Ecological Recovery Monitoring Program for Certified Reclaimed Sites in Alberta:

Monitoring Protocols for Grassland Wellsites

By

InnoTech Alberta

ERMP Project Advisory Group

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Ecological Recovery Monitoring Program Development Project

The Alberta Biodiversity Monitoring Institute contracted InnoTech Alberta in 2017 to develop the direction, framework and implementation plan for the Ecological Recovery Monitoring Program. The Project has been divided into a series of Tasks:

Task 1: Describe the Goals and Objectives for a Long-Term Monitoring Program in Alberta

Task 2: Develop a Science-Based, Practical Protocol for the Long-Term Monitoring Program

Task 3: Develop an Information Distribution Plan

Task 4: Develop an Implementation Plan for the Long-Term Monitoring Program

Project Team

The Project was led by InnoTech Alberta Reclamation Team staff (Small, C., and Powter, C.) with the advice and guidance from a Project Advisory Group (PAG). The PAG consisted of members from: Alberta Environment and Parks, ABMI, the University of Alberta, InnoTech Alberta, Canadian Forest Service, ATCO Electric, and several technical specialist consultants. PAG members included:

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Documents produced for each Task were developed as drafts by InnoTech Alberta and then discussed with the PAG in a workshop format to develop a consensus position on the key

Program components. The final draft document of each Task informed development of the next Task document.

Report

This is one of three monitoring protocol reports, each with a separate report containing field datasheets, prepared under Task 2. The other reports provide protocols for forested land sites and cultivated land sites.

This report may be cited as:

ERMP Project Advisory Group, 2017. Ecological Recovery Monitoring Program for Certified Reclaimed Sites in Alberta: Monitoring Protocols for Grassland Wellsites. 47 pp.

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1 INTRODUCTION

Alberta has a large industrial footprint, consisting of >400,000 oil and gas wells, >500,000 km of pipelines, hundreds of thousands kilometres of roadways, prairie and mountain coal mines, oil sands mines, oil production sites (in-situ oil sands sites), sand and gravel pits, quarries, plant sites and transmission lines. These disturbed sites, termed *specified land* in the *Conservation and Reclamation Regulation* (Government of Alberta, 1993), must be reclaimed and certified as having an equivalent land capability (*Environmental Protection and Enhancement Act*; EPEA; Government of Alberta, 2000).

Ecological recovery is achieved when the biological, physical and chemical properties (in terms of vegetation, soil and biota) of a reclaimed site return to similar structure and function as found in a representative undisturbed reference area or in the pre-disturbance site. Requirements for certification noted above may or may not fully facilitate return of ecological function at a site. Further complicating matters is the practice of certifying forested land, native prairie, or peatlands/wetlands sites that take decades to reach ecological maturity based on expectations or predictions of future performance (often referred to as being on an accepted trajectory to full recovery). As a result, immediately following reclamation certification, and for some unknown period of time afterwards, most sites will not have fully recovered their ecological function. Previous studies (e.g., Avrimed et al., 2014; Desserud et al., 2010) and site inspections have identified cases where soil and vegetation chemical and physical parameters (e.g., pH, organic carbon, bulk density, species composition, aboveground biomass, crop yield) and presence of invasive and/or undesirable plant species indicate a lack of full ecological recovery on reclaimed certified sites.

1.1 Ecological Recovery Monitoring Program

The Ecological Recovery Monitoring Program is enabled through section 15 of EPEA (Government of Alberta, 1993). The goals of the ERMP (ERMP Project Advisory Group, 2017a) are to:

1. Monitor, evaluate, report to Albertans regarding the science of potential long term impacts of human disturbance on landscape, soil and vegetation; and,
2. Better inform Albertans on the rate, magnitude, direction, and extent of ecological recovery at reclaimed and certified industrial sites in Alberta and to support government evaluation of current reclamation policies and practices.

The objectives of the Ecological Recovery Monitoring Program are to:

1. Provide landowners, the public and Aboriginal communities better understanding of the effectiveness and limitations of land conservation and reclamation practices;
2. Provide regulators with data to support: refinements to land conservation and reclamation requirements; land reclamation certification criteria; and, appropriate liability timeframes for different types of specified lands;

3. Provide data to support analysis of the impacts of changes over time in regulatory requirements and industrial practices on environmental outcomes;
4. Provide data to support development of reclamation trajectories that will better predict future performance and therefore permit certification of sites prior to full ecological recovery;
5. Provide data to assess which monitored parameters are key determinants of ecological recovery for disturbance types in each ecological zone (and therefore provide insights to improve conservation, reclamation and site assessment practices); and,
6. Improve understanding of linkages between monitoring parameters, ecological recovery, natural variability and regulatory requirements.

The Ecological Recovery Monitoring Program consists of four core components, each supporting and interacting with the other in an adaptive management framework:

1. **Monitoring** – an annual field-based program to gather data on the ecological recovery status of reclaimed certified sites in Alberta. Methods to be used and the parameters to be evaluated are identified in Protocols developed for each disturbance type (e.g., wellsites, pits, mines) and each relevant site type (e.g., grassland, cultivated, forested).
2. **Evaluation** – analysis of monitoring data from individual sites and between sites within the same type of specified land, and, where applicable, synthesis of parameters into integrated measures of ecological recovery.
3. **Reporting** – public dissemination of monitoring results in the form of summary reports (by year and/or by type of specified land) that provide information on the state and condition of reclaimed specified land. Results can also be provided as raw data or in various summary data formats.
4. **Research and Development** (R&D) – ongoing development and refinement of the monitoring program protocols and evaluation methodology[1].

1.2 Monitoring Program Design

The sampling design and protocols sample two different areas within a single assessment unit (called the Monitoring Site): the wellsite, and a reference area (i.e., a paired comparison design)[2]. For the purposes of this protocol, the wellsite is restricted to the disturbance footprint of the well pad. The reference area, selected so as not to have a footprint of human disturbance, is the reference against which ecological recovery is assessed.

[1] Additional research using ERMP data may be carried out by external organizations. The Program managers will need to maintain awareness of the findings so they can be incorporated into the Program as necessary.
[2] Definitions for key terms used in this document are provided in Section 10.

The design minimizes the effects of spatial variability of the monitoring site by systematically selecting sampling points – this increases the ability to precisely measure temporal change in selected indicators. The ease of use and the sampling efficiency makes it a better choice than random sampling for this monitoring program.

1.3 Grassland Protocols Report

This report provides the *monitoring protocols for grassland wellsites*. These protocols have been adapted from the Pilot Program report *Ecological Recovery Monitoring of Certified Wellsites: Field Data Collection Protocols for Native Grasslands* (Alberta Biodiversity Monitoring Institute, 2015). A separate report (ERMP Project Advisory Group, 2017b) contains the Field Data Sheets to be used in conjunction with these protocols.

Grassland Sites are permanently vegetated by native herbaceous species[3]. Native grasslands commonly present a mixture of different grass species, forbs, shrubs and trees. Grasslands include range improvement areas, grazing dispositions on public lands, native prairie and grassland areas, Special Areas, and the Eastern Irrigation District.

Tame grasslands (i.e., forage and tame pasture) produce agronomic seeded grass and legume species such as timothy and alfalfa – these are monitored as Cultivated Lands.

Grassland sites are currently subject to the *2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grasslands* (Environment and Sustainable Resource Development, 2013).

Protocols for forested land wellsites and cultivated wellsites, and their associated Field Datasheets, are available. Protocols for other forms of reclaimed and certified land disturbances will be developed through research as the program expands beyond wellsites.

[3] Riparian grasslands may require development of different monitoring protocols.

2 MONITORING SITE SELECTION

The goal of the early stages of Program implementation is to expand on the range of key site characteristics (Appendix 1, Table 3) represented in the monitoring database developed as part of the Pilot Program. As the program progresses monitoring sites can be selected to build in replication of selected key site characteristics to add statistical power to data analysis and to improve representation in the region.

In addition, specific monitoring sites may be worth revisiting periodically (perhaps every 5 or 10 years) to monitor trends in key monitoring parameters – protocols for determining which monitoring sites to revisit will be developed as more data are gathered.

2.1 Site Selection Methodology

The following steps are followed to select a site for monitoring:

1. Obtain list of potential sites from AER and AEP databases for the region(s) to be sampled in a given year.
2. Determine Candidate Site Ratings from Appendix 1, Table 3 and identify the highest rated candidate sites[4].
3. Review available data in AER, AEP and AbaData[5] records to further help screen sites.
4. Identify final list of candidate sites and any lower-priority sites in the area of a candidate site that could be sampled if time permits.
5. Confirm landowner approval to sample and request current status of site (e.g., active grazing)(see section 3.1 for more details).
6. Conduct a reconnaissance trip to the candidate site to make sure the site is suitable for inclusion in the Program. The site may be rejected permanently if clearly not reclaimed or another disturbance is present. Site logistics issues such as access are also assessed at this time.
7. Implement monitoring protocols on remaining sites.

Site selection should focus on sites that have higher ratings. Sites with lower ratings can be added to the Program where they are in proximity (short distance or travel time) to higher-rated sites[6] – this will help expand the range of monitoring sites while maximizing Program efficiency.

[4] Note the factors and ratings in Table 3 are recommended for consideration – they can be varied to suit alternative priorities.
[5] See http://abadata.ca/; note, use of this site requires payment.
[6] These are called opportunistic sites.

2.2 Site Records

The review of records provides information to help classify sites for future analysis and to help explain the monitoring results.

In addition to the information in Appendix 1, Table 4, records that should be captured (where available) include:

1. Reclamation certificate application form.
2. Reclamation certificate assessment data (e.g., Detailed Site Assessment, Phase I).
3. Comments by the Reclamation Inspector and landowner at the inquiry.
4. Spill and remediation records (potentially found on the Environmental Site Assessment Repository – http://aep.alberta.ca/lands-forests/land-industrial/programs-and-services/environmental-site-assessment-repository.aspx).
5. Complaint records (and any work required to address the complaint).
6. Whether or not the wellsite was deemed to be a potential problem site (Energy Resources Conservation Board, 2012) and the resulting adjustment to the site liability value.

These records may be found in databases of the Alberta Energy Regulator and Alberta Environment and Parks – some may be electronic and some may require access to paper archives.

