots • Absence of roots within or below reconstructed profile zones • Absence of roots within soil aggregates • Presence of soil layers or abrupt texture or structure transitions • Presence of dense and massive soil structure	• Presence of surface ponding • Evidence of chlorosis • Presence of surface vehicle (equipment) ruts • Presence of dense, massive or layered structure (compaction) • Presence of stratified or abrupt moisture changes within the soil profile • Presence of abrupt texture or structure transitions	• Presence of dense, massive or layered soil structure (compaction) • Presence of reduced pore size and pore space • Presence of brownish-red ped surfaces • Presence of sour odours

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

5.3.2 Penetrometer Resistance

Penetrometer resistance is a quantitative measurement of subsurface impedances. The results will be a qualitative interpretation of those values. Note that soil strength is affected by soil characteristics (moisture, texture, density, etc.). These characteristics must be recorded in the DSA along with the penetrometer numeric results and an interpretation ('restrictive' or 'equivalent') of those results.

- Describe the penetrometer used (size, type, model, etc.)
- Describe on-site and off-site soil moisture conditions
- Sample (at a distance < 1 m from bulk density sampling locations) in each grid and eight off-site control locations
- Each grid result shall be compared to the off-site mean control value
- Sample to similar depths at all locations
- Pressure applied must be consistent during sampling event to depth at any location, and between locations
- Results are to be included in DSA

5.4 Vegetation Assessment

Revegetation objectives for various land uses in Forested areas may include erosion control and water capture, timber production, wildlife habitat, aesthetics (recreational areas), forage productivity for livestock grazing and maintenance of biodiversity. Minimum disturbance operations are desirable for forested areas and result in the least amount of revegetation effort. The operator will revegetate according to the land use defined at the time of reclamation based on consultation with the landowner or land manager. There are several options that can be considered for revegetation for this land use:

- Seeding or planting a permanent cover of native plant species that will develop into the desired plant community over time

- Seeding an initial non-permanent cover (e.g., annual crops, short-lived native grasses) and adding appropriate tree and shrub species later or allowing regrowth from the seedbank or encroachment by species adjacent to the site

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

- Natural recovery (no addition of plant materials) where soils are suitable, persistent weed populations are low and grazing/browsing pressure is light

Colour photographs are to be taken from each corner of the lease to provide a comparison of the on-site and adjacent vegetation prior to initiation of the site assessment. Photographs must also be obtained from the well centre and towards all four directions. An object to provide scale must be included in all photographs and a record of the location and direction of each photo must be maintained.

Sampling Protocol for Vegetation Assessment

The assessment protocol incorporates objective and quantifiable vegetation performance comparisons of on-site versus off-site conditions based on species composition (including weeds), plant cover or density and plant community structure. Qualitative comparisons include the plant sustainability (health) characteristics of vigour, colour,disease and reproductive potential. If the vegetation types are different (e.g., different successional stages), then growth characteristics of the vegetation on-site must be compared to expected performance of the vegetation type for the geographic area (e.g., a recently harvested nearby cut-block). A vegetation assessment is not required on access roads or pads left in place. If the roads or pads have had soils replaced or have been amended and seeded, the vegetation criteria will apply.

A 10.0m^2 circular plot (radius of 1.78 metres) should be used for sampling trees and shrubs in forested areas. A stake is placed in the ground at the center of the plot and a line measuring 1.78 metres attached to it. This line is moved in a circle around the stake to delineate the plot. One plot is assessed in each quadrant, at well centre and at four representative control locations (if available). The herb/grass layer and litter are assessed within each circular plot using a 1.0 m^2 frame. On access roads, plots or frames must be paired (on and off the access) but do not need to be immediately adjacent.

Timing of the evaluation will vary according to the type of disturbance, soil salvage procedures and precipitation. A site in a moist environment may be ready for final assessment by the second growing season following seeding. However, revegetation of a similar site in a drought-prone environment may require more years before a final assessment is appropriate. Native species

should not be fertilized unless a CRI gives approval. Fertilizer use must be documented in the DSA. Final assessment of fertilized areas must take place until five years following the last application of fertilizer. This is to ensure that native plant communities are sustainable.

