Interim protocol for site verification and mapping of biophysical strategic agricultural land

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More information

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Cover image: Farm land adjacent to the Wagga Wagga Agricultural Institute in June 2011.

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1. Purpose

This protocol outlines the process for seeking verification of whether or not land mapped as biophysical strategic agricultural land (BSAL) meets the BSAL criteria. The *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) Amendment 2013* (the 2013 Mining SEPP amendment)[1] requires certain types of developments to verify whether the proposed site is on biophysical strategic agricultural land (BSAL). The purpose of this protocol is to assist proponents and landholders understand what is required to identify the existence of BSAL and outlines the technical requirements for the on-site identification and mapping of BSAL.

2. Context

Strategic Regional Land Use Plans (SRLUPs) for the Upper Hunter and New England North West regions have been developed to achieve balanced land use outcomes, particularly between mining, coal seam gas and agriculture, and are found at www.planning.nsw.gov.au. The SRLUPs identify strategic agricultural land, which is made up of BSAL and Critical Industry Clusters.

Under the 2013 Mining SEPP amendment, the Gateway process applies to the following State Significant Development located wholly or partially on BSAL:

- State significant mining development that requires a new mining lease,
- extraction of a bulk sample of more than 20,000 tonnes of coal or any mineral ore (ie. State significant mining exploration activity),
- State significant petroleum development that requires a new petroleum production lease,
- State significant petroleum exploration activity,
- excluding any associated development, such as linear infrastructure, outside the area of a proposed mining or production lease.

The Gateway process is an upfront, rigorous and independent assessment of the potential impacts of a project on agricultural land and water resources (including BSAL) before a development application can be lodged.

Maps accompanying the 2013 Mining SEPP amendment show BSAL at a regional scale. Due to the regional scale of the maps, it is important that appropriate processes are in place to provide for verification that particular sites are in fact BSAL. Verification can apply to both mapped and unmapped BSAL areas.

Landowners anywhere in NSW may apply for a BSAL verification if:

- their property is subject of a written notice of an intention to obtain an access arrangement under the *Mining Act 1992* or the *Petroleum (Onshore) Act 1991,* OR
- their property is the subject of a land access arrangement under the *Mining Act 1992* or the *Petroleum (Onshore) Act 1991,* AND
- their land is not subject to a pending development or modification application for mining or petroleum development.

For applicants for State significant mining and coal seam gas proposals located on mapped BSAL, the applicant can elect to either:

- accept that their project area is located on BSAL and proceed directly to the Gateway process, OR
- lodge a site verification application. This application will describe whether the land meets the site verification criteria for BSAL. If the proposal is verified as meeting the criteria then it will be subject to the Gateway process.

[1] At the time of gazettal of this interim protocol, the 2013 Mining SEPP amendment and the related Environmental Planning and Assessment Amendment (Gateway Process for Strategic Agricultural Land) Regulation 2013 (the Regulation amendment) had yet to be made. However, it is intended this SEPP amendment and Regulation amendment be made at the earliest possible time following gazettal of this interim protocol.

For applicants for State significant mining and coal seam gas proposals that are not located on mapped BSAL, the applicant may:

- apply for a site verification certificate to determine if any part of the project area meets the BSAL site criteria and would therefore be subject to the Gateway process, OR
- elect to proceed straight to the Gateway process on the basis that their project area or part of the project area does contain BSAL.

It is important to note that the 'project area' means the proposed development application area, not necessarily the entire property area or the mining lease area. Under clause 17A(2) of the 2013 Mining SEPP amendment, mining or petroleum development, as defined for the purposes of the Gateway process, does not include development on land outside the area of a proposed mining or petroleum lease. Therefore, any components of the proposal, for example linear infrastructure such as roads and pipelines, outside of the proposed lease areas are not subject to either the site verification or Gateway processes. In addition, should the BSAL identified on the project site be part of a larger mass of BSAL which lies outside the project area then the applicant will need to indicate the boundaries of this larger area.

This protocol developed by the New South Wales Government is interim until a technical review is completed in 2013. The information from these reviews will be made available. This protocol does not address verification of Critical Industry Clusters.

The NSW Government acknowledges the use of the guidelines 'Protecting Queensland's strategic cropping land' (DERM 2011) in the preparation of this protocol.

3. Biophysical strategic agricultural land (BSAL)

BSAL is land with a rare combination of natural resources highly suitable for agriculture. These lands intrinsically have the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity and require minimal management practices to maintain this high quality. BSAL is able to be used sustainably for intensive purposes such as cultivation. Such land is inherently fertile and generally lacks significant biophysical constraints.

The regional maps of BSAL meet the following criteria:

- properties with access to a reliable water supply, defined by:
    - rainfall of 350mm or more per annum (9 out of 10 years), OR
    - a regulated river (maps show those within 150m), OR
    - a 5th order or higher unregulated river (maps show those within 150m), OR
    - an unregulated river which flows at least 95 per cent of the time (maps show those within150m), OR
    - highly productive groundwater sources, as declared by the NSW Office of Water. These are characterised by bores having yield rates greater than 5L/s and total dissolved solids of less than 1,500mg/L and exclude miscellaneous alluvial aquifers, also known as small storage aquifers.

AND

- land that falls under soil fertility classes 'high' or 'moderately high' under the Draft Inherent General Fertility of NSW (OEH), where it is also present with land capability classes I, II or III under the Land and Soil Capability Mapping of NSW (OEH).

OR

- land that falls under soil fertility classes 'moderate' under the Draft Inherent General Fertility of NSW (OEH), where it is also present with land capability classes I or II under the Land and Soil Capability Mapping of NSW (OEH).

4. Submission of applications

Site verification applications are to be made via the online lodgement of an application form, available on the Department of Planning and Infrastructure's website www.planning.nsw.gov.au. The application must fully address the requirements as described in Section 12 and Appendix 1.

5. Initial steps to verify BSAL

The following key steps assist the proponent in verifying BSAL:

Step 1: Identify the project area which will be assessed for BSAL

The assessment area should include the entire project area and include at least a 100 m buffer to take into account minor changes in design, surrounding disturbance and minor expansion. If BSAL is part of a larger contiguous mass of BSAL then the boundary of this area must also be identified.

Step 2: Confirm access to a reliable water supply

BSAL lands must have access to a "reliable water supply".

All of the area in the Upper Hunter and the New England North West SRLUPs has access to a "reliable water supply". This is because there is either rainfall of 350 mm or more per annum in 9 out of 10 years or the land is underlain by a groundwater aquifer with a bore yield rate greater than 5 L/s and total dissolved solids of less than 1,500 mg/L.

Proponents seeking guidance for those project areas outside the Upper Hunter and the New England North West will need to work through Figure 1.

Step 3: Choose the appropriate approach to map the soils information

Access to the project area will define the level of investigation that the proponent can undertake. If the proponent has access to the land then the BSAL verification requirements for on-site soils assessment as described in sections 6 and 9 should be met. If the proponent does not have access then the proponent should develop a model of soils distribution guided by sections 6 and 9.6 based on landscape characteristics using the information listed below. This approach can also be used if the proponent has access but the area is not used for agriculture (for example, heavily forested areas) or the proponent needs to identify the boundary of BSAL outside the project area. Relevant information includes:

- estimate of BSAL criteria for slope, rockiness, and gilgais;
- available soils datasets;
- geology extrapolated to identify parent material;
- local knowledge;
- vegetation;
- aerial photography;
- other remotely-sensed resources (e.g. EM, LIDAR); and
- soils assessment of nearby accessible sites of similar landscape.

Some common sources of this information are described in Appendix 1, section 10.