3 PLOT ESTABLISHMENT

Plot establishment is designed to facilitate field sampling by having predetermined information identified, including the route to site centre recorded on an access sheet[7] (note: this may not always be possible depending on what information is available ahead of time and whether a crew has previously scouted the location as is recommended in step 6 above). Crews will have an estimated timeframe for getting to the site and knowledge of potential access hazards.

Several tools are available for developing the predetermined site access route. Oil Trax and Avenza PDF maps were used in the Pilot Program. The latter was the best but it requires that a modeler prepare the maps and import wellsite coordinates into an app-specific map.

Accessing monitoring sites has multiple components:

- Prior to the first site visit map/GIS and data reconnaissance work in the office that gathers as much data as possible about accessing the site and the site history are needed to assist field crews in their first visit to the site.
    - The wellsite centre should be labeled and GPS coordinates from the map/GIS recorded for the wellsite centre and four corners.
    - The need for surveying for ground disturbance needs to be established prior to the first visit to the site. This involves setting up an account on Alberta OneCall (http://www.albertaonecall.com/) and submitting ground disturbance requests a minimum of 3 business days before sampling is going to be conducted. Companies with potential below-ground pipelines etc. should contact you to let you know whether or not there is a conflict and whether marking of lines will be required (if you haven't heard back then you may need to check the site to see if it has been marked).
- Finally before going into the field, additional maps and descriptions are prepared and put together into a site information package that can be used to aid in locating the site, and access materials are compiled to facilitate data collection during future monitoring visits.
- During the first visit to the monitoring site, the most efficient route is found, and potential hazards are described on Datasheet #1 and supplied maps.
    - Ensure that compass declination is set appropriately for the location. Declination for the region is determined by checking on the GPS and recorded on Datasheet #1. The accuracy of the GPS used during site establishment is also recorded on the Datasheet.

[7] All datasheets referred to in this report are available in a separate report (xx, 2017).

- Where site access is complicated, record on Datasheet #1 the GPS locations of turnoffs, corners, significant landmarks, and parking locations. Include detailed direction and distance measures to aid staff in relocating all access points and site centre. This will be most relevant for locations after you have turned off a main road/highway.

3.1 Securing Landowner Permission

Permission from the landowner, public land manager and occupants is required to access and sample land. Landowners may place timing restrictions on access that may result in a decision to discard the site from the list of potential candidates.

3.1.1 *Private Land Access*

Several counties and municipal districts have land ownership maps that will provide a starting point for current contact information. Depending on the time since certification, the certificate application and transmittal letter will also contain landowner information that may be current.

There are some key points to remember when accessing and working on private land:

- No materials can be left on site: no flagging, rebar, or equipment at all will be left at the site, and crews will be diligent to not leave any garbage of any kind on site.
- It is critical to the Program that crews be very respectful of land owners as ambassadors for the program. This includes:
  - Notifying landowners when you will arrive, how long you will stay and when you leave.
  - No quadding on private property at all unless specifically requested by landowners.
  - Take corporate logos off the vehicle (or cover them up) while on private property.
  - If you find gates open, leave them open. If you find gates closed, close them.

3.1.2 *Public Land Grazing Leases*

Get information for access to grazing leases on public lands by going to: https://maps.srd.alberta.ca/RecAccess/?TermsOfUseRequired=true&Viewer=RecAccess. The site provides information on who has the grazing lease so you can contact them for permission to access their site. Note: it is important to tell the occupant that work is being conducted on behalf of the government – the contact is good relations but the occupant can't refuse access for government-sponsored research.

3.2 Plot Layout

Field Equipment Needed:

- Cell phone for communications (be prepared that, depending on location, phones may not always work)
- 2-way radios for communications among partners
- Clipboard
- Site maps and wellsite information package
- GPS and compass
- 9 (1 per 10x10m plot – centre location gets metal marker) – permanent magnetic metal markers per site
- 75 pigtails to mark the 50x50 m quadrants, the 5x5 m and 10x10 m plots, and wellsite centre within the wellsite and reference sites
- 4 – 50 m tapes, 4 – 100 m tapes and 4 – 30 m tapes
- Multiple colors of flagging tape (e.g., blue = 50x50 m, pink = 10x10m, purple = 5x5m)
- Fine tipped coloured marker (to delineate polygons on human disturbance sketch)
- Pencils for recording data on datasheets
- Pin locator – magnetic metal detector
- Plot layout cheat sheet (see Appendix 2)
- Datasheets #1 to 4

3.2.1 *Wellsite*

For level and near-level sites, the following sampling design will be used (Figure 1). On monitoring sites where there is significant across-slope curvature, it is important that all slope elements are represented. Hence the sampling squares should encompass all slope positions within the 1 ha site with one square in each convergent-divergent sequence across the slope and this should be noted on the site disturbance sketch.

Every effort should be made to reduce the impact of the plot layout and sampling work (e.g., trampling, weed movement, damage to property such as fences and gates).

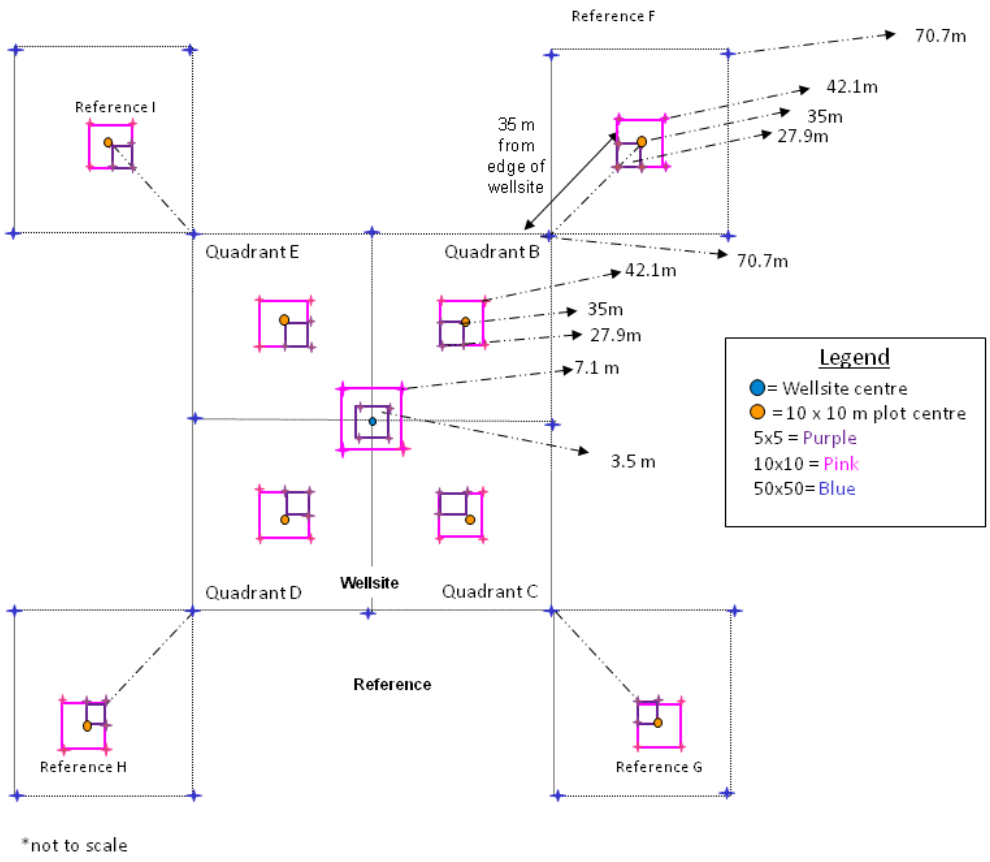

Figure 1. Sampling layout of wellsites and adjacent reference areas with distance measurements for pigtail placement.

Procedures:

- When the field crew arrive onsite, the first step is to identify the wellsite centre, which will be the centre point for the reclamation wellsite 1 ha plot too. It must be located as precisely as possible using a hand-held GPS with an accuracy of < 7 m (GPS coordinates will have been identified from the maps and GIS investigation prior to the site visit). If due to poor satellite coverage accuracy values from the GPS are > 7 m, this is noted on Datasheet #2.

- At wellsite centre place a pigtail in the ground and flag it so that you can readily identify the wellsite centre. Note that you may have troubles identifying the wellsite centre so you may have to measure the diagonals between the four corners and then identify the wellsite centre as the point where the two diagonal lines intersect.
    - A permanent metal marker (or metal magnet) will also be inserted in the sample hole at wellsite centre after the soil sampling is complete so that the location can be readily identified with a metal detector during future visits to the site.
    - Note that these permanent markers will also be used on private land, but approval for them should be obtained from the landowner. Record the GPS coordinates at the wellsite centre on Datasheet #2.
- The crew will need to lay out four sub-ordinal transects that are oriented to the four corners of the wellsite (e.g., if the wellsite is square in cardinal directions, then the bearings of the 4 transects would be northeast 45°, southeast 135°, southwest 225°, northwest 315° – if not cardinal then adapt the directions of the four transects to angles so they intersect the four corners of the wellsite). Each quadrant is assigned a letter code (wellsite = B, C, D, E; reference = F, G, H, I – see Figure 1).
    - Record the bearings for the Wellsite Corners for B, C, D, E quadrants on Datasheet #2 and also record the GPS coordinates for the centre of each 10x10 m plot (i.e., 9 GPS measurements per site including wellsite centre).
- Establish the first transect for the wellsite – it is most efficient to have both crew members establish each transect together and use the plot layout cheat sheet (Appendix 2). Leaving the tape on the ground is useful for the next steps. Carry an extra 100-m tape and 50-m tape and 20 pigtails with you.
  Using a 100-m tape attached to the wellsite centre pigtail, lay out your tape along the bearing of the sub-ordinal transect. You should flag the different plots with different colors of flagging to help identify them (e.g., blue = 50x50 m, pink = 10x10m, purple = 5x5 m). Hint: it is helpful to use 2 people and triangulate with a single tape (e.g., 50 m) to complete the final 2 corners for the 5x5 m and 10x10 m plots. You may prefer to use GPS coordinates to identify and label the 50x50 m plot corners (note that there is a bit of room for error in the locations of the 50x50 m quadrants because during the plant censuses the observer usually will not travel all the way to the edges of the quadrant).
    - When you have laid out 3.5 m of tape insert a pigtail (this will be the pigtail for the corner of the centre 5x5 m plot).
    - When you have laid out 7.1 m of tape insert a pigtail (this will be the pigtail for the corner of the centre 10x10 m plot for soil sampling).
    - Continue laying out the tape measure until you reach 27.9 m from wellsite centre and insert a pigtail (this will be the near corner of your 10x10 m plot).