5.4.1 Species Composition

The vegetation on the site must be a sustainable desired plant community (compatible with original or control species, or meets end land use and land management objectives of the landowner). The use of appropriate plant materials is critical for the successful establishment of a native plant cover (e.g., prairie). The *Native Plant Revegetation Guidelines for Alberta* (2001) must be consulted for more information.

Assessment must be made based on observations in each plot and frame, and compared to four controls. In each plot or frame, the dominant species (up to five in each plant layer) must be recorded in the DSA. The ability of the reclaimed area to be utilized in the same manner and in conjunction with the adjacent lands (unless end land use is changed) must not be impaired. Vegetation on the site must be developing along expected successional trends (e.g., annual weeds are not significantly inhibiting native perennial establishment or growth. Restricted or noxious weeds must not be present).

On sites where natural recovery (no seeding) has been used, revegetation success depends on the establishment of early successional native plant species that are compatible with the surrounding landscape and protect the site from erosion. Assessment for species composition is the same as for seeded sites. The integrity of native plant communities must be maintained. See the Information Letter R&R /03-6: *Sites Reclaimed Using Natural Recovery Methods: Guidance on Site Assessment* (AENV, 2003) for more information.

5.4.1.1 Weeds

Under the Alberta *Weed Control Act,* restricted weeds listed in the *Weed Regulation* or in a municipal bylaw must be destroyed and noxious weeds listed in the *Weed Regulation* or in a municipal bylaw must be controlled. The spread or scattering of nuisance weeds should be prevented. Two stage evaluations must be employed.

NOTE: The *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update* remains in effect until further notice.

Stage 1 Observations are to be made from a walk through of the reclaimed area and adjacent control areas for all listed weeds in the *Weed Regulation* and any weeds listed by the local municipality. All weeds found must be listed in the DSA. A sample Weed Survey is attached in Appendix 3.

Stage 2 observations record the degree of infestation in hectares or, if linear, metres, according to the levels that follow. Growth stage of the weeds must also be recorded (e.g., seedling, bolt, bud, flower, seed set, mature). No restricted weeds are allowed on-site at the time of certification (whether they are found off-site). Nuisance or noxious weeds should be in the same class (re:degree of infestation). Sites left to recover naturally often get a flush of non-persistent annual weeds (such as *Descurainia sp.* flixweed) in the first few years. This is not usually a concern since they provide early erosion control. Sites must be assessed after this phase is past, when native plants are well established.

Degree of Weed Infestation:

- Trace (Rare): <1 percent cover
- Low (Occasional plants): ≥ 1 percent and <5 percent cover
- Moderate (Scattered plants): ≥ 5 percent cover and <25 percent cover
- High (Dense infestation of plants): ≥ 25 percent cover
- Linear (access road): length of infestation in metres

5.4.2 Plant Community Structure

Diversity in plant community structure is important for erosion control, ecosystem functioning and wildlife habitat. Plant layers in forests usually include: herb/grass layer, shrub layer and tree layer. For sites constructed prior to the release date of these criteria, one plant layer is acceptable. Sites constructed after this date must have a minimum of two plant layers. The distribution of plants in the community in either case does not have to be even but should simulate off-site plant distribution and ensure site stability.

5.4.3 Live Plant Cover or Plant Density and Litter Cover

Plant cover and density are important measurements for determining the sustainability of the plant community and its ability to control erosion. Live plant cover/litter and live plant

density/litter are assessments that are appropriate for different plant communities or situations. Live plant cover/litter assessment is appropriate for open areas where there are few trees. Live plant density plus litter cover is appropriate for assessing younger sites planted to trees and shrubs, open sites in a drought year or overgrazed sites. The reason for using one or the other assessment method must be documented in the DSA. The amount of litter and bare ground must also be assessed. If the site has had other erosion control products applied (e.g., straw crimping), this must be documented.