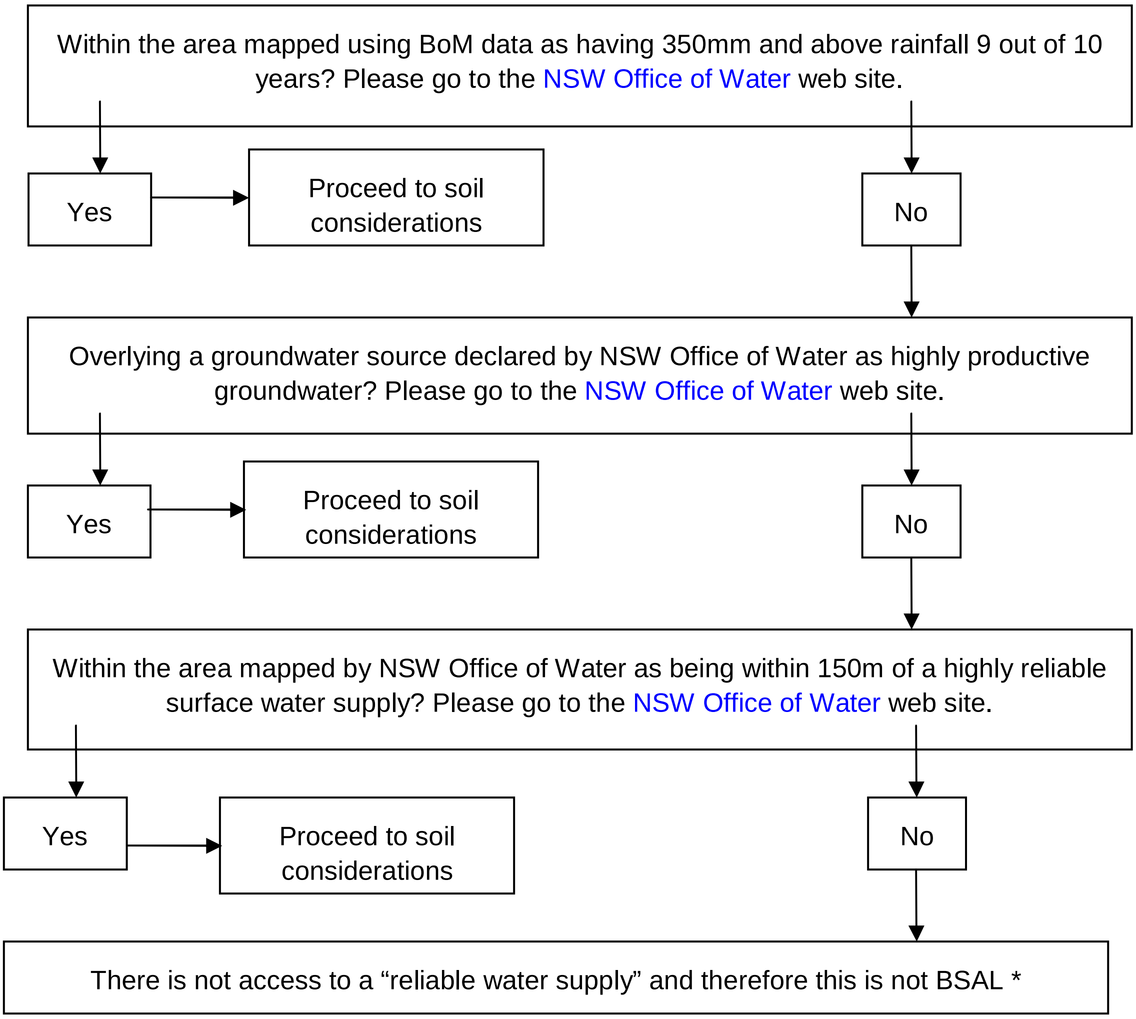
It is important to note that for either approach, if any criteria indicate that the site is not BSAL, then no further assessment is necessary. The flow chart in Figure 2 is designed to assess the simplest criteria first, to avoid more costly assessments if the site can be easily discounted as BSAL.

Step 4: Risk assessment

The proponent should undertake a risk assessment as this will influence the density of soil sampling required as explained in Section 9.6.1. The proposed activity on parts or all of the project area may be of low risk to agriculture and so may only require a sampling density of 1:100 000. Alternatively other areas may be at higher risk of impact and so should have a sampling density of 1:25 000.

Figure 1: Flow chart to verify water reliability

Is the proposed site:



* unless an on-site verification can show access to a reliable water supply by:

- localised groundwater conditions or
- alternate access to a highly reliable surface water supply via an easement.

Any such access needs to be endorsed by the NSW Office of Water (please contact: information@water.nsw.gov.au). If the site is determined to have access to a “reliable water supply”, then proceed to soil considerations.

6. Soils and landscape verification criteria

Ten site verification criteria have been identified, with the easy to measure criteria assessed first. They are:

- slope;
- rock outcrop;
- surface rock fragments;
- gilgai;
- soil fertility (soil type);
- effective rooting depth to a physical barrier;
- soil drainage;
- soil pH;
- salinity; and
- effective rooting depth to a chemical barrier.

Figure 2 describes the order in which the site verification criteria are assessed and the decision making to identify BSAL at each representative site. For soil to be classified as BSAL it must meet all of the criteria outlined in Figure 2. If any criteria are not met, the site is not BSAL and there is no need to continue the assessment.

The minimum area for BSAL is 20 hectares. If the area subject to assessment falls below 20 hectares at any point of the assessment because of exclusion of land that does not meet the criteria, then the land is not BSAL and there is no need to continue the assessment.

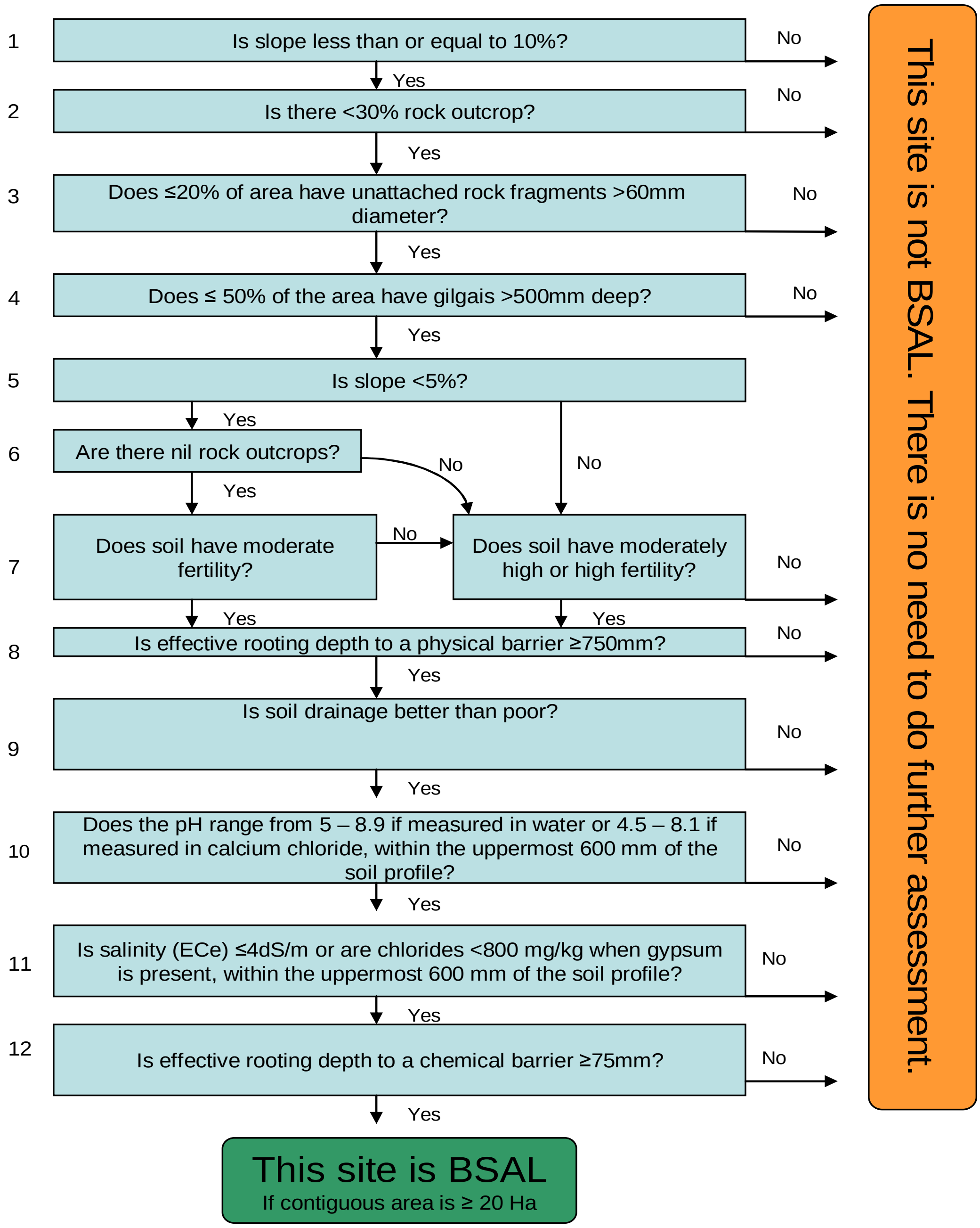
Steps 1-6 in Figure 2 can be measured with relative ease in the field or via remotely sensed data as these are basically landscape criteria that can be ascertained without soil profile information. If these landscape requirements are not met, simple observation sites called exclusion sites are used. However, Steps 7-12 in Figure 2 are determined by soil profile description and will require detailed assessment sites complemented by check sites. These assessment sites are explained in section 9.4.

The ten criteria used to define BSAL at a site are explained from sections 6.1 to 6.10. Further detail and the assessment methods for the soil criteria are described in Appendix 1. Because this protocol is dependent on site specific information at a much finer scale than the regional BSAL maps, the site verification criteria in this section are more detailed and include additional criteria to those used for regional BSAL maps to identify BSAL.