- Continue out to 35 m from the wellsite centre and insert a pigtail (this is the centre of your 10x10 m plot). Record the GPS coordinates on Datasheet #2.
- Continue to 42.1 m (this will be the far diagonal corner for the 10x10 m plot).
- Insert pigtails for the remaining sides of the 10x10 m plots by measuring 10 m (using the 30-m tape), N or S and E or W (depending on the quadrant of the wellsite you are setting up).
- Add two additional pigtails for the remaining sides of the 5x5 m plots by measuring 5 m, N or S and E or W (again will depend on the quadrant, using the 25-m tape).
- Finally continue measuring the tape out from the far end of the 10x10 m plot (located at 42.1 m from the wellsite centre) to the edge of the wellsite or to a distance of 70.7 m (whichever comes first):
  - if the wellsite corner is less than 70.7 m (this will apply if the wellsite is < 1 ha) record the distance from wellsite centre on Datasheet #2 and insert pigtail, or
  - if the edge of the wellsite is beyond 70.7 m from the plot centre then place the wellsite quadrant corner pigtail at 70.7 metres but still run the tape out to the edge of the wellsite and record the distance to the edge of the wellsite on Datasheet #2. You should also insert a pigtail at the two other corners of the 70.7 metre quadrant to delineate the full 50x50 m quadrant square, which will be used for the plant censuses.

Repeat the procedures described above for the remaining sub-ordinal transects that have not yet been established.

All flagging and pigtails must be removed after each visit, but magnetic metal markers should be inserted along the transect at the plot centre of each 10x10 m plot so the plots can be re-identified in future visits to the site.

3.2.2 *Selecting Adjacent Reference Areas*

The following section describes establishment procedures for adjacent reference areas located 35 m from the four wellsite corners.

If one or more of the reference areas selected by this method are not representative of the recovery target for the wellsite then:

- Try to find another location for the reference area(s) near the wellsite;
- If that fails see Section 3.2.2 below for non-adjacent reference area procedures.

Adjust the location of the reference area if necessary to ensure the location is undisturbed (e.g., not on a pipeline or access road).

To establish adjacent reference area plots, walk to the corner of the wellsite footprint and then roll out the 100-m tape and lay out the line transect at the same bearing as for the same sub-ordinal quadrant transect.

- Insert pigtails at 27.9 m, 35 m, and 42.1 m (these 3 pigtails will mark the two diagonal corners and plot centre for the 10x10 m reference square plot). Record the GPS coordinates on Datasheet #2 at 35 m (plot centre for 10x10 m plot).
- Insert pigtails for the remaining sides of the 10x10 m square plot by measuring 10 m, N or S and E or W (depending on the wellsite or reference site quadrant).
- Add two additional pigtails for the remaining sides of the 5-m square plots by measuring 5 m, N or S and E or W (depending on the quadrant).
- Insert a pigtail at 70.7 m and then add 2 additional pigtails for the remaining sides of the quadrant (which will be used for the plant census).
  *If the wellsite is < 1 ha (i.e., the distance to corner of quadrant is < 70.7 m) then adjust the length of the reference transect to the length of the diagonal distance for the wellsite (i.e., the wellsite and reference areas should have the same area sampled for vascular plant surveys).

3.2.3 *Selecting Non-Adjacent Reference Areas*

When the land adjacent to the wellsite is not suitable as a reference area then there will have to be an alternative strategy to locate reference areas. These will require an expert in the field identifying an area as close as possible to the wellsite that is undisturbed and representative of the natural conditions that were likely to be present on the wellsite prior to disturbance.

A total reference area that is similar in size to the wellsite (1 ha) should be sampled – following modified protocols that adapt the protocols described throughout the document to the shape of the reference condition site. GPS points should be marked for the centres of the 10 x 10 m plots that are sampled in the reference area plots.

4 SITE DESCRIPTION

A variety of information about a site should be captured in the Program records to allow for: improved data analysis and reporting; updating the Program protocols; and, future research. The information is obtained through reviews of existing records and through site observations.

4.1 Site Observations

Sketches and photographs provide a permanent record of the site as of the date the monitoring was conducted. This will be particularly helpful in case a site is selected for later reassessment. Effective sketches and photographs can also be used to visually link monitoring findings to the site which may provide insights into patterns that raw data will not provide.

4.1.1 *Site Sketch*

Draw sketches of the wellsite and each of the reference areas – these can be combined if the reference areas are adjacent to the wellsite but may have to be separate sketches if the reference areas are at some distance. Sketches should represent both historical information culled from records (e.g., well bore and access road locations) and from onsite observations.

Field Equipment Needed:

- Datasheets #3A and #3B

Sketches will include, where available:

- North arrow to orient site
- Wellsite development information (e.g., wellhead, access road and sump location)
- Location of nearby roads
- Presence and/or evidence of standing water
- Arrows to indicate slope direction
- Bare soil areas
- Excessive weed areas
- Erosional and depositional areas
- Sample locations, plots and transects (based on the Plot Layout Protocols in Section 3)

Use the Datasheet provided to complete a map outlining all disturbance evidence present at the site (e.g., wellhead bore location, roads nearby). Write the type of disturbance in the polygons using the codes described under “Human Disturbance” included on the Datasheets. Once mapping is completed, review the diagram to ensure that it reflects the site conditions.

4.1.2 *Site Photographs*

Field Equipment Needed:

- Digital camera with a 35 mm focal length and a quality setting of at least 3 Mega-pixels (take extra batteries and charger)
- Backpack (or some other suitable object) for scale
- Datasheet #4

Procedure:

- Use "landscape" orientation for all photos.
- Take five photographs at each wellsite:
  - Four Transect Photos – Standing at wellsite centre take a photograph at eye level in each of the four sub-ordinal directions so that you are pointing towards the transect associated with each Quadrant (B, C, D, E – begin with 'B' quadrant and move clockwise).
  - Representative Site Photo – From anywhere within the 1 ha wellsite take a single photograph that best represents the physical and vegetation characteristics; provide the location and direction of this photo on the site diagram.
- Take four photographs of the reference areas – one of each 10x10 m plot that best represents the physical and vegetation characteristics. Record which plot you took each photo in.
- In each photo, include a back pack approximately 5 m from the camera for scale.
- Record each photo number on Datasheet #4.
- Check the resolution and quality of all photos at the site; re-take if the photo is blurry.
- Transfer photo files onto a laptop computer once back at camp or in the office and label them as follows:
  - Transect photos are labeled [Region]_[year]_[site]_"W" or "R"_[quadrant].jpg (e.g., DMG _2013_3_W_C.jpg).
  - Representative site photo for the wellsite is labeled with [Representative] at the end of the label name.
- Copy all photos to an external hard drive/flash key for backup.

4.1.3 *Field Notes*

Field notes should be written while on site. Notes should be recorded on rite-in-rain type of paper using a pencil. Write on one side of the paper only.

Documentation of the personnel involved and procedural issues that arose provides additional context for the data and can assist in future revisions to the Program. Examples of the types of notes to be taken include:

- Date and time of day
- Weather
- Mistakes made
- Changes required to the protocols
- Samples lost or damaged
- Comments on site accessibility and changes to route of travel
- Personnel names and associated roles

Scientifically-defensible, replicated data form the basis for the assessment of the status of ecological recovery for each site. However, there is considerable value in subjective field observations as an additional tool to help explain and validate the monitoring results. Of particular interest are obvious differences between the wellsite and the reference areas.

Examples of subjective observations that can be recorded include:

- General impressions of the monitoring site (e.g., easy to spot wellsite or not)
- Evidence of new disturbances (e.g., ATV tracks, etc.)
- Evidence of landowner management practices
- Soil horizon features in reference areas (based on the soil cores in section 6.2), such as cumulative thickness of mineral and organic topsoil horizons (Ah, Ae, Ahe, Ap), upper subsoil features (genetic horizon codes, structure, consistence, properties of mottles), slope positions – information that can be used to understand the soil and landscape context
- Uniformity of vegetation and soils
- Vegetation health and vigour
- Evidence of invasives (non-native forages) and potential location of ingress (i.e., from adjacent disturbances, etc.)
- Sensory information (e.g., specific sights, sounds, smells)
- Evidence of grazing/trampling
- Evidence of wildlife use (e.g., browse, scat, bedding, travel)
- Difficulty/ease of digging soil (e.g., compacted, rocky, wet)

In addition to the observations of the assessor, any comments by landowners, land managers or occupants who may be present at the time of the assessment or that are made during discussions about site access should be recorded.

5 VEGETATION ASSESSMENT

5.1 Shrubs and 2-Dimensional Cover

This protocol is designed to measure shrubs and vascular plant vegetation at the level of vegetation groups (e.g., shrubs, grasses, forbs), except for shrubs which are measured at the species level.

Field Equipment Needed:

- Plant Field Guide (one that is relevant to the area which you are studying)
- Plant press
- Datasheets #5 and #6

Procedure:

- 2-dimensional cover of the ground layer and shrub layer is measured at each 5 x 5 m plot (n = 9 5x5 m plots total, Figure 2 – shaded boxes highlight the 5x5 m plots). Record on Datasheet #5.
- For the shrub layer estimate 2-dimensional cover (0, <1, and 5% increments) of shrubs and small trees (seedlings/saplings)[8].
    - Shrubs are defined as non-tree woody vascular plants that have woody stems.
    - Small trees are defined as trees <1.3 m in height and are included with shrubs in the estimates.
    - Shrub/small tree cover is estimated for three height categories (0 to 0.5, 0.5 to 2 m, and 2 to 5 m high). Note: Each of these estimates cannot be greater than 100%.
    - The estimate for height class 0.5 to 2 m is recorded as if a photo was taken 2 m above the ground and foliage from all shrubs/trees <0.5 m was excluded.
    - The estimate for height class 2 to 5 m is recorded as if a photo was taken 5.0 m above the ground and foliage from all shrubs/trees <2 m was excluded.
- For the ground layer (<0.5 m), estimate 2-dimensional cover (0, <1, and 5% increments) as the percentage of the 5x5 m plot covered by shrubs/trees, grasses (including sedges/rushes), all "other" vascular plants combined (Herbs/forbs), mosses (includes all bryophytes), lichens, fungi, litter (dead vegetation material plus downed woody debris (DWD) <2 cm in diameter), wood (live and dead trees >1.3 m tall, plus DWD >2 cm diameter), water, bare ground, rock, and animal matter. These estimates are recorded as if a photo was taken 0.5 m above the ground. Values of all these independent categories must sum to 100%.