Plant Density/Litter Cover: In each plot, the following information must be recorded if sampling plant density:

- The number of individual plants or groups of stems (for rhizomatous species) of each tree and shrub species
- The percent cover of litter, erosion control products and bare ground

Live Plant/Litter Cover: In each frame, the following information shall be recorded:

- The plant layers that are present
- The amount of live aerial cover provided by the various layers
- The amount of cover at ground level provided by lichens, mosses, and litter (defined as dead plant material that is produced naturally on a site, expressed as a percent of the total area)
- The percent erosion control products and bare ground in the frame.

5.4.4 Sustainable Plant Community (Health)

Vegetation health assessment includes: vigour, colour, disease, vegetation quality and reproductive performance. A visual assessment or diagnosis involves a comparison of the vegetation on the wellsite to the off-site or control vegetation. If deficiency symptoms or evidence of disease are present in the vegetation on site but not in the control areas, the site will fail.

Some diseases may have an appearance similar to deficiency symptoms. Deficiencies are manifested in symptoms of growth response, reproductive effects, chlorosis and necrosis. Chlorosis is a loss of chlorophyll or a "yellowing" in color. Necrosis refers to dead plant tissue

or lesions in the plant. Growth response often shows up in stunting or reduced root and shoot growth.

Symptoms related to reproduction stresses include suppressed, delayed or absence of flowering, and reduced viable seed production. Where perennial plants are established, there must be evidence of successful reproduction (e.g., seeds, rhizomes), and healthy root systems.

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6 PEAT LAND ASSESSMENT PROTOCOL

Peatlands are important as water storage areas, wildlife habitat and maintenance of biodiversity. Key assessment items include: landscape parameters, soil replacement, soil profile characteristics and vegetation. Drainage and associated surface water flow regimes are of primary importance. See *Vol. 1: 2004 Criteria*, Table 5 for peat land criteria.

Table 7. Minimum required sampling densities for Peat Land

	SS	SC	PCS	C/D	Health
4 control	X	X	X	X	X
WC	X	X	X	X	X
Quadrant	X	X	X	X	X

Legend

SS	Surface soil depth	LPC/LPD	Surface cover and plant density
SC	Species composition	H	Sustainable plant community (Health)
PCS	Plant community structure		

4 control	four control locations per wellsite assessment
WC	well centre
Quadrant	four quarters of wellsite

6.1 Landscape

Drainage, contours, stability, gravel and rocks, debris and weeds are the five characteristics that must be assessed. These parameters are assessed in the four quadrants.

Pads or roads may only be left in place with the landowner's approval.

6.2 Soil Profile Assessment

- n/a

6.2.1 Surface Soil Quantity

The mean surface soil depth data from the PCSA or controls (12 locations) will determine whether soil salvage is required on a lease (> 40 cm peat – no soil salvage required if a pad is used; < 40 cm peat – soil salvage is required).

Assess one location per quadrant and well centre to determine if surface soil has been evenly replaced.

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6.3 Soil Profile Assessment

n/a

6.4 Vegetation Assessment

Minimum disturbance operations are desirable for peatlands and result in the least amount of revegetation effort. The operator must revegetate according to the land use defined at the time of reclamation based on consultation with the landowner or land manager. There are several options that can be considered for revegetation for this land use, though natural recovery is the preferred method:

- Seeding or planting a permanent cover of native plant species that will develop into the desired plant community over time
- Seeding an initial non-permanent cover (e.g., annual crops, short-lived native grasses) and adding appropriate tree and shrub species later or allowing regrowth from the seedbank or encroachment by species adjacent to the site
- Natural recovery (no addition of plant materials) where soils are suitable, persistent weed populations are low and grazing/browsing pressure is light

Colour photographs are to be taken from each corner of the lease to provide a comparison of the on-site and adjacent vegetation prior to initiation of the site assessment. Photographs must also be obtained from the well centre and towards all four directions. An object to provide scale must be included in all photographs and a record of the location and direction of each photo must be maintained.