In general a fertile soil is one that has no permanent limitations to plant growth. Hence the criteria selected include attributes well known to limit plant growth across significant areas of NSW. The Australian Soil Classification (Isbell 2002) is used to assess many of the soil attributes.

Figure 2: Flow chart for site assessment of BSAL

Note: that if the criteria is not met at any step the contiguous area may fall below 20 Ha.



6.1. Slope (Steps 1 and 5 in Figure 2)

Slope is the upward or downward incline of the land surface, measured in per cent. BSAL soils must have a slope of less than or equal to 10 per cent.

Slope can be an impediment to farming as erosion potential rapidly increases once slope increases beyond 10 per cent. Increased slope is also an impediment to the safe operation of machinery. It is a useful criterion for clearly identifying lands that are not BSAL.

6.2. Rock outcrop (Steps 2 and 6 in Figure 2)

Rocks hinder cultivation operations (e.g. damage to machinery). BSAL must have less than 30 per cent rock outcrop.

6.3. Surface rockiness (Step 3 in Figure 2)

Rockiness refers to the presence of unattached coarse rock fragments on the soil surface and to rock outcrops at the soils surface. It does not apply to coarse fragments found within the soil profile. Buried coarse fragments are assessed during soil profile description and form part of the criteria for determining effective rooting depth.

BSAL soils must have surface rockiness where no more than 20 per cent of area has unattached rock fragments greater than 60 mm diameter.

Rocks hinder cultivation operations for example through damage to machinery. BSAL is limited to those soils that do not have many rock fragments and where the size of these fragments range from small to large pebbles (NCST 2009). The area may also be slightly rocky. This criterion is a feature that is easy to observe.

6.4. Gilgai (Step 4 in Figure 2)

Gilgai microrelief is a natural soil feature of mounds and depressions commonly associated with cracking clays or Vertosols. Although gilgai microrelief can be ameliorated, gilgais will typically reform if deeper than 500 mm.

If the average depth of gilgai depressions is deeper than 500 mm, and if the depressions occupy more than 50 per cent of a mapped area of gilgai, then the area is not BSAL.

Uneven surfaces interfere with cultivation, drainage and irrigation and may have elevated salinity and sodicity levels. Gilgai is a feature that is simple to identify.

6.5. Soil type (Step 7 in Figure 2)

BSAL must have a particular soil type which has naturally high, moderately high or moderate fertility.

For each soil type, a combination of factors such as inherent fertility, soil permeability, soil structure, tilth and typical soil depth determine soil fertility. The ranking is based on soil classification (Isbell 2002). Note Appendix 2 which describes the relative fertility of the Australian Soil Classification (ASC) classes.

Soils with moderately high or high fertility are capable of sustaining high levels of productivity. Soils with moderate fertility are capable of moderate levels of productivity. The soil type can be initially determined simply in the field using a hand auger. Some laboratory analysis may be required for a comprehensive assessment of the classification.

6.6. Effective rooting depth to physical barrier (Step 8 in Figure 2)

Effective rooting depth refers to the depth of soil over which plant roots can function effectively. It is the depth of soil material from the surface to (i) a physical barrier and/or (ii) a chemical barrier (see 6.10).

Physical barriers include bedrock, weathered rock, hard pans and continuous gravel layers.

BSAL soils must have an effective rooting depth to a physical barrier greater or equal to 750 mm.

Depth to a physical barrier is simple and cost effective to identify.

6.7. Drainage (Step 9 in Figure 2)

Water logging caused by poor drainage is generally associated with low-lying landscape positions, drainage restrictions or impediments which can severely reduce crop productivity. In very poorly drained soils or poorly drained soils, water moves from the soil very slowly. These are defined in NCST (2009:202-203).

Areas that have poor drainage severely reduce crop and pasture productivity and root growth is inhibited due to poor aeration. Drainage is normally tested in the field.

Poorly drained or very poorly drained soils are not BSAL soils.

6.8. Soil pH (Step 10 in Figure 2)

Soil pH refers to the acidity or alkalinity of the soil.

BSAL soils range from acidic to alkaline soil conditions within the range of 5.0 - 8.9 when measured in water or 4.5 – 8.1 when measured in calcium chloride, within the uppermost 600 mm of the soil profile.

pH influences the availability and behaviour of many soil elements which in turn affects the productivity of a range of plants. The above is an acceptable range for most crop and pasture species. pH will need to be measured in the laboratory as this is more accurate.

6.9. Soil Salinity (Step 11 in Figure 2)

Soil salinity refers to the concentration of soluble salts present in a soil. Salinity effects are mostly negligible when ECe<2dSm/m. Yields of very sensitive crops may be affected when ECe ranges from 2 to 4dSm/m (Taylor 1996).

BSAL soils have a level of soil salinity where electrical conductivity in a saturated extract (ECe) is less than or equal to 4 dSm/m or if gypsum is present, chlorides are less than 800mg/kg. This applies to the uppermost 600 mm of the soil profile.

Salinity affects the ability of plants to extract nutrients and water and affects root development. Soil salinity will need to be measured in the laboratory as this is more accurate.

6.10. Effective rooting depth to a chemical barrier (Step 12 in Figure 2)

Effective rooting depth refers to the depth of soil over which plant roots can function effectively. It is the depth of soil material from the surface to (i) a physical barrier and/or (ii) a chemical barrier.

Chemical barriers include pH, electrical conductivity, chloride content, exchangeable sodium percentage and the calcium to magnesium ratio.

BSAL soils must have an effective rooting depth to a chemical barrier greater or equal to 750 mm.

pH and salinity have been addressed in sections 6.8 and 6.9.

6.11. Non-site criteria: minimum area

BSAL soils must have a contiguous area of greater or equal to 20 Ha.

The minimum area refers to the extent of the biophysical resource not the lot or holding size.

This is the minimum area considered necessary to commercially produce a high value agricultural crop.

7. Technical expertise

Assessment of BSAL is a very technical task and should only be authorised by persons with appropriate qualifications. An example of core competencies for soil surveyors is the Certified Professional Soil Scientist (CPSS) accreditation program managed by the Australian Society of Soil Science Inc. See the 2012 Recommended Competencies for Soil Surveyors at www.soilscienceaustralia.com.au

Other persons may assist with associated tasks such as sampling, geographical information system (GIS) mapping, and laboratory testing, however a suitably qualified person must certify the quality and accuracy of the work.

The suitably qualified person conducting the assessment of BSAL is responsible for the report and ensuring all soil data collected is lodged in appropriate format with the NSW Soil and Land Information System (SALIS). This will assist with auditing and refinement of regional BSAL mapping.

8. Soils analysis

Suitable laboratories for performing the analysis of soil samples will comply with the Australian Standard AS ISO/IEC 17025 'General requirements for the competence of testing and calibration laboratories', and have the technical expertise for the specified methods. Laboratories must participate in Australasian Soil and Plant Analysis Council (ASPAC) proficiency trials and maintain certification for the listed soil test methods. The ASPAC website is www.aspac-australasia.com.au. It is also preferred that laboratories are accredited under the National Association of Testing Authorities (NATA). More information can be found at http://www.nata.asn.au/

If tests are undertaken in the field or by non-compliant laboratories this should be clearly stated. Where results are within 15 per cent of threshold values it is important that tests be undertaken with laboratory analysis.

Soil laboratory tests include:

- soil pH (1:5 soil:water or 1:5 soil:CaCl2);
- salinity (EC 1:5 and ECe 1:5); and
- exchangeable cations and cation exchange capacity (for deriving exchangeable sodium percentage (ESP) and the Ca:Mg ratio).

Great care must be taken in selecting the appropriate laboratory, selecting appropriate analytical methods and in reporting the results (see Rayment & Lyons 2011). The validity of the results depends strongly on the quality provided by an accredited laboratory. The laboratory report should be included with the BSAL report.

9. Collecting and presenting soils information

Applicants must define the extent of BSAL. A series of site inspections will describe whether the site verification criteria are met. Sites that are relatively uniform in nature represent one distinct soil type and are shown in a soil map as individual map units. If these maps units meet the verification criteria they are identified as BSAL.

9.1. Mapping

Three maps are to be prepared:

- A geographically accurate base map at 1:25,000 is to be surveyed and prepared showing all existing infrastructure (fences, buildings, pipes, cables and roads), native vegetation, water features and land contours. The boundary of the development area and areas where BSAL status is to be assessed should be shown on the base map.
- A soil map showing all observation sites. Any existing soil mapping units may be shown on the map if ease of map interpretation is not compromised. Depiction of existing map units will only be indicative due to probable differences in scale of mapping.
- A map showing areas of BSAL, including exclusion zones marked according to their BSAL limitation/s. This will be a modification of the soil map.