[8] In the Pilot Program % cover of seedlings/saplings was estimated. It may be more appropriate in future to count the seedlings/saplings instead. Future repeat sampling cold then be used to estimate survival rates.

- Record percent cover for each individual shrub/tree species rooted within the plot, including which strata (see Table 1) it is located in. Record on Datasheet #6.
- Percent cover is determined by ocular estimation (this requires practice before the start of the data collection to ensure the estimates are precise).

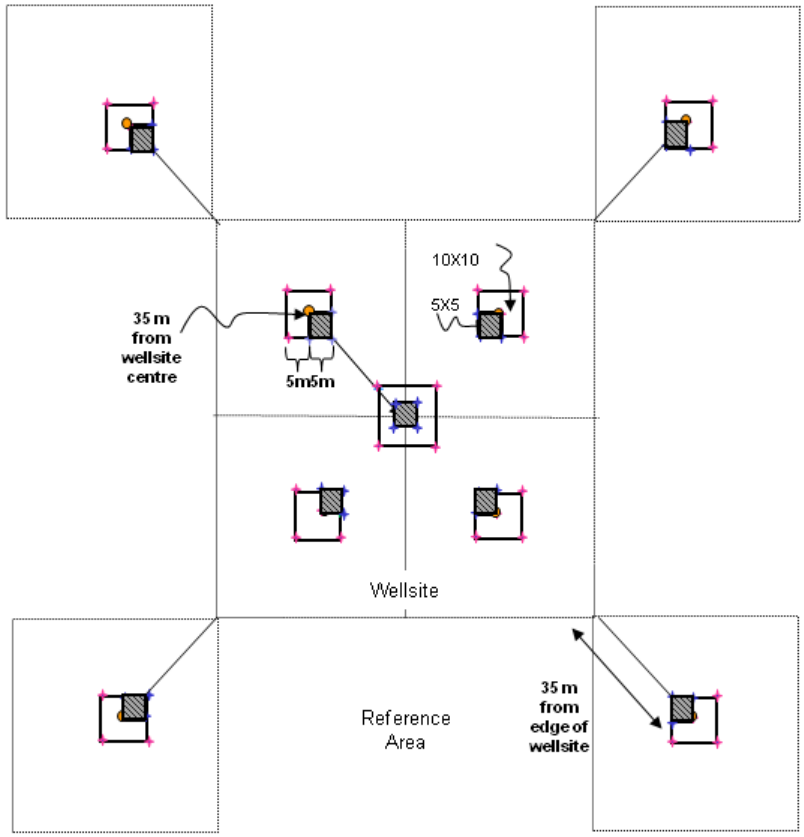

Figure 2. More detailed scale of 5x5 m and 10x10m plot sampling.
Shrub and 2-D cover are measured in the 5x5 m plots (shaded in grey).

5.2 Plant and Lichen Cover by Species (0.25 m^2 plots)

This protocol is designed to monitor relative abundance of vascular, non-vascular, and lichen species by height strata.

Field Equipment Needed:

- Plot frame (0.5 m x 0.5 m)
- Plant press
- Vascular plant field guide (one that is relevant to the area which you are studying)
- Datasheets #7A & #7B

Procedure:

Ten plant and lichen cover quadrats (0.5x0.5 m = 0.25 m^2) are established in the wellsite, and eight plant and lichen cover quadrats are established in the reference area (Figure 3). For both the wellsite and reference area two 0.5x0.5 m cover quadrats are located in each of the 5x5 m plots at the two diagonal corners of the plot that intersect the sub-ordinal transects (see Figure 3).

- Percent cover of individual vascular, non-vascular, and lichen species by strata are recorded within each 0.5x0.5 m quadrat. The strata are described in Table 1. Record on Datasheets #7A and #7B.
    - Use the same order of species list on the reference area at a site as you did for the wellsite – then add additional species not found on the wellsite below this list (this will be helpful when data are being entered so the species data match up).
- Estimate percent cover (0, <1, and 5% increments) by strata (see Table 1) for each species in each of the 0.5x0.5 m quadrats (Figure 3).
- In addition, estimate percent cover for rock, bare mineral soil, litter, and water in the quadrat.
- Plants must be rooted within the quadrat to be included in the estimates.
- Due to overlapping of leaves at different heights, percent cover for each species, and all species combined can be greater than 100%.
- Collect voucher specimens of unknown or uncertain specimens from outside the 5x5 m plot if possible. Take the voucher specimens to camp for identification – be sure to properly label them so you can match them up with your datasheet.
- When collecting voucher specimens, record the reclamation site number and a unique reference code (UIS-Site Number- Specimen Number) and collector's name on the field data sheet and on the sheet in the plant press (e.g., the fifth unidentified specimen from site 1 in the DMG region would be: UIS-DMG-1-05). Ensure that specimen numbers do not repeat those collected during the vascular plant search.
- For specimens that cannot be identified in the evening – place them in a plant press for temporary storage. Ensure that the information (site number, plot (if applicable), reference code, date, collector's name) on the data sheet matches the information included with the specimen in the plant press.
- Any plants that are identified at camp are discarded, the UIS line on the data sheet crossed out, the species code indicated beside the row, and a new row added for that species with all of the appropriate information added to the species record.
- At the end of the season, take the press to the laboratory. These unknown specimens will be identified by experts (see Processing of Specimens and Samples in Section 7.8).

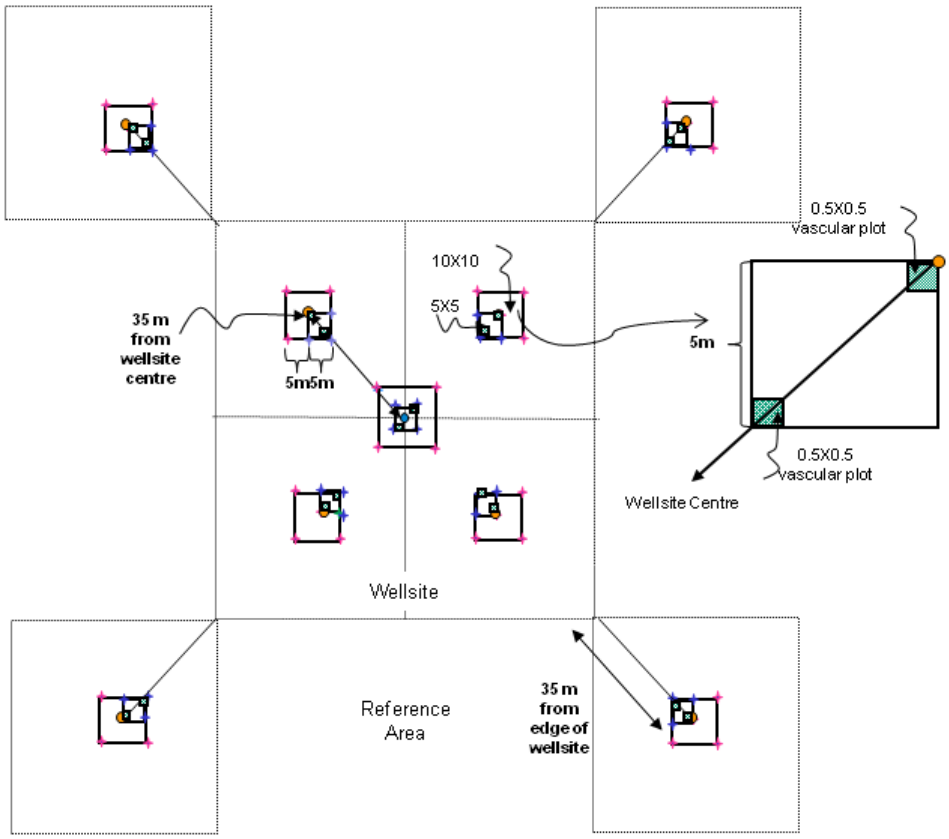

Figure 3. Locations of the 0.5x0.5 m quadrats where vegetation are sampled at the species x height strata level.
Note that the wellsite centre 0.5x0.5 m plots are always in the B and D quadrants.

Table 1. Description of vegetation strata as described in the Ecological Land Site Description Manual (Alberta Sustainable Resource Development, 2003)[9].

Code	Strata	Definition
T1	Tree (main canopy)	Trees that make up the upper part of the height distribution population and form the general layer of the canopy or foliage
T2	Tree (understory)	Trees and/or shrubs whose crowns extend into the bottom of the general level of the canopy or are located below the main canopy. Trees and/or shrubs must exceed 5 m height
S1	Shrub (tall)	All woody plants between 2 – 5 m tall (includes regeneration of taller trees)

[9] The S1 to S3 strata categories could be further subdivided into shrub and seedling/sapling sub-categories if finer detail is desired.

Code	Strata	Definition
S2	Shrub (medium)	Shrubs and regenerating trees between 0.5 – 2 m tall
S3	Shrub (low)	All woody plants up to 0.5 m tall
H	Herbs (forbs)	Record all forb species regardless of height
G	Grass/graminoid	Record graminoids (grasses, sedges, rushes)
M	Moss	Record all bryophytes
L	Lichen	Lichen species growing on dominant substrate (usually mineral or organic soil) included
E	Epiphytes	Lichens or bryophytes growing on other plants, usually trees or shrubs
F	Fungi	Fungi (excluding lichen) growing on dominant substrate – mushrooms

5.3 Vascular Plant Searches

This protocol is designed to detect as many species of vascular plants as possible during a time constrained search within the wellsite area along with the reference site. To standardize sampling effort a single person completes all of the vascular plant surveys at a site, in the time specified. It is recommended that this be done after the 0.5x0.5 m quadrats are measured so that the observer is already familiar with and identified some of the species.