Sampling Protocol for Vegetation Assessment

The assessment protocol incorporates objective and quantifiable vegetation performance comparisons of on-site versus off-site conditions based on species composition (including weeds), plant cover or density and plant community structure. Qualitative comparisons include the plant sustainability (health) characteristics of vigour, colour,disease and reproductive potential. If the vegetation types are different (e.g., different successional stages), then growth

characteristics of the vegetation on-site must be compared to expected performance of the vegetation type for the geographic area. A vegetation assessment is not required on access roads or pads left in place. If the roads or pads have had soils replaced or have been amended and seeded, the vegetation criteria will apply.

A 10.0 m^2 circular plot (radius of 1.78 metres) should be used for sampling trees and shrubs in peatlands. A stake can be placed in the ground at the center of the plot and a line measuring 1.78 metres attached to it. This line is moved in a circle around the stake to delineate the plot. One plot must be assessed in each quadrant, well centre and twelve representative control locations (if available). On access roads, plots or frames should be paired (on and off the access) but do not need to be immediately adjacent.

Timing of the evaluation will vary according to the type of disturbance, soil salvage procedures and precipitation. Native species must not be fertilized unless a CRI gives approval. Fertilizer use must be documented in the DSA. Final assessment of fertilized areas cannot take place until five years following the last application of fertilizer. This is to ensure that native plant communities are sustainable.

6.4.1 Species Composition

The vegetation on the site must be a sustainable desired plant community (compatible with original or control species or meets end land use and land management objectives of the landowner). Assessment must be made based on observations in each plot, and compared to four controls. In each plot or frame, the dominant species (up to five in each plant layer) must be recorded in the DSA. The ability of the reclaimed area to be utilized in the same manner and in conjunction with the adjacent lands (unless end land use is changed) should not be impaired. Vegetation on the site must be developing along expected successional trends (e.g., annual weeds are not significantly inhibiting native perennial establishment or growth).

Restricted or noxious weeds must not be present (see Weed Assessment below).

On sites where natural recovery (no seeding) has been used, revegetation success depends on the establishment of early successional native plant species that are compatible with the surrounding landscape and protect the site from erosion. Assessment for species composition is the same as

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for seeded sites. The integrity of native plant communities must be maintained. See Information Letter R&R /03-6: *Sites Reclaimed Using Natural Recovery Methods: Guidance on Site Assessment* (AENV, 2003) for more information.

6.4.1.1 Weeds

Under the Alberta *Weed Control Act,* restricted weeds listed in the *Weed Regulation* or in a municipal bylaw must be destroyed and noxious weeds listed in the *Weed Regulation* or in a municipal bylaw must be controlled. The spread or scattering of nuisance weeds should be prevented. Two-stage evaluations should be employed.

Stage 1 observations are to be made from a walk through of the reclaimed area and adjacent control areas for all listed weeds in the *Weed Regulation*, and any weeds listed by the local municipality. All weeds found should be listed in the DSA. A sample Weed Survey is attached in Appendix 3

Stage 2 observations must describe the degree of infestation in hectares or, if linear, metres, according to the levels that follow. Growth stage of the weeds should also be recorded (e.g., seedling, bolt, bud, flower, seed set, mature). No restricted weeds are allowed on-site at the time of certification (whether they are found off-site). Nuisance or noxious weeds should be in the same class (re: degree of infestation). Sites left to recover naturally often get a flush of non-persistent annual weeds (such as *Descurainia sp.* flixweed) in the first few years. This is not usually a concern since they provide early erosion control. Sites must be assessed after this phase is past when native plants are well established.

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- Trace (Rare): <1 percent cover
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- Moderate (Scattered plants): ≥ 5 percent cover and <25 percent cover
- High (Dense infestation of plants): ≥ 25 percent cover
- Linear (access road): length of infestation in metres

6.4.2 Plant Community Structure

Diversity in plant community structure is important for erosion control, ecosystem functioning and wildlife habitat. Plant layers in peatlands usually include: moss layer, shrub layer and tree layer. The distribution of plants in the community in either case does not have to be even but should simulate off-site plant distribution and ensure site stability.