All maps should be at 1:25,000 scale. The base map data, soil map data and BSAL map data should also be supplied as individual spatial datasets. Each should be free of errors such as no overlapping polygons or gaps, and preferably topologically correct.

Each spatial dataset shall form a separate feature class within an ESRI file geodatabase, or as individual ESRI shapefiles if geodatabases are not supported by the user's GIS. All feature classes and shapefiles should use GDA94 geographic (latitude/longitude) coordinates. Wherever possible, each feature class shall be accompanied by a layer (LYR) file defining the symbology used in the final maps. All spatial data should be accompanied by metadata statements compliant with the ISO 19115 standard. Proponents can use the ANZMet Lite tool which is available for free download from the Office of Spatial Data Management at http://spatial.gov.au. Other maps and imagery may be prepared of the survey area including Light Detection And Ranging (LIDAR), electromagnetic, radiometric, satellite or geophysical imagery. They may highlight minor landscape variations that are associated with soil distribution patterns.

All maps must include north points, unambiguous legends, meaningful colour ramps, scale bars and the sampling grid.

9.2. Identifying the assessment area

As advised in Section 5, the assessment area should include the entire project area including at least a 100 m buffer to take into account minor changes in design, surrounding disturbance and minor expansion. Further expansion is likely to require further survey. If BSAL in the assessment area is part of a larger contiguous mass of BSAL then the boundary of this area must also be identified on the map (see 9.6.3). The boundary should be derived by extrapolation of the assessment area. On-ground assessment is confined to the proposed development application area.

The boundary of the assessment area and areas where the BSAL status is to be assessed should be shown on the base map.

9.3. Site selection and description

A site is a "*small area of land considered representative of the landform, vegetation, land surface and other land features associated with soil observation*." (Speight & McDonald 2009, p.5). For the purpose of BSAL verification sites occur within a 10-20 m radius of the point of observation (e.g. soil profile). Speight & McDonald (2009) recommend a 10 m radius for land surface attributes and a 20 m radius for land element attributes.

There should be a relatively even distribution of observation sites across the entire survey area. Where possible sampling should be based on stratified random sampling (McKenzie et al. 2008) or generalised random tessellation stratified sampling (Stevens and Olsen 1999). Stratified random sampling based on available covariate data sets that are relevant to soil distribution such as landform elements, parent material, land use and vegetation, or remotely sensed data data sets such as radiometrics or electromagnetic survey are encouraged. Demonstration of the random sampling process and rules used to reject and further select alternate sites should be included with the survey report.

The following factors need to be considered when selecting sites:

- Samples should not be taken from areas disturbed by physical infrastructure (contour and diversion banks, dam full supply lines, road verges, table/spoon drains, grassed waterways, built terraces, etc);
- In areas of gilgai microrelief where the depth of the gilgai is less than 500 mm, site descriptions should be taken both from the mounds and from the depressions; and
- In areas cropped using permanent mounds, permanent or semi-permanent beds or other seasonally enduring land management methods, samples should be taken, wherever possible, from the bed or mound where the crop is planted.

Sites should be described 'as found' in the field. For example, areas that have been levelled or stone-picked should be described against the BSAL criteria in their current state. This includes those areas of gilgai that have been levelled for cultivation.

Areas that do not comply with BSAL due to obvious surface features such as slope, gilgai microrelief or surface coarse fragments may be excluded from further survey but appropriate exclusion sites (see section 9.4.1) should be recorded.

The location coordinates for each site should be obtained using a GPS with units specified in Map Grid of Australia units (Easting, Northing, Zone) using the Geocentric Datum of Australia (ie: GDA 94).

It is desirable that a soil and landscape description is provided for the soil map units. Full details about soil profile and landscape description are available in the Australian soil and land survey field handbook (NCST 2009), commonly referred to as the 'yellow book' and for the New South Wales Soil and Land Information System in Milford et al. (2001).

9.4. Sites

There are three types of BSAL assessment sites: exclusion, detailed, and checked sites. The use of these sites depends on the particular soil and landscape attributes of the assessment area and the degree of detail of evidence necessary to support the application.

9.4.1. Exclusion sites

These are observation sites used solely within areas that fail the obvious landscape requirements, that is, slope, rock outcrop, surface rockiness or gilgai microrelief criteria as explained in steps 1 to 6 in Figure 2. Neither soil profile description nor soil survey is necessary.

The following data should be collected at each exclusion site:

- unique identification;
- location (provided as geographical position system (GPS) recorded coordinates);
- required attribute values for slope, rockiness and gilgai microrelief (LIDAR may be used for slope determination - see section 1 in Appendix 1); and
- landscape photograph clearly labelled with the unique site identification, photo direction and the landscape or soil feature being assessed.

Excluded areas should have at least two sites (exclusion sites) per polygon to demonstrate that the polygon does not contain BSAL. If the excluded area is based on slope determined by LIDAR, sites are unnecessary but the relevant methodology must be clearly explained.

9.4.2. Detailed sites

Detailed sites are soil profile inspection sites that are described in sufficient detail to allow all major physical and chemical soil features of relevance to BSAL to be clearly identified as described from steps 1 to 12 in Figure 2.

The location of detailed sites should be representative of the soil type being assessed and have attributes that are typical for that soil. The description of the detailed site should be accompanied by a photograph of the site and of the soil profile (or soil material) being described.

It is desirable that the soil type name from any existing soil survey or soil map is used, providing the observed soil can be correlated to the published soil type.

The following data should be recorded at each detailed site:

Site data

- unique identification;
- location (provided as GPS recorded coordinates);
- nature of exposure;

- current land use and/or land cover;
- current surface condition;
- slope gradient description;
- microrelief;
- rock outcrops;
- photographs of site and profile; and
- soil profile description. The following is a list of essential fields to be completed. If a feature is absent this should be indicated:
    - layer lower depth (mm);
    - layer colour (moist Munsell; if a bleached A2 horizon thought to be present also dry Munsell colour for this horizon);
    - layer boundary distinctiveness;
    - layer mottles;
    - base of observation (mm);
    - layer field texture;
    - layer structure (grade, ped shape, ped size);
    - coarse fragments (amount, type, size) - includes surface fragments;
    - segregations (amount, type, size);
    - field pH;
    - profile drainage;
    - permeability;
    - estimated effective rooting depth; and
    - Australian Soil Classification (to family level).

Laboratory analysis

- soil pH (1:5 soil:water or 1:5 soil: $CaCl_2$;
- salinity (EC 1:5 and ECe 1:5); and
- exchangeable cations and cation exchange capacity (for deriving exchangeable sodium percentage (ESP) and the Ca:Mg ratio).

9.4.3. Check sites

Check sites are examined in sufficient detail to allocate the site to a soil type and soil map unit. Check sites are commonly used to accurately position the boundaries of soil map units, to describe the variability within a soil map unit and to validate soil predictions. Check sites complement detailed sites.

If existing soil mapping is available, check sites could be used to investigate its accuracy and relevance of the existing mapping to the assessment area. If the check sites confirm the existing mapping, then the existing soil map units may be sufficient to support a BSAL assessment. However if the on-ground assessment shows inconsistencies or errors in the available information, then more detailed site descriptions and mapping will be required.

Only attributes that confirm a check site as belonging to a particular soil type need to be recorded along with the unique identification and the location (provided as GPS coordinates).

9.5. Site observation requirements

All site observations must have:

- a unique site identification (UI) which includes the observation type and is attached to all the field data, samples, photos, notes and test results for each site;
- GPS (GDA 94 datum) coordinates accurate to the nearest 5 metres;
- location and UI shown on all maps;
- completed profile description and sample test laboratory results as appropriate (see Section 8); and
- photos taken at the site of the surface soil and of the landscape.

Each **soil type** identified should have at least three detailed sites.

9.6. Preparing the maps

The preparation of a map is essential for identifying BSAL areas. This is done first by separating out the exclusion sites and then mapping and assessing the remaining parts of the assessment area. During the soil mapping fieldwork, site descriptions are obtained and soil types are identified by recognising and grouping sites that are similar. The BSAL status is then determined by assessing the detailed and/or analysed sites within each unit or polygon.

9.6.1. Map scales and site density

All maps should be prepared at a scale of 1:25,000.

Where it can be demonstrated that areas of land less than 10 per cent slope, and likely not to satisfy BSAL land and/or soil type criteria, and will be subject to low agricultural risk impact (DTIRIS, 2012), a sampling density appropriate to a scale between 1:25 000 and 1:100 000 is adequate.

For example, sampling density should be:

1. 1 site per 5 - 25 ha (Gallant et al. 2008) for more intensive developments, e.g., open-cut coal mining; or
2. 1 site per 25 – 400 ha (Gallant et al. 2008) for less intensive developments, where there is a low risk to agriculture.