Field Equipment Needed:

- Datasheet #8
- Plant field guide (only for use before or after timed searches)

Procedure:

Wellsite Survey

- The crew member surveying vascular plants spends an initial 10 minutes populating a species list with the names of vascular plants seen at the wellsite. This initial listing of plant names is conducted so that the subsequent timed searches of the 50x50 m quadrants are spent mainly looking for species, with less time recording plant names/codes. During the initial 10 minutes when species are being recorded, locate the most diverse habitat types within the 1 ha site and spend time in these habitats recording species names. Record on Datasheet #8.
- The crew member then spends 20 minutes in each of the four quadrants (B to E; a total of 80 minutes) finding as many species of vascular plants as possible while walking a predetermined path (Figure 4).
- To maintain consistency among observers, start at the 10x10 m plot centre, and then begin heading toward site centre, to within 5 – 10 m. Then head in a clockwise direction around the quadrant staying approximately 5 – 10 m from the quadrant

edge. Stop every 4 or 5 steps to examine the plants in the immediate area (see Figure 4).

- Ensure that all habitat types in the quadrant are searched for vascular plants.

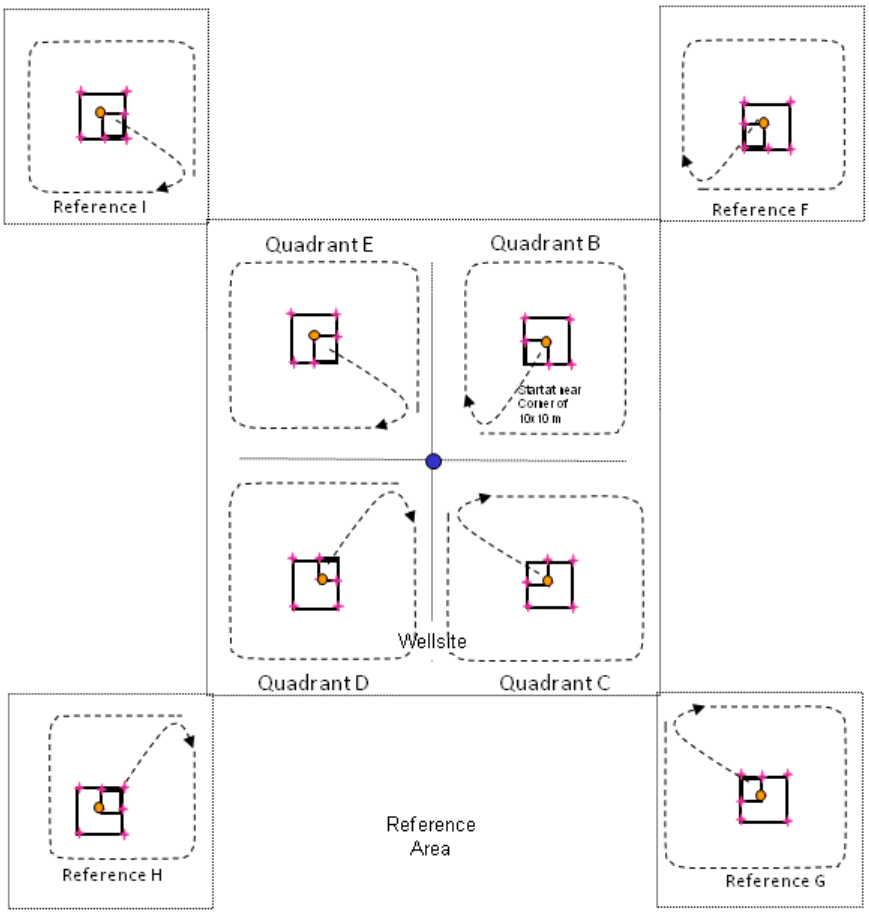

Figure 4. Layout of survey to identify vascular plant richness within the wellsite and reference areas.

- When a vascular plant species is detected in a quadrant, place a tick mark for that species in that quadrant on Datasheet #8.
- Always start the surveys in the NE quadrant (B) and progress clockwise to the next quadrant (SE-C, SW-D and NW-E).

Reference Area Survey

- The crew member surveying vascular plants uses the plant species list developed in the wellsite survey and adds easily identifiable species found in the reference areas.
- The crew member then spends 20 minutes in each of the four 'quadrants' (50x50 m = 2,500 m^2 – dimensions will vary depending on shape of reference area polygon) (F to I; a total of 80 minutes) finding as many species of vascular plants as possible while walking a predetermined path (Figure 4). Record on Datasheet #8.
- To maintain consistency among observers, start at the 10x10 m plot stake, and then begin heading toward the edge of the wellsite, to within 5 to 10 m. Then head in a clockwise direction around the 'quadrant' staying approximately 5 to 10 m from the quadrant edge. Stop every 4 or 5 steps to examine the plants in the immediate area (Figure 4). Ensure that all habitat types in the quadrant are searched for vascular plants.
- When a vascular plant species is detected in a reference 'quadrant', place a tick mark for that species in that quadrant on Datasheet #8.

For Unidentified Species:

- Unknown species can be quickly identified after the initial 10-minute search, but if the crew member is unable to identify the species quickly, they will collect the specimen from a population of greater than 5 individuals, outside the plot if possible. These samples are assigned a unique specimen number and carried with the crew member so as to avoid multiple collections in each quadrant if possible. Unidentified specimens are named UIS-Site Number-Wellsite/Reference-Specimen Number e.g., UIS-3-W-1.
- Field guides should not be used during the 20-minute search time. Collect voucher specimens of unknown or uncertain vascular plant species. After the 20-minute search in a quadrant is complete, attempt to quickly identify the species you have collected using field guides. Place labeled unknown specimens in a plant press and take them to camp for identification during the evening.
- The label on the specimen tag and in the plant press log will be written as UIS-Site Number-Wellsite/Reference-Specimen Number (e.g., the fifth unidentified specimen from site 3 in the wellsites would be: UIS-3-W-5). Ensure that specimen numbers are not repeated for the site. Be diligent when collecting specimens from the low vegetation and shrub cover plots that specimen numbers are not repeated within-site.
- For any vascular plant categorized as S1 or S2 by Alberta Natural Heritage Information Centre (ANHIC), collect a specimen so its identity can be confirmed by experts. Collect the specimen from a population of greater than 5 individuals, outside the plot if possible.

- Specimens that cannot be identified in the evening or for ANHIC S1 or S2 plants, place them in the camp press.
- Any plants that are identified at camp are discarded and the UIS number will be removed and replaced with the correct species code. Do not forget this step.
- Any species found after the vascular plant search is complete are to be recorded under incidental species.
- At the end of the field season (or sooner if the plant press is full), plant presses are delivered to the lab. These unknown specimens will be identified by experts (see Processing of Specimens and Samples in Section 7.8).

6 SOIL ASSESSMENT

This Section describes the field-based protocols for sampling of soil parameters. Soil sampling should be conducted in the 10x10 m plots only after all other sampling has been done at the sites to minimize the effects of the destructive sampling on the other measured indicators. Most of the lab analysis that will then be conducted on the samples is not described in detail in these protocols.

Soil measures include:

- Bulk density – because it has tremendous influence on the soil's capability for water partitioning, air exchange and plant growth.
- Soil organic carbon – because it is an important indicator of a soil's ability to sustain plant growth, rooting, water partition and air exchange.
- Soil electrical conductivity (EC) and pH – two useful indicators of soil quality and its capacity to support plant growth. EC in particular is a good indicator of salinity as well as admixing of the surface soil and sub-soil.
- Total Nitrogen (TN) – as it is used to calculate C:N ratios.

6.1 Sampling

Offset the location of any of the soil sampling sites by approximately 1 m if they coincide with the location of the well bore.

6.1.1 *Number of Samples*

In a systematic grid sampling design, one composite sample per depth made up of 5 cores from each of the 10x10 m plots is sufficient for each indicator analysis with the exception of bulk density (Figures 5 and 6). Compositing samples to reduce analysis cost is suggested for measuring SOC, soil EC and pH.

Bulk mixing of samples should not be conducted in the field. Samples should be stored separately and bulking should be done in the laboratory after bulk density has been measured and the samples have been air-dried and ground to 2 mm.

For soil bulk density measurements, it is suggested on the first initial sampling interval to collect 5 core samples for the two depths (0 to 15 cm and 15 to 30 cm).

6.1.2 *Depth of Sampling*

The sample depth combinations were selected based on the indicator chosen. Two sample depths are recommended: 0 to 15 cm (0" to 6") and 15 to 30 cm (6" to 12"), for soil EC, pH SOC and bulk density. EC and pH will also be monitored at the 30 to 60 cm (12" to 20") and 60 to

100 cm (20” to 40”) depths for the centre sampling point in each of the 10x10 m square (Figure 5).