6.4.3 Live Plant Cover/Live Plant Density

Plant cover and density are important measurements for determining both the sustainability of the plant community and its ability to control erosion. Live plant cover/litter and live plant density/litter are assessments that are appropriate for different plant communities or situations. Live plant cover/litter assessment is appropriate for open areas where there are few trees. Live plant density plus litter cover is appropriate for assessing younger sites planted to trees and shrubs, open sites in a drought year, or overgrazed sites. The reason for using one or the other assessment method must be documented in the DSA. The amount of litter and bare ground must also be assessed. If the site has had other erosion control products applied (e.g., straw crimping), this must to be documented.

Plant Density/Litter Cover: In each plot, the following information must be recorded if sampling plant density:

- The number of individual plants or groups of stems (for rhizomatous species) of each tree and shrub species
- The percent cover of litter, erosion control products and bare ground

Live Plant/Litter Cover: In each frame, the following information shall be recorded:

- The plant layers that are present
- The amount of live aerial cover provided by the various layers
- The amount of cover at ground level provided by lichens, mosses, and litter (defined as dead plant material that is produced naturally on a site, expressed as a percent of the total area)
- The percent erosion control products and bare ground in the frame

6.4.4 Sustainable Plant Community (Health)

Vegetation health assessment includes: vigour, colour, disease, vegetation quality and reproductive performance. A visual assessment or diagnosis involves a comparison of the vegetation on the wellsite to the off-site or control vegetation. If deficiency symptoms or evidence of disease are present in the vegetation on site but not in the control areas, the site will fail.

Some diseases may have an appearance similar to deficiency symptoms. Deficiencies are manifested in symptoms of growth response, reproductive effects, chlorosis and necrosis. Chlorosis is a loss of chlorophyll or a "yellowing" in colour. Necrosis refers to dead plant tissue or lesions in the plant.

Growth response often shows up in stunting or reduced root and shoot growth. Where perennial plants are established, there must be evidence of successful reproduction (e.g., seeds, rhizomes) and healthy root systems. Symptoms related to reproduction stresses include suppressed, delayed or absence of flowering, and reduced viable seed production.

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APPENDIX 1:

Definitions

1995 Criteria: The criteria developed by stakeholders called *Reclamation Criteria for Wellsites and Associated Facilities – 1995 Update*.

Access Roads or Pads Left in Place: Access roads or pads that will be left in place must support current or proposed future land uses. Such roads or pads must be stable, non-hazardous and non-erosive. Revegetation is not required for such roads, but weeds must be controlled. Pads left in place must be decompacted and revegetated, unless otherwise authorized.

Alberta Environment: **(AENV)**: The department responsible for developing environmental programs, policies, criteria and standards for all of Alberta under the *Environmental Protection and Enhancement Act*. AENV inspectors and investigators have a mandate to oversee and enforce industry operations on private and public lands in Alberta.

Alberta Sustainable Resource Development (ASRD): The department responsible for land management on public land for those activities governed by the *Public Lands Act* and including the delegated inspection and enforcement of all industry operations governed by the *Environmental Protection and Enhancement Act.*

Anomaly: On-site characteristics that do not appear to reflect those found off-site. If an anomaly is encountered, a step-out assessment procedure may be used to verify the initial assessment.

Assessment Grid: A portion of a lease (area typically 18 m by 18 m, to 22 m by 22 m) resulting from the overlay of a grid pattern on the lease. An assessment grid provides a method of distributing collection locations for soils and vegetation data. Collection locations are normally placed near grid centre.

Assessment Volume: A common soil volume for comparing soil organic carbon between control and on-site. That volume will include a) the depth (cm) from the soil surface to the topsoil/subsurface interface of the control, and b) a common core diameter.

Bare Areas: Areas where vegetation has not been established, not including areas between drill-seeded rows.

Bulk Density: Dry bulk density (D_b) is to be calculated as the ratio of the mass of the dried soil (M_s) to the total soil sample volume (V_t), or $D_b = M_s / V_t$

Canadian System of Soil Classification (CSSC): The recognized scientific system of soil classification in Canada published as *The Canadian System of Soil Classification, 3rd ed.* Soil Classification Working Group. 1998. Agriculture and Agri-Food Canada Publication 1646. 187 pp.