In determining the risk level, both the proposed activity and where it will likely occur must be taken into account. By using Tables 7, 8 and 9 in Appendix 3, the risk of agricultural impact can be determined. Examples of situations which have a low risk to agriculture include: areas of land that are unlikely to be BSAL over a proposed underground mine; where the duration of the proposed activity will be very short (ie a month) and where it is unlikely to damage the resource. Examples of high risk include a proposed open cut mine on alluvial soils that are very likely to be BSAL.

The minimum areas shown on 1:25 000 and 1:100 000 scale maps is 2.5 ha and 40 ha respectively (Gallant et al. 2008).

9.6.2. Preparing the soil map

A soil map must be prepared for the assessment area not identified as exclusion zones. Prior to field investigation a draft map will be prepared using aerial photograph interpretation (API), geology maps, etc. Exclusion zones based on slope and rock outcrop will be initially identified at this stage. Depending on moisture conditions at the time of imagery acquisition, areas of gilgai may also be identified. Initial map boundaries can be determined by changes in landform elements and/or slope variations within landform elements. Speight (2009) provides landform definitions and any related slope categories.

Ideally the soil map unit will consist of a single taxonomic unit (i.e. ASC to great group level) with minor impurities of one or more other soil taxonomic units.

Any initial mapped units that satisfy exclusion zone criteria should be identified and no further soil investigation undertaken in these areas. Exclusion zone map units should be separated on the basis of the limiting criterion or criteria. Thus an area of land with slopes >10 per cent will be a separate exclusion map unit to one with >50 per cent gilgai. Where combinations of limiting criteria are co-dominant, such as steep and rocky slopes, these areas should be mapped as one exclusion unit. Map tags should reflect the limiting criteria.

Soil types and patterns of the remaining assessment area will be determined following field investigation. Soil landscape combinations can be derived and initial map boundaries can be validated or adjusted. Map unit tags should reflect the soil type and landform information as concisely as possible.

All soil map units will have some soil variation. The dominant soil type upon which BSAL status is determined should comprise great than 70 per cent of a soil map unit. If there is no clearly dominant soil type the soil map unit should be further split until a map unit with more uniform soil occurrence is derived. There may be instances where soil variation must be accepted and the soil map unit should be indicated as such. BSAL status is not necessarily affected by soil variance.

9.6.3. Preparing the BSAL map

All analytic data should be completed and available for incorporation into BSAL assessment. The BSAL map is prepared in three steps:

1. Exclusion zones identified in the soil map remain the same. Map units are not merged, thus indicating the exclusion criteria that are applicable;
2. BSAL status is determined on the dominant soil type within a soil map unit. The dominant soil type must comprise greater than 70 per cent of the soils comprising a soil map unit. For those soil map units that cannot be reduced to one dominant soil type the combination of main soil types comprising greater than 70 per cent of the unit must each be assessed. If any fail to satisfy the BSAL criteria the soil landscape map unit is not BSAL; and
3. Discrete mapped areas truncated by property boundaries may not satisfy the minimum area criteria within the area being assessed but may continue into the adjoining area. The size of the BSAL map unit should be determined using the following approach:
   - where the adjoining area has been mapped and validated in a previous assessment, the BSAL status of that adjoining area must be used when combining with other contiguous BSAL soil map units inside the current assessment area boundary; and
   - if the adjoining area is unmapped (and not validated) an estimated boundary is to be drawn showing the extent that the BSAL soil map unit extends into the adjoining unmapped area. Land within this estimated boundary is to be then added to the BSAL soil map unit for assessing minimum area.

10. Soil profile description requirements

All soil profile descriptions and observations must be recorded and submitted to the State soil data system SALIS (NSW Soil and Land Information System). This is the NSW Government’s repository of soil information.

Soil profile data shall be recorded in the field on SALIS Soil Data Cards (see Appendix 4). Contact the Office of Environment & Heritage (OEH) for supply of these cards. Lab data should be submitted in spreadsheet form using a template available from OEH (contact soils@environment.nsw.gov.au).

Each major soil horizon should be described. Where major horizons are greater than 300 mm thick a data card layer should be recorded at least every 300 mm. Photographs of the site and soil profile are also required.

Detailed soil profile descriptions are taken to at least 750 mm depth. A backhoe or other soil pit is to be used for all detailed sites. For work health and safety reasons, pits should be no more than 1.5 m deep if they are to be entered.

A hand auger and/or spade is suitable for check sites. Depth of observation for check sites is either to the B horizon or 500 mm (whichever comes first).

This ensures adequate information for allocation to both an Australian Soil Classification (ASC) (Isbell 2002) class and to a soil map unit.

The soil at each detailed site must be classified using the ASC to family level. The soil at each check site should be classified using the ASC to suborder level. These may be complemented by a Great Soil Group class (Stace et al. 1968).

For the purposes of an ASC determination Isbell (2002) notes that particle size analysis can be estimated in the field and is therefore not an essential analytic requirement for determining texture contrast properties. All textures are field textures at the family level (Isbell 2002). Isbell also notes that pH can be determined in the field and is not an analytic requirement for classification. Check sites can be classified using field pH. Detailed sites will have laboratory derived pHs (as BSAL criteria) and these results should be used for classification.

Laboratory soil tests will be uploaded to SALIS by OEH.

All soil profile data collected for this purpose will be made publicly accessible through SALIS.

11. Soil sample collection and handling

Soil samples must be collected in accordance with sampling protocols outlined in Ryan and Wilson (2008).

Recommended sampling depths are 0-50 mm, 50-150 mm, 150-300 mm, 300-600 mm and 600-1000 mm. Allowances should be made for horizon boundaries - samples should be collected from within single soil horizons (i.e. they must not cross soil horizon boundaries). Samples should coincide with soil profile layers as described and submitted to SALIS.

Surface soil samples should be bulked. This is achieved by combining at least 12 sub-samples taken at random within a 10 m radius of the soil profile and on the same landform element. A 50 mm diameter push tube can be effective for collecting these sub-samples.

All samples must be identified using the project name, unique profile number and depth range from where the sample was taken.

12. Checklist

Please ensure that:

- a qualified soil scientist is overseeing the verification assessment and has signed off on the quality and extent of the work;
- laboratories for soil samples are compliant with AS ISO/IEC17025;
- results within 15 per cent of threshold levels are analysed in a laboratory;
- all soil profile descriptions and observations are recorded and submitted to SALIS; and
- laboratory data is supplied to OEH using their standard spreadsheet templates.

The report supporting the BSAL site verification application must include:

- reporting requirements for site verification criteria as described in Appendix 1;
- three 1:25000 maps showing: base level information; soil types and BSAL;
- GIS output files, and metadata statements; and
- laboratory report.

13. Terminology

ASPAC	Australasian Soil and Plant Analysis Council
ASRIS	Australian Soil Resource Information System
BSAL	Biophysical Strategic Agricultural Land
DPI	NSW Department of Primary Industries
ECe	Electrical conductivity of a saturated extract
ESP	exchangeable sodium percentage
GIS	Geographic Information System
OEH	Office of Environment and Heritage
GPS	global positioning system
LSC	Land and soil capability
LIDAR	Light Detection and Ranging
NATA	National Association of Testing Authorities
SALIS	Soil and Land Information System
SWS	Soil Water Storage
SRLUP	Strategic Regional Land Use Plan
UI	unique site identification

14. Contacts

Department of Planning & Infrastructure – email: slrup@planning.nsw.gov.au

Office of Environment & Heritage (OEH) – email: soils@environment.nsw.gov.au

Office of Agricultural Sustainability & Food Security – email: landuse.enquiries@dpi.nsw.gov.au (attention OAS&FS)

NSW Office of Water – email: information@water.nsw.gov.au

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Appendix 1. Measuring BSAL criteria

1. Slope

Desktop, remotely sensed and modelled information, such as analysis of a topographic map, aerial photo interpretation or Digital Elevation Model (DEM), may be used prior to field assessment to identify likely areas where land may fail this criterion. For the purposes of BSAL assessment these methods will generally need to be validated by field measurement.

If high quality LIDAR imagery is available slope may be determined without field validation.

More precise measurements of slope can be obtained using a tripod mounted device such as a ‘dumpy level’ and more modern variants such as the ‘automatic level’ (or ‘builder’s auto level’), a ‘digital electronic level’ or a laser level. Other options for accurate slope measurement include GPS real-time kinematics (RTK) or static station methods with a quoted accuracy of up to 0.1 per cent.

Slope should be measured over a distance of 20 m or greater and generally 50 m is a useful distance. Measurement should be directly up-down the slope along the maximum gradient line, straddling the point of soil observation (the site). The area being assessed should not include any significant change in slope.

Artificial features, such as contour banks and tracks, should be ignored in slope measurements.