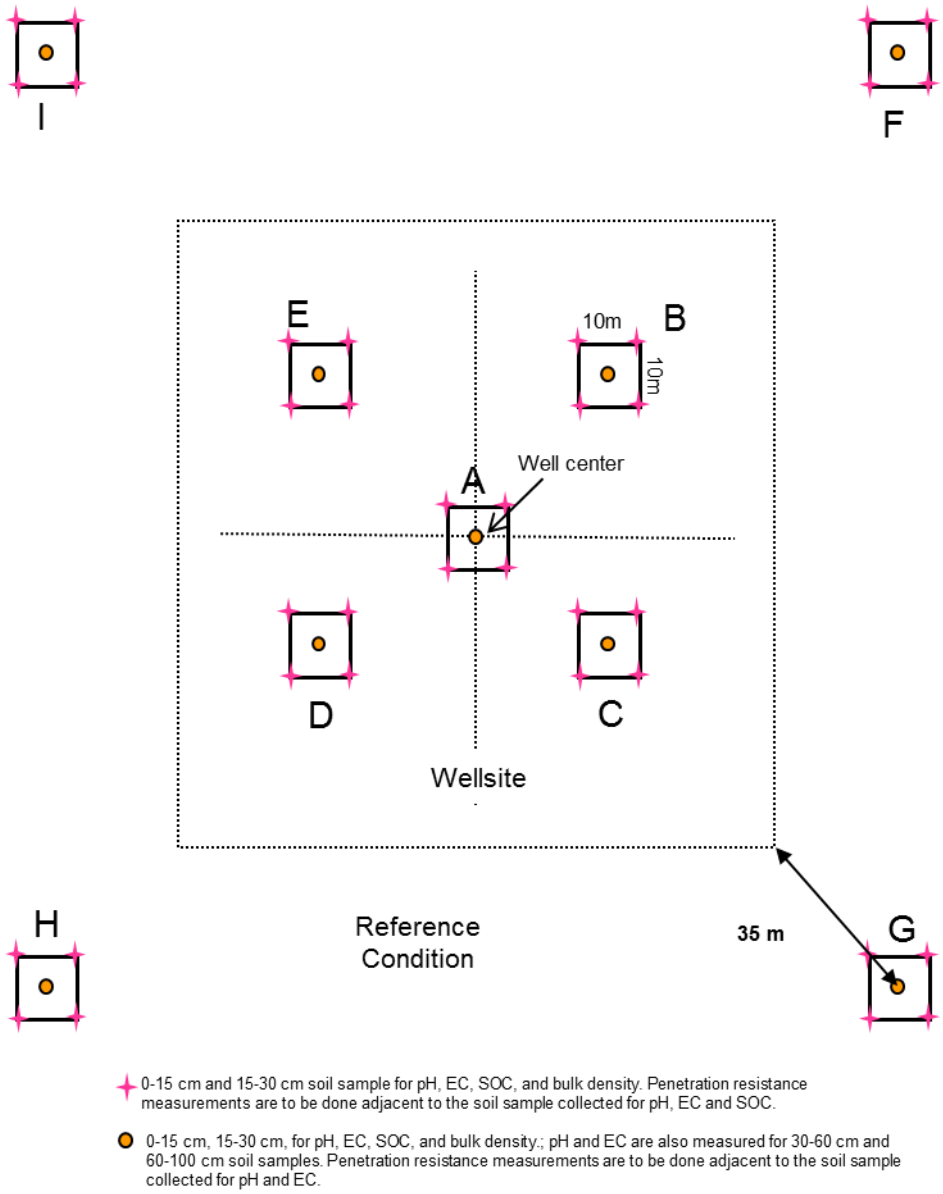

Figure 5. Soil parameters are sampled within the 10x10 m plots identified in the diagram.

6.1.3 *Locations for Repeat Sampling*

It is recommended that the sampling frequency for the soil parameters be 10 years or more depending on the parameter, budget and number of sites. The sampling frequency has not yet been determined and will be determined in a future version of the protocol. There are 10 different sets of sampling locations identified so that soils can be destructively sampled

10 times within each 10x10 m plot (Figure 6). Each sampling point will be located a minimum of 1 m apart from the previous sampling location.

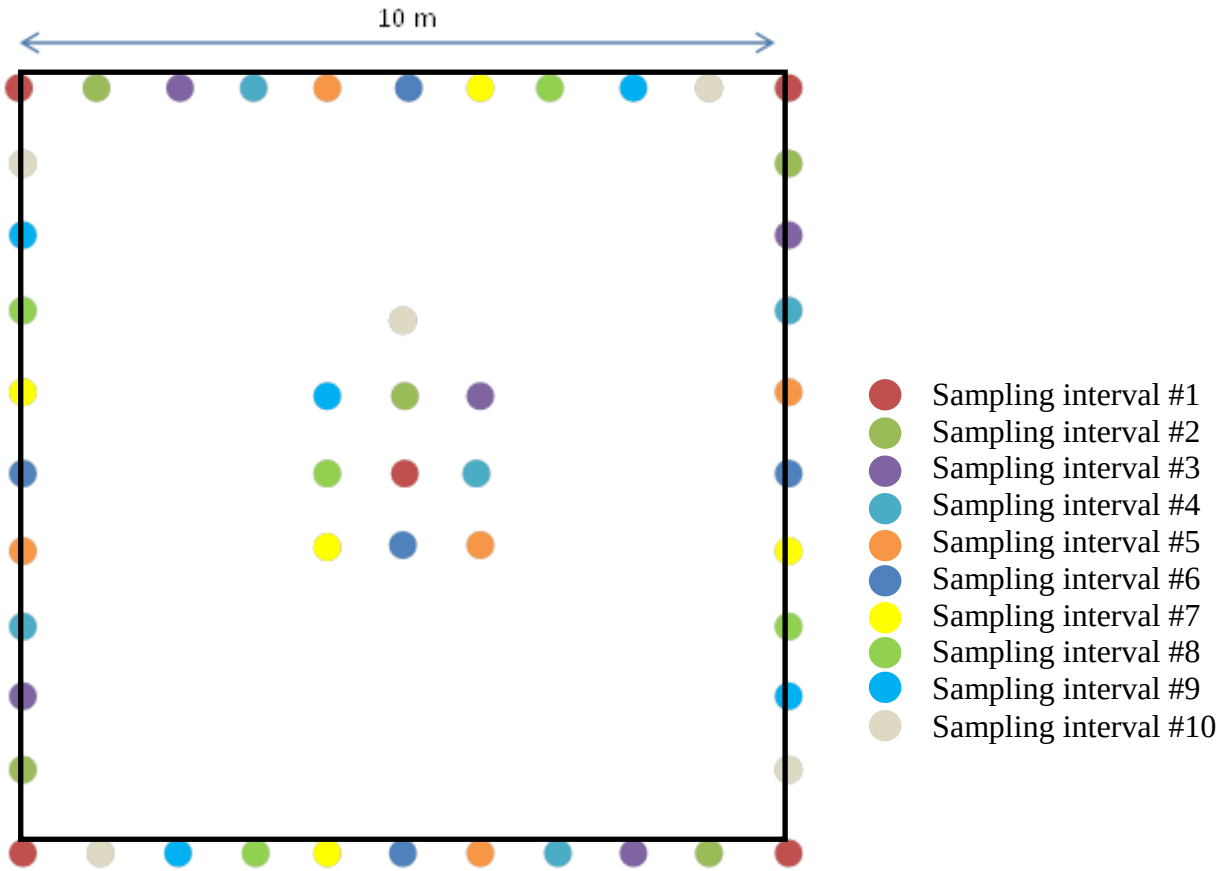

Figure 6. Sampling layout for repeat sampling within each 10x10 m plot on the wellsite and reference sites.
Each colour represents a different sampling interval, for a total of 10 sampling intervals.

6.2 Bulk Density

There are a variety of soil sampling techniques to assess bulk density; the appropriate sampling method depends largely on the distribution of coarse fragments (particles with diameter > 2 mm) at the given site. The most common method is the core method, and should be used when coarse fragments occupy less than 25% by volume (Maynard and Curran, 2006).

6.2.1 *Core Method*

A double-cylinder, drop-hammer sampler with a liner core is designed to collect an undisturbed soil sample (Figure 7). The sampler head contains an inner cylinder with a liner and is driven into the soil with blows from a drop hammer. The liner containing an undisturbed soil core can

then be removed and, where necessary, trimmed to the end with a knife to yield a core whose volume can easily be calculated from its length and diameter. The weight of this soil core is then determined after drying in an oven at 105°C for 24 hours.

Figure 7. AMS Inc. double-cylinder, drop-hammer soil core sampler.

Field Equipment Needed:

- Double-cylinder core sampler. The most common core diameter range from 2” to 3” (5.1 cm to 7.6 cm). Having a second core sampler on hand in case one breaks is recommended
- Two crescent wrenches to tighten the core parts while in the field if they become loose (note that these should be checked regularly – for example, after each sample is collected, as they regularly become loose and this will weaken them and lead to them breaking)
- Clean, dry and uniform stainless steel liners with a known internal diameter and height for volume calculation
- Soil knife or metal spatula
- Polyethylene plastic bags (2 per sample – 7 pound)
- Shipping tag labels (pre-labeled) – insert between the two 7 pound plastic bags
- Pam cooking spray
- Tape measure (to determine core hole depth)
- 2 buckets with lids – it is useful to have a couple of buckets per field crew to help with storage of samples as they are being collected
- Datasheet #9

Lab Equipment Needed:

- Analytical balance
- Drying oven capable of heating up to 105°C

Procedure:

Lab (pre-sampling)

- Label shipping tags with appropriate label (naming convention is currently the following: Region-Site Number – Wellsite(W) or Reference (R) – Quadrant (A-I) – Starting depth of sample (0, 15, 30, 60 – e.g., DMG-5-W-C-30) (this should be done in the laboratory before the samples are obtained).

Field

Avoid sampling in equipment/tire/ridges in the soil

- Select a smooth and relatively undisturbed surface at the appropriate sampling point.
- Remove the live vegetation at the surface of the grassland so that the core is collecting the soil rather than live vegetation (e.g., a quick kick of the vegetation with your boot).
- Drive or press the core sampler into the soil sufficiently to fill the inner liner without inducing compaction. In frictional or dense soils, lubricant (e.g., Pam spray) may be required to prevent compaction of the soil and to facilitate emptying the collected core sample from the sampler. When the corer is at the required depth, gently rock in a circular motion to break the contact of the soil core with the ground.
- Carefully remove the undisturbed soil core and trim the ends flush with the edge of the cylinder if necessary (most often the soil breaks off naturally). Resample adjacent to the original sampling point if large coarse fragments or roots protrude from the sample. Any deviation from the original sampling scheme will be recorded by the field staff.
- Be sure to measure the start and end depths using a tape measure to record the length of the core on Datasheet #8.
- Store the sample in the pre-labelled in polyethylene bags. Tie the bag closed. Store in large durable plastic bag for transport.
- Repeat a second time in the same hole to collect the 15 to 30 cm depth sample.

Lab (post-sampling):

- Place the sample in an oven set to 105°C for 24 h.

- Record the weight of the dry soil.

6.3 Chemistry

Soil organic carbon, TN, EC and pH can be analyzed from the same composite sample. The section below describes the sampling protocol for collecting the core sample in the field as well as the sample handling, processing and compositing/bulking in the lab.

Equipment needed:

- Bucket auger (also known as barrel and core auger) for dry, coarse textured soil and Dutch auger for wet, finer textured soil (Figure 8)
- Pre-labelled heavy duty polyethylene bags (see information for bulk density described above)
- Wire brush
- Soil knife
- Perforated drum grinder with 2 mm perforations
- Tape measure

Figure 8. Soil sampling tools.
Left – Dutch auger and Right – Bucket auger.