Control: An off-site assessment point where the collected information is considered representative of the lease or access road, and will be used to compare with the site values.

Cultivated Land: Lands that have a well-defined Ap horizon, and have been ploughed continuously. This includes cultivated peat lands, haylands, and forested lands that have been converted to continuous cropping or hayland systems. Cultivated Land does not apply to range improvement areas in grazing dispositions or reserves, which are assessed under Grassland criteria and timeframes.

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CRI: Conservation and Reclamation Inspector (AENV or ASRD).

Desired Plant Community: A self-sustaining plant community that meets or is on a successional trajectory that will meet agreed upon end land use goals and management objectives.

Detailed Site Assessment (DSA) Report: A report that must be attached to a Wellsite Reclamation Certificate Application form that provides all data collected onsite. The report must justify why a site should be certified if all criteria have not been met. The report must also detail the information exchange that has occurred with the landowner. The report must be signed an authorized employee of the operator.

Forested Land: Treed (or bush) lands that are allowed to revert to forest or are planted to forest species. These areas are either designated for multiple uses (e.g., wildlife habitat, recreation) or for timber production. They may include a mixture of private and public land. Land that has been converted to continuous cropping or hayland should be assessed as Cultivated Land. Land that has been converted to rangeland should be assessed as Grassland.

Grassland: Lands that are permanently grassed including, but not limited to, range improvement areas, grazing dispositions on public lands, native prairie and grassland areas, Special Areas Board land, and Eastern Irrigation District land. Grasslands that have a well-defined Ap horizon, and have a reasonable likelihood of cultivation, must use assessed as Cultivated Land.

Hard Dough Stage: In reference to the development of a plant's seed, the hard dough stage follows the soft dough stage (initial stage of seed development).

Industry Assessment: A detailed site assessment undertaken by an operator (or their consultant) where data for a certificate application is collected.

Landowner: Landowner or occupant, or land manager on public lands (ASRD).

Lease: Wellsite, excluding access road.

Litter cover: The area of ground covered by all dead plant material expressed as a percentage of total area.

Mineral Soil Contact: The point of transition from an overlying layer of organic material (e.g., Om for peat soils) to the underlying mineral (i.e. clay, silt and sand) material.

Natural Recovery: The goal of the natural recovery is the re-establishment of a native plant community through use of the native seedbed found either in the salvaged topsoil or from seed sources adjacent to the site.

Particle Size Analysis (PSA): The sand, silt, and clay size percentages of a known soil mass, determined by an established hydrometer method.

Peat Land: Peat Land may or may not be treed. The assessment protocol and criteria apply only to those peat soils that have not been cultivated. All cultivated peat soils are dealt with under the Cultivated Land criteria.

Plant Cover: the proportion of ground within a two dimensional area that is covered by living plant material (including stems and leaves).

Plant density: Number plants per unit area.

Potential assessment tool: An analytical method that can provide important information on the condition of a reclaimed lease. Results of analysis are to be included in DSA as supporting evidence of alternate findings. Criteria values have not been established for this assessment tool.

Pre-Construction Site Assessment (PCSA): An inventory and analysis of baseline landscape, soils, and vegetation data. Unique land characteristics (e.g., eroded knolls, saline seeps, previous disturbance) are also included. The PCSA data provides site-specific standards against which reclamation activities are judged.

Process Restrictions: Soil physical characteristics that have changed as a result of human activity on the land, and which may restrict air and water movement and therefore normal root development.

Root Pedestals: The exposed plant roots and/or stalks as a result of wind and water erosion.

Site: Lease and the access road.

Soil Profile Assessment: An evaluation of the characteristics of the replaced soil and underlying subsoil. The purpose of the assessment is to ensure that there are no restrictions to rooting, or to water or air movement. The soil is assessed to a maximum depth of 60 cm.