Reporting Requirements

The device used to measure slope should be reported along with the slope value.

For a hand-held clinometer, slope is to be rounded to the nearest whole number. For other instruments, slope is to be rounded to the nearest 0.1 per cent.

If using LIDAR the methodology must be clearly stated.

2. Rock outcrop and surface rockiness

For the purposes of this criterion, only unattached surface rock fragments with an average maximum dimension larger than 60mm and presence of outcropping bedrock need be recorded as the average density within a 10 m radius surrounding the site. Where there are multiple size ranges of coarse fragments, the total abundance of fragments greater than 60 mm in diameter must be measured.

McDonald *et al.* (2009) contains charts for visually estimating abundance of coarse fragments.

Reporting Requirements

The percentage abundance of surface coarse fragments greater than 60 mm in diameter and rock outcrops are to be reported.

Photographs of the soil surface as required for detailed sites should be provided. These should be taken with as much vertical and scale perspective as possible.

3. Gilgai microrelief

The key attributes of gilgai microrelief in the context of BSAL are the depth (vertical interval) of the gilgai depressions and the areal extent of depressions within a particular area of gilgai. If the average depth of gilgai depressions is deeper than 500 mm, and if the depressions occupy more than 50 per cent of a mapped area of gilgai, then the area is not BSAL.

The depth of the depression is measured in millimetres from the lowest point in the depression to the highest point on the adjacent mound or planar surface.

This can be done in the field in two ways:

- stretching a horizontal tape or rope between adjacent mounds and measuring the height from the tape to the lowest part of the intervening depression; or
- use of a level and staff.

If it can be clearly demonstrated that the gilgai microrelief has depressions that are all shallower than the 500 mm depth threshold, then no further assessment of gilgai microrelief is required and the site satisfies this criterion.

If depressions of approximately 500 mm or deeper are present, their depth and density requires further investigation.

An area can be excluded from BSAL on the basis of representative measurements of gilgai at two exclusion sites. However, some areas with gilgai can exhibit substantial variability in gilgai features. Where depressions are not evenly spaced, additional measurements of the density of depressions should be taken in areas which are to be excluded due to this criterion. In such cases, additional sites may be recorded or the spatial variation across the area to be excluded can be estimated using the methods described below.

To determine if gilgai microrelief is severe enough to cause a site to become an exclusion site, the average depth of gilgai depressions and the density of the depressions need to be determined.

The depth of the ten depressions closest to the site is measured and the average depth calculated.

The density of the gilgai depressions needs to be determined by one of the following methods:

- visual estimation on-ground. This may be done using the charts provided on page 141 of the Australian Soil and Land Survey Field Handbook (NCST 2009). However, if this proves difficult across large areas of land, the technique could be validated by capturing GPS points at the centre of depressions and plotting those on maps/imagery; or
- if available, high resolution imagery (>1:40 000 scale) may be used in conjunction with the visual estimation charts.

Reporting requirements

If the gilgai microrelief attribute is being used to determine if a site is an exclusion site, then the following information needs to be reported:

- the depth measurements for the gilgai depressions (average depth of the ten closest depressions); and
- density of the gilgai depressions.

For other sites with gilgai microrelief, the depth of the gilgai depressions will need to be recorded as part of the detailed site description that adequately characterises the site.

Typical landscape photographs of the gilgai microrelief (including a clearly visible scale rod/tape to show depth of the depressions) will assist in the assessment process where the gilgai depressions are >500 mm deep. Photographs are to be clearly labelled with the site identification.

Only gilgai microrelief are required to be reported; other forms of microrelief may be noted but need not be reported.

4. Australian Soil Classification (ASC) and determination of fertility

Table 6 in Appendix 2[2] is a ranking of inherent soil fertility based on the ASC (Isbell 2002). This table is an adaptation of Table 8.2 in Murphy et al. (2007) and is a correlation of the ASC with the approximate equivalent Great Soil Groups (Stace et al. 1968). Initial broad correlation of ASC orders is based on information in Appendix 5 of Isbell (2002).

The rationale for fertility ranking is explained in Murphy et al. (2007) and summarised in Table 1. The groupings are based on the physical and chemical features of soils in their natural, undegraded condition. Murphy et al. (2007) note that there can be a wide variety of soil fertility within one Great Soil Group. Table 6 attempts to address this issue by correlating to ASC great group level. Consequently some ASC orders have been repeated in rankings - the suborder or great group is the basis for ranking in these cases but there may be no change to the equivalent Great Soil Group as shown in Murphy et al. (2007).

5. Drainage

Landscape and vegetation indicators of waterlogged soils, such as reeds and rushes in low lying landscape positions, may be useful prior to field assessment to identify likely areas where land may fail this criterion. These indicators must be validated by field measurement as described below.

For the determination of BSAL, soil structure can be used to infer internal soil drainage. This includes techniques developed under SOILPak (Anderson et al. 1998) or visual soil assessment (e.g. Shepherd 2009).

Ideally, saturated hydraulic conductivity (Ks) should be measured to determine internal drainage rates (permeability) which will affect soil drainage. McDonald and Isbell (2009) have relevant saturated hydraulic conductivity figures for very slowly permeable (Ks range <5 mm/day) and slowly permeable (Ks range 5-50 mm/day) for soil layers. Less permeable soils will generally contribute to poorer drainage and saturation. The terms 'very poorly drained' and 'poorly drained' are defined in McDonald and Isbell (2009).

Soil colour and the presence of any mottles can also be an indicator of soil drainage conditions. Therefore both the dominant colour and the colour of any mottles need to be recorded. Abundance and contrast of mottles are to be described. Colour patterns due to biological or mechanical mixing or other inclusions are not included in the BSAL assessment.

Colour is to be described using a standard soil colour chart (eg: Munsell Colour Company 2009; Fujihira Industry Company 2001).

Generally the presence of grey and gley colours, and/or the presence of mottles and/or the presence of a bleached horizon are indicators of a very poorly drained/poorly drained soil. These features are identified by colour (see Table 2). Mottles must occupy greater than 10 per cent of the layer and be distinct or prominent (see McDonald and Isbell 2009).

[2] Table 6 is a first approximation and will be subject to review with further use.

Table 1. Summary of fertility rankings (adapted from Murphy et al. 2007).

Fertility ranking	Description
1 Low	Soils which due to their poor physical and/or chemical status only support limited plant growth.
2 Moderately low	Soils that generally can only support plants suited to grazing; large inputs of fertiliser are required to make the soil suitable for arable purposes.
3 Moderate	Soils usually require fertilisers and/or have some physical restrictions for arable use.
4 Moderately high	Soils with a high level of fertility in their virgin state which is significantly reduced after a few years of cultivation.
5 High	Soils that generally only require treatment with chemical fertilisers after several years of cultivation.

Table 2. Colour indicators for very poorly drained/poorly drained layers (adapted from Department of Environment and Resource Management 2011)

Colour	Colour chips from Munsell Color Company (2009) or Fujihira Industry Company (2001)
Gley	a) any colour chip on the gley chart b) any colour chip with a value of 7 or 8 and a chroma of 3 or less on the 2.5Y or 5Y chart
Grey	any colour chip with a value of 4 or more and a chroma of 2 or less on any chart
Bleached	any colour chip with a value of 7 or 8 and a chroma of 4 or less on the 5YR, 7.5YR or 10YR charts

The depth from the soil surface to the top of the very poorly drained/poorly drained horizon (if present) should also be recorded to a maximum soil depth of 750 mm.

5.1. Cracking clay soils (Vertosols)

Determination of drainage characteristics for cracking clay soils (Vertosols) is complex and the colour criteria of Table 2 is not appropriate for these soils. Vertosols are generally considered to be poorly drained but are seldom waterlogged. For BSAL determination any site with Aquic Vertosols does not satisfy the soil type criteria (see Table 6). Further work is being undertaken to better discriminate those Grey Vertosols that are better drained. As an interim guide Grey Vertosols with a Munsell value of 5 or more and a chroma of 2 or less are poorly drained.

Reporting Requirements

If a Vertosol is being assessed this should be noted.

Soil moisture status (McDonald and Isbell 2009) at time of observation should be recorded.

All colours (including those of mottles) must be described and reported in the moist soil state. However, for conspicuously bleached horizons (>80 per cent of the horizon is white or almost white) the dry soil colour must also be reported. The depth from the soil surface to the top of any waterlogged layer should also be recorded.

6. Soil pH

Because field test methods are less accurate than laboratory methods, analysis of pH in accordance with the method in Rayment and Lyons (2011) is necessary to support the application. This pH analysis must be measured in a 1:5 soil:water suspension in accordance with method 4A1 in Rayment and Lyons (2011), and/or a 1:5 soil:$CaCl_2$ suspension in accordance with method 4B1 or 4B2 in Rayment and Lyons (2011).