Procedure:

Field:

- I Use the bulk density samples for chemistry of soils to 30 cm depth.

- For the deeper samples, drill the auger tip into the bulk density sample hole by turning the handle in a clockwise rotation to the desired depth (30 to 60 cm and 60 to 100 cm). The soil is forced into and retained in the auger.
    - Be prepared to discard cores that are unrepresentative (e.g., excessively compacted during sampling, evidence of rodent activities and obstructed by rocks).
    - Remove any surface materials that have fallen into the hole before starting the collection for the next depth.
- Empty the soil into the labeled bag, avoid any loss of soil.
    - Note that you only need to keep a representative subsample of each depth range – otherwise you will end up with excessive amounts of soil.
- Carefully place the auger in the same hole and repeat the process until the desired depth is reached (use tape measure to measure depth).
- Store the sample in polyethylene bag in a large durable plastic bag for transport.

Laboratory:

- In the laboratory, remove soil from the polyethylene bags and air dry in lined trays at 37.5 °C. Avoid sample losses during processing and contamination by dust, plant material, and other C-rich contaminants.
- Once the samples are air dry, crush and grind the samples to pass a 2 mm sieve and screen out any rocks that are > 2mm in diameter.
- Thoroughly mix the 5 core samples after they have been coarsely ground to < 2mm and then subsample the soil for SOC, TN, EC and pH analysis.

Soil sample handling and storage requirements are provided in Table 2.

Table 2. Soil sample handling and storage requirements for the selected soil parameters.

Parameter	**Sample grinding**	**Moisture**	**Storage before analysis**	**Archival Storage Conditions**
Bulk Density	Avoided	Generally reported on an oven-dried basis	Indefinite if refrigerated, may change upon freezing	Indefinite if refrigerated, may change upon freezing
EC, pH, Organic Carbon and TN	Aggressive grinding acceptable to 2 mm	Generally reported on an oven-dried basis	Short term refrigerated, indefinite if dried	Indefinite if dried

7 MANAGING PERSONNEL, DATA QUALITY AND INTEGRITY

This section provides background information related to the number of individuals needed to collect the data, the training field staff should receive prior to data collection, how datasheets should be completed in the field, including some metadata for the coding of data, ensuring data quality and completeness, procedures for storage and transfer of field-collected samples, and entry of data after it has been collected.

7.1 Safety

A first aid kit, emergency contact information, and the location and route to the nearest hospital facility must be on site at all times. Additional safety gear (e.g., bear spray and bear bangers when working in bear country) should be readily available.

All field crews and laboratory personnel are required to follow the safety procedures stipulated by their employers for the type of work being conducted and to comply with all provincial and national safety laws.

If at any time during the season you feel safety (of yourself or anyone else) is being compromised, tell a field coordinator immediately. Safety ALWAYS comes before the objectives of data collection.

7.2 Personnel and Sampling

These data collection protocols are optimally designed to be implemented by a field crew of two personnel working together or, at times, semi-autonomously. At least one of the field crew members should be familiar with reclamation and reclamation practices and regulations.

7.3 Crew Training Prior to Data Collection

All field staff are to receive proper and appropriate training so they can operate vehicles and equipment safely. In addition, staff are to receive extensive training (in the classroom and field) prior to the beginning of the field data collection. This protocol training includes learning what to do in the variety of field conditions that will be encountered, as well as conducting data collection at test sites. Crew members are first required to become familiar with the protocol documents, datasheets and general field procedures. Then they practice the data collection in the types of grassland where they will be sampling. Questions that arise during the training are discussed with the field supervisors. When possible, this training is provided by experts in the field.

At least one member of the crew should be trained in plant identification (especially for problematic species likely to be encountered such as grasses, mosses and lichens). Where this is not possible crews must be able to collect high-quality specimens for later identification.

Field crews are to review the protocols regularly to ensure that data collection remains accurate throughout the field season and nothing is being missed.

7.4 Preparation Prior to Data Collection

The plastic bags and labels for the soil sample collecting should be completed prior to going out in the field. Paper bags and plant presses should be available for any vegetation specimens to be identified later.

A large waterproof bag that includes the datasheets and the sampling bags for each site should be organized and ready for collection of samples in the field. See additional sampling sections for additional information.

Bring a wagon or sled to help carry equipment and samples.

Bring additional pencils.

A laptop with card reader to download images onto is an asset though this can be done back at camp.

7.5 Completing Datasheets in the Field

Crews are responsible for filling information into the datasheets while conducting field protocols (in the future data may be collected using tablets in place of field datasheets, but for now datasheets (rite in the rain) are used). Data should be reviewed by a supervisor before moving to the next site.

Datasheets must reflect exactly what was found / measured at the site. If options for the data field do not include an appropriate response, crews are instructed to record the most appropriate descriptors and make extensive notes on the data sheets. Technicians do not create new categories or descriptors. All fields on the data sheet must have information recorded – even if it is a "zero", "not applicable", "did not collect" (see below for description of each). If data could not be collected for a specific element, then this must be noted on the data sheet and the crew supervisor advised as soon as possible (note that supervisors must be notified by the end of the day at the latest).

> **None or 0** – None or "0" is applied to any variable that was examined by field crews and found to be absent. "None" is used for text entries and "0" is used for numerical entries. Note: "0" can also be used as a code – for example, wind conditions can be recorded as "0".
>
> **Variable Not Applicable (VNA)** – VNA indicates that the cell cannot have data present.
>
> **Did Not Collect (DNC)** – Use "DNC" to describe variables that should have been collected but were not due to crew oversight, equipment failure, safety concerns, environmental conditions, or time constraints. The use of DNC highlights that the cell ordinarily would have contained data.

7.6 Checking Field Data and Storing Datasheets Daily

Datasheets must be checked every evening for legibility and completeness. If data on a sheet cannot be corrected so they are legible, the data must be transcribed onto a new data sheet and

both copies filed. Wet datasheets are allowed to dry, and then all data sheets are stored in a secured area if possible while in the field (e.g., in a folder in the trailer). Datasheets from one site cannot be taken to the field at another site. Crews must re-collect lost or missing data.

7.7 Transferring Field Datasheets to a Secure Location

Datasheets are transferred in person to the crew supervisor when the supervisor visits, or at the end of a shift. The completeness (i.e., all datasheets present and all data fields filled in) of the datasheets is confirmed during the transfer. Missing fields or datasheets must be re-collected. Field supervisors take the datasheets to a secure office at the end of the shift, or sooner if possible. Data for each site are stored in a separate folder, with the folders organized by site number. Original datasheets are not allowed to leave the secure office.

7.8 Processing of Specimens and Samples

Soil samples are transported by crew members to an accredited laboratory selected by the Program lead.

Vegetation specimens are to be placed in plant presses as soon as possible and transported to the facility selected by the program lead for identification.

In general sample and specimens are stored until the end of the season and then submitted as a group for analysis.

Chain of custody records must be maintained to track samples and specimens from field to laboratory.

7.9 Data Entry and Verification

Data are entered into an electronic database. If data are entered at a different location than they are stored the data sheets are photocopied or scanned and data entry occurs from the copies. Data entry is verified by comparing the electronic information against the information on the original data sheet. Electronic verification routines are performed on the database to ensure that data are consistent with the allowable codes and among sites.

8 GLOSSARY OF TERMS AND ACRONYMS

8.1 Terms

Candidate Site

A site within the universe of available certified sites that has a high rating based on the Appendix 1, Table 4 criteria.

Monitoring Site

An area of land subject to the Ecological Recovery Monitoring Program that includes:

1. Land that has been disturbed while conducting a specified land activity as defined in s. 1(t) of the *Conservation and Reclamation Regulation* (Government of Alberta 1993); and, has been certified by a government agency as being reclaimed pursuant to the requirements of the *Environmental Protection and Enhancement Act* (Government of Alberta 2000) and the *Conservation and Reclamation Regulation* (Government of Alberta 1993); and,
2. The associated Reference Areas.

The area of land subject to the monitoring program may form all or part of the area occupied by the specified land activity and/or certified as reclaimed.

Opportunistic Site

A site that has a lower rating based on Appendix 1, Table 4 but is within a reasonable distance from a candidate site and could be added to the Program with minimal travel cost impacts.

Parameter

A specific characteristic such as plant height or bulk density that is evaluated as part of the Program.

Pilot Program

A four-year research program (2012-2015) to determine the need for, and if required the design of, an integrated, scientifically robust and financially sustainable program for the long-term assessment of ecological recovery of certified reclaimed specified lands. Partners in the Program included Alberta Environment and Parks (AEP) (formerly the Alberta Environmental Monitoring, Evaluation and Reporting Agency [AEMERA]), the Alberta Biodiversity Monitoring Institute (ABMI), and InnoTech Alberta (formerly Alberta Innovates – Technology Futures [AITF]).

Plot

A sampling unit of varying size depending on the parameter of interest. Usually a square (e.g., 10x10m for soils). Plots are located in the wellsite and in the reference areas.

Program

The Ecological Recovery Monitoring Program.

Quadrant

A sampled area that is 50x50m (or may be slightly smaller if the wellsite was smaller than 1 ha) that is sampled on and off the wellsite – there are four quadrants that collectively comprise the well pad and four quadrants that collectively comprise the reference area.

Recovery Target

A description of the environmental conditions – expressed in terms of physical, chemical and biological properties – of a site that represents the desired endpoint of successful reclamation. Properly selected reference areas will match the physical, chemical and biological properties describing the recovery target.

Reference Area (often called a control)

Undisturbed location adjacent to, or nearby, the certified site, from where data are collected for comparison to the certified site data. Each reference area represents the ecological target for the entire certified site, or for a specific portion of the certified site where there is more than one ecological target represented.

Site Characteristics

Parameters that are used to classify the site during data analysis and reporting.

Well Bore

The location on the well pad where the well was drilled (and, if produced, where the wellhead was located).

Well Pad

A subset of the area of land occupied by a wellsite. The well pad is usually a square (approximately 100 m x 100 m) or rectangular area which contains the wellhead and may have contained additional infrastructure for processing the oil or gas.