Step-Out Assessment: An optional assessment procedure for an operator to conduct to determine if an apparent anomaly is representative of the grid as a whole. A step-out consists of assessing an additional three locations, at a distance of 3 m from the anomaly, in a triangular shape around it. The average value for the three step-outs and the original location are reported for all parameters assessed (e.g. soil replacement depth, vegetation vigour).

Subsoil: The soil layers underlying the topsoil, according to land use.

Surface Soil in Forested Lands: The layer of plant litter and organic matter accumulation in mineral soils layers (e.g. LFH, Ah and Ahe horizons) (CSSC, 1998) that will be salvaged and replaced to serve as a plant growth medium on a reclaimed site. Ae and possibly upper 10 cm of B horizons (e.g. Bt - Luvisols) might also be included in the salvage. Bn and Bnt horizons are not to be salvaged as surface soil.

Surface Soil in Peat Lands: The accumulated plant material (Of, Oh, Om horizons) (CSSC, 1998) that has developed under water-saturated conditions, and that will be salvaged and replaced to serve as a plant growth medium on a reclaimed site. Thin peat soils may include a minor portion of the underlying mineral horizon (C) in the salvage.

Topsoil in Cultivated Lands and Grasslands: The layer of organic-enriched mineral A horizon soil material (Ap, Ah and Ahe) (CSSC, 1998) that will be salvaged and replaced to serve as a plant growth medium on a reclaimed site. The upper portion of transitional A, and/or B horizons (e.g. AB, Bm - Chernozems) might also be included in the salvage. Salvaged Bn and Bnt horizons are not to be replaced as topsoil.

Two-Lift Stripping: The selective salvage of all surface soil or topsoil as the first lift of good quality upper subsoil as the second lift. The lifts must be replaced in the proper order during reclamation.

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APPENDIX 2

		4, 5		5		
	1	1, 2	1	1, 2	1	
5	1, 2	1, 3	1, 2	1, 3	1, 2	4, 5
	1	1, 2	1, WC	1, 2	1	
4, 5	1, 2	1, 3	1, 2	1, 3	1, 2	5
	1	1, 2	1	1, 2	1	
		5		4, 5		

Figure 1. Assessment locations

1 grid sample
2 Alternate grid sample
3 Quadrant sample
4 4 controls
5 8 controls
WC well centre

This example is common wellsite with 25 grids, each grid with 20m x 20m sides.

Duplicate sampling at any location (other than compositing) is not required. For example: 4, 5 does not indicate two controls per location.

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Alberta ENVIRONMENT

APPENDIX 3

Weed Survey

Survey Date: _____ **Observer:** _____

Legal Land Description: _____ _____ _____ _____ _____
¼ Sec Sec Twp Rge Mer

Comments/Description: _____

GPS Latitude: _____ **Longitude:** _____

A. Land Use Type: Circle the appropriate category or fill in other.

Road, trail, wellsite, pipeline, seismic line, utility line, timber processing site, cutblock, camp, mine, sand or gravel pit, crown land (grazing reserve, facility, natural), private land (grazing land, cropland, natural)

Other Land Use Type: _____

B. Weed Species (or Description):
1. _____
2. _____
3. _____

C. Degree of Infestation and Approximate Infested Area: Record the approximate infested area in hectares or, if linear, meters, according to the level of infestation.

	Species 1	Species 2	Species 3
Trace (Rare) = < 1% cover	_____ ha	_____ ha	_____ ha
Low (Occasional plants) = ≥ 1% and < 5% cover	_____ ha	_____ ha	_____ ha
Moderate (Scattered plants) = ≥ 5% and < 25% cover	_____ ha	_____ ha	_____ ha
High (Fairly dense) = ≥ 25% cover	_____ ha	_____ ha	_____ ha
Linear (i.e. Trail, Seismic line)	_____ m	_____ m	_____ m

D. **Growth Stage:** From the list below, record the letter(s) representing the appropriate growth stage.

Species 1 _____ **Species 2** _____ **Species 3** _____

S = Seedling B = Bolt Bd = Bud Fl = Flower SS = Seed Set M = Mature

E. Control Action Taken: _____

_____

_____

F. Signature:

Company Representative: _____

Public Land Officer/Land Owner: _____

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