7. Salinity

Two standard methods of measuring soil salinity are used in the BSAL criteria:

- Electrical conductivity of a 1:5 soil:water suspension (EC1:5), measured in dS/m (Method 3A1, Rayment & Lyons 2011); and
- Concentration of soluble chloride (Cl) in a 1:5 soil:water suspension, measured in mg/kg (Method 5A2, Rayment & Lyons 2011).

Salinity levels are usually determined by the electrical conductivity ($EC_{1:5}$) method. However gypsum and other sparingly soluble salts in solutions can cause problems in salinity measurement so where gypsum is likely to occur salinity should be assessed using the chloride content method. Within eastern and most of central NSW it is unlikely that soils containing significant natural gypsum will be present.

$EC_{1:5}$ can be measured in the field with a probe device. However the accuracy of this method is inferior compared to the laboratory method and it is not to be used for determining BSAL salinity criteria. Chloride content cannot be measured accurately in the field.

$EC_{1:5}$ is converted to electrical conductivity in a saturated extract (ECe) by the use of a conversion factor dependent on the field texture of the soil. ECe approximates soil solution conditions. The approximate conversion factors for a range of soil textures are given in Table 3.

Table 3. Approximate conversion factor from $EC_{1:5}$ to ECe

Based on Slavich and Petterson (1993)

Soil texture	Approximate conversion factor from EC1:5 to ECe
Sand, Loamy Sand, Clayey Sand	22.7
Sandy Loam	13.8
Loam, Silty Loam, Sandy Clay Loam	9.5
Clay Loam, Clay Loam Sandy, Silty Clay Loam, Sandy Clay, Silty Clay Light Clay	8.6
Medium Clay	7.5
Heavy Clay	5.8

In some soils, salinity (and pH) can change rapidly over short distances. A handheld probe device can be used as a guide to determining salinity/pH trends down the profile, based on the recommended sampling depths for 0-300 mm and at 100 mm intervals for recommended sampling depths >300 mm. If it is subsequently discovered that one of the effective rooting depth thresholds for salinity and/or pH is exceeded at any point of the soil profile, this information can assist in more accurately establishing the point of change.

8. Effective rooting depth (physical and chemical)

In the context of BSAL, effective rooting depth to a physical barrier is the depth of soil material from the surface to bedrock, weathered rock, hard pans or continuous gravel layers. These physical barriers may restrict penetration by plant roots and effectively mark the bottom of the soil profile.

Soil depth can be determined by hand augering, soil coring, digging a soil pit or inspecting a cutting or existing exposure. The latter methods often detect physical barriers that may refuse entry by sampling equipment.

It is very difficult to accurately measure soil depth with vehicle mounted screw type augers without a hollow stem as these devices can easily penetrate physical barriers such as hard pans and gravel layers. Therefore, the use of this type of auger should be avoided.

If a depth of 750 mm is reached without encountering a physical root barrier, then deeper observations can cease. This is because none of the BSAL criteria apply deeper than 750 mm soil depth.

In the context of BSAL, effective rooting depth to a chemical barrier is the depth of soil material from the surface to a depth where limiting values of pH, chloride content, electrical conductivity, exchangeable sodium percentage, and the calcium to magnesium ratio (Ca:Mg) exist. These may occur individually or in combination.

pH and salinity have been described separately in sections. Exchangeable sodium percentage and calcium to magnesium ratio are described below.

Table 4 summarises the criteria used to determine effective rooting depth and the relevant threshold values.

Table 4. Criteria for determining effective rooting depth

Criteria	Attributes / thresholds
Physical:	
Compacted layers and/pans	Defined in McDonald and Isbell (2009) pp 192-195
Gravelly/rocky	Includes both coarse fragments (defined in McDonald et al. (2009) pp 139-143) and segregations (defined in McDonald and Isbell (2009) pp 195-198). Soil horizons >100mm thick contain >20% (volume) of coarse fragments and/or segregations >60 mm diameter..
Chemical:	
pH	pH (1:5 soil:water) is 5.0-8.9; pH (1:5 soil: $CaCl_2$) is 4.5 – 8.1
Salinity	ECe <4dS/m (or chlorides < 800mg/kg when gypsum is present)
ESP	<15
Ca:Mg ratio	>0.1

8.1. Exchangeable cations – exchangeable sodium percentage (ESP) and Ca:Mg ratio

Exchangeable cation data is necessary to determine ESP and the Ca:Mg ratio. Measurement of the cation exchange capacity (CEC) is affected by many factors (Rengasamy and Churchman 1999). Table 5 summarises a framework used by ASRIS (Australian Soil Resource Information System) which may assist in the determination of the appropriate test for CEC. Test method codes as used by ASRIS are those of Rayment and Higginson (1992) which are identical to the method codes of Rayment and Lyons (2011), an update of the earlier text.

Table 5. CEC measurement where EC1:5 <0.3 dS/m

Adapted from http://www.anra.gov.au/topics/soils/pubs/national/rogers.pdf

pH_w	Procedure and method code
≤5.0	Give preference to Method 15E-3. Include exchangeable Al and H in CEC estimates. Check location (sub-tropics, Ferrosols, volcanic soils).
5.1 - 7.9	Use and merge data for Methods 15A-1 and 15D-3 (saturated NH_4^+ at pH7).
8.0 - 8.4 (alkaline/calcareous)	Use Method 15C-1 (Alcoholic 1M NH_4Cl pH8.5). Methods 15A-1 and 15D-3 may over-estimate exchangeable cations.
≥8.5 (alkaline/sodic)	Use Method 15C-1, as soluble Na^+ will be high.

Exchangeable calcium, magnesium, potassium and sodium are the amounts of cation exchange sites occupied by any of these cations on the cation exchange complex relative to the valency of the cation in question. ESP is reported as a percentage and is the percentage of exchangeable sodium ions compared to CEC. Ca:Mg ratio is the ratio of exchangeable calcium to exchangeable magnesium.

Isbell (2002) notes the problems associated with deriving misleading ESP results from soils with low levels of exchangeable Na and and/or low CECs. Consequently ESP should not be calculated if the CEC is very low (ie 3 cmol(+)/kg or less, which equals 3 milliequivalents per 100 g (meq/100g)) and exchangeable Na is 0.3 cmol(+)/kg or less (Isbell 2002). For similar reasons, misleading ESP results may also be derived from soils with a field texture of sandy loam or lighter (<20 per cent clay).

Reporting requirements

Effective rooting depth must be recorded to the nearest 50 mm increment. If depth to a physical barrier can be measured more accurately it should be rounded off to the nearest 50 mm.

Reported information must include a description of the type of physical barrier. This may include information on the pan type and degree of cementation, the size and abundance of coarse fragments within a gravel layer, and the presence and degree of weathering of bedrock.

9. Minimum area

BSAL must have a contiguous area equal to or exceeding 20Ha which meets the verification criteria. The minimum area refers to the extent of the biophysical resource not the lot or holding size. Hence if the mining lease area or holding includes less than 20 Ha of BSAL but this BSAL is part of a larger contiguous mass that equals to or exceeds 20 Ha then the land is regarded as BSAL.

Determination of the minimum area is based on the area of land required to commercially produce a high value agricultural crop. The 20Ha size constraint for BSAL applies to the areas covered by the New England/North West and Upper Hunter Strategic Regional Land Use Plans only. The area constraint will be reviewed as subsequent plans are developed across NSW.

10. Sources of information to support a soils distribution model

For more information on the OEH soils information currently available see http://www.environment.nsw.gov.au/soils/index.htm. Additional information will be supplied in the future in relation to Fertility and Land and Soil Capability mapping which form part of the baseline data for Strategic Regional Land Use Plans including BSAL. OEH is currently enabling better access to BSAL soils information through spatial viewer access and enhancing the SALIS profile display.