Wellsite

In regulatory language, a wellsite is an area of land leased for the purposes of drilling a well (defined in s. 1(aaaa) of the *Environmental Protection and Enhancement Act* (Government of Alberta 2000) as: an orifice in the ground that is completed or is being drilled: (i) for the production of oil, oil sands or gas, or (ii) for injection into an underground formation). The wellsite includes the well pad, and may include additional infrastructure such as an access road, a construction material borrow, or an off-site drilling waste sump.

However, for the purposes of the Ecological Recovery Monitoring Program, the term wellsite means the well pad.

Wellsite Centre

The middle of the well pad. This may or may not be the same as the well bore location.

8.2 Acronyms

ABMI	Alberta Biodiversity Monitoring Institute
AEMERA	Alberta Environmental Monitoring, Reporting and Evaluation Agency
AEP	Alberta Environment and Parks
AITF	Alberta Innovates – Technology Futures
CV	Coefficient of Variation
D&A	Drilled and Abandoned
DNC	Did Not Collect
EC	Electrical Conductivity
SOC	Soil Organic Carbon
TN	Total Nitrogen
UIS	Unidentified Species
VNA	Variable Not Applicable

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APPENDIX 1: Site Selection Criteria

Determine the Candidate Site Rating by:

1. Selecting the appropriate rating for each of the Factors in Table 3 (note: these are recommended factors and ratings – they can be varied to suit alternative priorities)
2. Subtracting
   a. 1 from the Factor rating if the monitoring database already has some representation of the sub-category component, or
   b. 2 from the Factor rating if the monitoring database already contains enough representation of the sub-category component
      Note: lowest possible rating value is 0
      Note: Doesn't apply to Soil type Factor
3. Summing the Factor ratings to get the Candidate Site Rating (Maximum score is 70).

Table 3. Key characteristics to be considered in stratified site selection.

Factor	**Rating**			**Comments**
	1	**3**	**5**	
Time since spud date		Spud date before 1983	Spud date is 1983 or later	Spud date will often determine level of soil salvage
Time since abandonment date		Abandoned before 1995	Abandoned after 1995	Reclamation criteria were in effect in 1995 so sites abandoned afterwards are more likely to be reclaimed according to recent expectations
Time since certification		Less than 10 years	Greater than 10 years	Focus on sites that have had adequate time to settle and begin the long-term healing process; however there are also benefits to collecting early-stage recovery sites (i.e., <10 years)

Factor	Rating			Comments
	1	**3**	**5**	
Time From Abandonment to Certification	<5 years	5 to <10 years	>10 years	Sites that sit for a long period of time may indicate problems existed and/or are subject to deterioration that may impact reclamation success (e.g., soil loss or weed ingress)
Production history	Not produced		Produced	Production increases impacts due to traffic, soil loss and spills
Certification criteria	None	1995 Criteria 2007 Forested Criteria	2010 Criteria (and updates)	Emphasize sites certified under published criteria
Inquiry or Audit		Inquiry held	No inquiry	Sites certified prior to 2003 (1998 on Green Area public land) had inquiries
Soil type	Soil series well-represented	Soil series somewhat represented	Soil series not yet sampled	Want to get wide variety of soil series in the database
Number of Reference Areas	Site very complex – will require three or more sets of reference areas	Site moderately complex – will require two sets of reference areas	Site is apparently uniform – one set of references will be representative	Uniform site simplifies protocols and reporting; representative of most wellsites Moderately complex sites are easiest to address when there is clear demarcation in boundaries and site is split 50:50. Uncertain boundaries and/or different splits increases complexity and could reduce rating to 2 May still be worthwhile making observations about success if a very complex site is close to a sample site

Factor	Rating			Comments
	1	**3**	**5**	
Reference area location	Reference area in different section or different landowner	Suitable reference area within section and same landowner	Reference areas adjacent to site	Travel, access permission and interpretation difficulty increases
Infrastructure	Pipelines or wells within 100 m of the sampling location(s)			Ground disturbance rules require you stay 30 m away from a pipeline on either side and this makes sampling difficult
Adjacent or overlapping disturbances	Complete wellsite cannot be sampled		Complete wellsite can be sampled	Problematic if there will be difficulty in allocating responsibility for the results

Factor	Rating			Comments
	1	**3**	**5**	
Access impediments	Site only accessible by air or in winter	Site accessible year-round – long travel time from road, OR Site accessible year-round but travel route difficult (e.g., dense forest, wet areas) OR Site access in desired sampling window uncertain	Site accessible year-round – short travel time from road	Any site that requires additional access time and/or has uncertain access adds to time and reduces efficiency

Factor	Rating			Comments
	1	**3**	**5**	
Site proximity		Multiple sites of same ages and/or operators and/or production history in close proximity	Multiple sites of different ages and/or operators and/or production history in close proximity	Maximizes travel efficiency while allowing for replication of site characteristics in the database

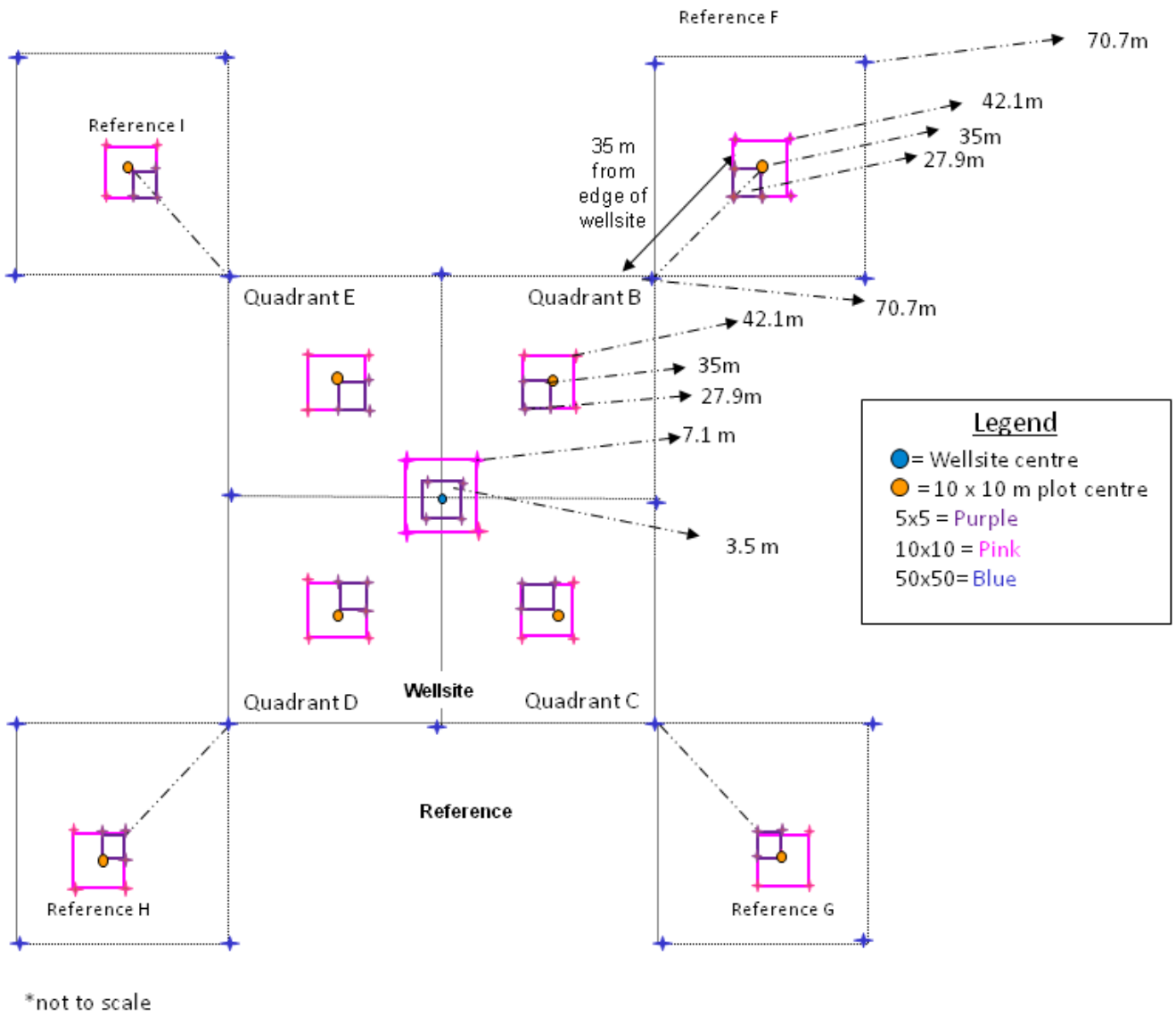
AER (http://mapviewer.aer.ca/Html5/Index.html?viewer=aerabnwells) or AbaData (http://abadata.ca/) are sources for information on spud date, abandonment date and certification date.

APPENDIX 2: Cheat Sheets

These are the PowerPoint slides that also live in a separate PowerPoint file that can be used to help lay out plots. Copies of the slides with visuals can be printed out in color and laminated to be used in the field.

Distances & Colors of Pigtails when Laying out Plots

- Wellsite centre - BLUE
- 7.1 m – PINK (corner of centre 10x10 m plot)
- 27.9 m – PINK & PURPLE (near corner of 10x10 m and 5x5 m quadrant plots)
- 35 m – PURPLE (centre of 10x10 m quadrant plot and far corner of the 5x5 m plot)
- 42.1 m – PINK & ORANGE (far corner of 10x10 m plot).
- 70.7 m – BLUE (far corner of 50x50 m plot)
- Using the 50 m tape:
  1. Triangulate the 5x5 m plot to fill in the other 2 corners of the 5x5 m – PURPLE
  2. Triangulate the 10x10 m plot to fill in the other 2 corners of the 10x10 m – PINK
  3. Triangulate the 50x50 m plot to fill in the other corners of the 50x50 m plot, or alternatively use the GPS to locate them - BLUE


Reference F
70.7m
42.1m
35m
27.9m
Reference I
35 m
from
edge of
wellsite
Quadrant E
Quadrant B
70.7m
42.1m
35m
27.9m
7.1 m
3.5 m
Legend
= Wellsite centre
= 10 x 10 m plot centre
5x5 = Purple
10x10 = Pink
50x50= Blue
Quadrant D
Wellsite
Quadrant C
Reference
Reference H
Reference G

*not to scale