Appendix 2. Relative fertility of ASC classes

Table 6. Relative fertility of ASC classes (first approximation)

ASC Order [1]	ASC Suborder	ASC Great Group	Fertility ranking
Calcarosols	Shelly, Hypergypsic, Hypocalcic, Lithocalcic, Supracalcic, Hypercalcic, Calcic	Duric, Petrocalcic, Rendic, Lithic, Paralithic, Marly	1 Low
Hydrosols	Intertidal, Supratidal, Extratidal, Hypersalic, Salic	any	
Organosols	any	any	
Podosols	any	any	
Rudosols	Hypergypsic, Hypersalic, Shelly, Carbic, Clastic, Leptic	any	
Tenosols	Chernic-Leptic, Sesqui-Nodular, Bleached-Leptic, Leptic	any	
Calcarosols	Hypocalcic, Lithocalcic, Hypercalcic, Calcic	Argic, Pedal, Regolithic	2 Moderately low
Chromosols	any	Dystrophic, Magnesic, Supracalcic, Pedaric	
Dermosols	any	Pedaric	
Hydrosols	Redoxic, Oxyaquic	any but some Sulfuric could be 1	
Kandosols	any	Mellic, Magnesic, Dystrophic, Mesotrophic, Lithocalcic, Supracalcic, Hypercalcic	
Kurosols	any	Petroferric, Magnesic-Natric, Magnesic, Natric, Dystrophic	
Rudosols	Arenic, Lutic, Stratic	none applicable	
Sodosols	any	any	
Tenosols	Chernic, Calcenic, Red-Orthic, Brown-Orthic, Yellow-Orthic, Grey-Orthic, Black-Orthic	any, but soil depth is <1000 mm and solum is light sandy textured (sands to sandy loams)	
Vertosols	Aquic	any	
Dermosols	any	Duric, Petroferric, Petrocalcic, Subplastic, Magnesic, Dystrophic, Lithocalcic, Supracalcic, Hypercalcic	3 Moderate
Kandosols	any	Duric, Petroferric, Petrocalcic,Placic, Hypocalcic, Calcic	
Kurosols	any	Mesotrophic, Eutrophic	
Vertosols	Red, Brown, Yellow, Grey, Black	Crusty, Massive	
Chromosols	any	Mesotrophic, Eutrophic, Calcic, Hypocalcic, Hypercalcic,	4 Moderately high
Dermosols	Red, Brown, Yellow, Grey	Mesotrophic, Eutrophic, Hypocalcic, Calcic	
Ferrosols	any	any	
Tenosols	Chernic, Calcenic, Red-Orthic, Brown-Orthic, Yellow-Orthic, Grey-Orthic, Black-Orthic	any, but soil depth is >1000 mm and solum is medium-textured (loams, clay loams)	
Vertosols	Red, Brown, Yellow, Grey	Self-mulching, Epipedal	
Dermosols	Black	Hypocalcic, Calcic	5 High
Vertosols	Black	Self-mulching, Epipedal	

1 Anthroposols have not been considered in the table. This order consists of soils that have considerable variation of properties and generally localised extent. Of the 7 suborders Hortic is the most likely to be associated with food/fibre production.

Appendix 3. Risk assessment

Risk assessment to guide density of soil sampling

To identify the potential for a project to impact on agricultural resources and the appropriate level of soil survey required, applicants can undertake an evaluation of risk to agricultural resources and enterprises. This risk assessment is taken from the Guideline for Agricultural Impact Statements at the Exploration Stage (DTIRIS, 2012) and is based on the probability of occurrence and the consequence of the impact, as described in the Land Use Conflict Risk Assessment Guide (NSW DPI 2011).

Depending on the risk, sampling densities can range from 1 site per 25-400 ha for low risk to 1 site per 5-25 ha for high risk (Gallant et al.2008).

Please use Tables 7, 8 and 9 to guide you.

Examples of proposals which are low risk:

- areas of land that are unlikely to be BSAL over a proposed underground mine;
- the activity is located in an area where no agricultural land uses exist such as in a well forested area;
- the duration of the activity is short (1-3 months) and any disturbance to the resource is minor;
- the proposal is located on rural land with a low potential for commercial agricultural land use and there is a low risk of conflict with adjoining agricultural lands; and
- the activity will not result in permanent impacts on water or land resources.

Examples of moderate to high risk:

- activities which are located on or near land which is highly likely to be BSAL such as fertile alluvial soils; and
- a proposed open cut mine on fertile alluvial soils.

Table 7: Agricultural Impacts Risk Ranking matrix

PROBABILITY / Consequence	A Almost Certain	B Likely	C Possible	D Unlikely	E Rare
1. Severe and/or permanent damage. Irreversible impacts	**A1 high**	**B1 high**	**C1 high**	D1 high	E1 medium
2. Significant and /or long term damage. Long term mgt implications. Impacts difficult or impractical to reverse.	**A2 high**	**B2 high**	**C2 high**	D2 medium	E2 medium
3. Moderate damage and/or medium-term impact to agricultural resources or industries. Some ongoing mgt implications which may be expensive to implement. Minor damage or impacts over the long term.	**A3 high**	**B3 high**	**C3 medium**	D3 medium	**E3 medium**
4. Minor damage and/or short-term impact to agricultural resources or industries. Can be managed as part of routine operations	A4 medium	B4 medium	C4 low	D4 low	**E4 low**
5. Very minor damage and minor impact to agricultural resources or industries. Can be effectively managed as part of normal operations	A5 low	B5 low	C5 low	**D5 low**	**E5 low**

where:

= low risk (yellow)

= medium risk (orange)

= high risk (red)

Table 8: Agricultural Impact Risk Ranking – probability descriptors

Level	Descriptor	Description
A	Almost Certain	Common or repeating occurrence
B	Likely	Known to occur or it has happened
C	Possible	Could occur or I've heard of it happening
D	Unlikely	Could occur in some circumstances but not likely to occur
E	Rare	Practically impossible or I've never heard of it happening

Table 9: Agricultural Impact Risk Ranking – consequence descriptors

Level: 1	Severe Consequences	Example of Implications
Description	Severe and/or permanent damage to agricultural resources, or industries Irreversible Severe impact on the community	Long term (eg 20 years) damage to soil or water resources Long term impacts (eg 20 years) on a cluster of agricultural industries or Important agricultural lands
Level: 2	**Major Consequences**	**Example of Implications**
Description	Significant and/or long-term impact to agricultural resources, or industries Long-term management implications Serious detrimental impact on the community	Water and / or soil impacted, possibly in the long term (eg 20 years) Long term (eg 20 years) displacement / serious impacts on agricultural industries
Level:3	**Moderate Consequences**	**Example of Implications**
Description	Moderate and/or medium-term impact to agricultural resources, or industries Some ongoing management implications Minor damage or impacts but over the long term.	Water and/ or soil known to be affected, probably in the short – medium term (eg 1-5 years) Management could include significant change of management needed to agricultural enterprises to continue.
Level: 4	**Minor Consequences**	**Example of Implications**
Description	Minor damage and/or short-term impact to agricultural resources, or industries Can be effectively managed as part of normal operations	Theoretically could affect the agricultural resource or industry in short term, but no impacts demonstrated Minor erosion, compaction or water quality impacts that can be mitigated. For example, dust and noise impacts in a 12 month period on extensive grazing enterprises.
Level: 5	**Negligible Consequences**	**Example of Implications**
Description	Very minor damage or impact to agricultural resources, or industries Can be effectively managed as part of normal operations	No measurable or identifiable impact on the agricultural resource or industry

Appendix 4. Soil date cards

Soil data cards are used to record land and soil information from field observations for later entry into SALIS. Data is entered by either blacking out with a 2B pencil the relevant numbered box or by entering characters or codes. Several versions of soil data cards exist (see Milford et al. (2001). A data card is being developed for specific BSAL assessment use.

The various fields on each soil data card, and standards for data entry, are described in Milford et al. (2001). These will also be applicable to the BSAL data card. Soil data cards may be obtained from OEH (contact soils@environment.nsw.gov.au). Prior to commencement of data collection, the soil survey contractor will need to have registered their identity and the survey details with SALIS, and received surveyor numbers for each of their personnel intending to record soil profile information.

The data to be collected at each detailed site is shown in Table 10. Other data that could be useful to record include crumb test, salinity and hydrology. These are a record of field indicators at the time of observation and may provide complementary information to the other soil criteria.

Table 10. Soil profile description requirements

Data	Relevant SALIS field(s)
Unique identification and meaningful location description	Survey No., survey title, profile No., site location
Location provided as GPS recorded coordinates	Eastings, northings, 1:100,000 map sheet No.
Identity of person describing the detailed site	Described by
and date of description	Profile date
Current land use and/or land cover	Land use; vegetation; coarse fragments; site condition
Landform	Landform element and site and slope morphology
Surface rock	Abundance and size of coarse fragments
Outcropping bedrock	Lithology; coarse fragments
Gilgai microrelief	Microrelief
Slope %, direction and method of measurement	Topography; landform; notes for method of measurement
Soil surface condition	Current condition and surface moisture content
Lower depth and type of each soil horizon or described layer	Layer status
Colour of the soil matrix and abundance, size, contrast and colour of any mottles for each soil horizon or described layer	Moist Munsell colour; mottles
Soil texture of each soil horizon or described layer	Field texture
Field pH of each soil horizon or described layer	Chemical tests
Boundary distinctiveness between soil horizons	Layer boundary
Horizon name and notations for all layers	Layer status
Abundance, nature, form and size of segregations (mineral and organic accumulations that have formed in the soil) for each layer	Segregations
Abundance and size of coarse fragments (loose pebbles, cobbles, stones and boulders) for each layer	Coarse fragments