# 5.5 Land and Soil Resource Assets

Version History

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| Version 3 | Prepared by Peter Wilson, circulated for Exp Panel 2 |
| Version 4 | Updated 06/03/2015 by George Martin with a Version table and updates from EP2 - page numbers, Vertosol Forestry area,<br><br>Updated 9/3/15 by PW based on meeting comments.<br><br>Updated 16/3/15 by PW based on edit comments from AE |
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### 5.5.1 Overview - Description and Values

Living soil developed from the interaction of climate, geology, time, topography and biological interactions (plants, animals and micro-organisms) have resulted in a complex distribution of soils in the region. Apart from narrow strips of young alluvium deposited by rivers and streams, and coastal sand-mass deposits, the majority of the region has comparatively old undulating to hilly landscapes.

Effective land management practices and adoption of industry Best Management Practices (BMPs) relies on understanding landscape and soil processes. Management aims to maintain good soil health and land condition which in turn will maintain soil/land productivity while avoiding degradation; and reduce fragmentation of agricultural land to maintain long-term economic viability and avoid land use conflict.

Ultimately improving Land Condition through effective planning and innovative/adaptive management (particularly with respect to climate variability) will enable continuing agricultural production, biodiversity conservation, functioning of ecosystem services, urban development, mineral and gas resource extraction, and improved surface, ground and marine water quality.

### 5.5.2 Asset Delineation

The Soil Resource Management Unit (Table xx) developed by the then Department of Natural Resources and Mines  groups soil based on inherent similarities in chemical and physical properties and management aspects.

**Table xx**. Soil Management Units

| **Asset Code** | **Asset Description** |
|---|---|
| SR 1 | Dermosols (sandy surface) includes non-sodic Chromosols/Kurosols/Kandosols |
| SR 2 | Dermosols (sealing loamy surface) includes non-sodic Chromosols/Kurosols/Kandosols |
| SR 3 | Dermosols (structured clay/clay loam surface) |

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|---|---|
| SR 4 | Ferrosols |
| SR 5 | Hydrosols (sandy surfaced) |
| SR 6 | Hydrosols (sealing loamy surfaced) |
| SR 7 | Hydrosols (structured clay/clay loam surface) including Organosols |
| SR 8 | Rudosols/Tenosols (loamy) |
| SR 9 | Sodosols (loamy surface) including sodic Chromosols/Kurosols |
| SR 10 | Sodosols (mod deep (>0.5m) sandy surface) including sodic Chromosols/Kurosols |
| SR 11 | Sodosols (shallow (<=0.5m) sandy surface) including sodic Chromosols/Kurosols |
| SR 12 | Tenosols/Rudosols/Podosols (sandy) |
| SR 13 | Vertosols |

The Dermosols are predominantly moderately deep to deep, permeable, gradational to uniform textured soils on a diverse range of geologies and landforms. Water holding capacity is moderate and nutrient supply is predominantly low to moderate. The structured clay/loam group may have high fertility with high water holding capacity especially when developed on intermediate to basic geologies or alluvium. These soils occur extensively in near coast areas and are used extensively for agricultural production under irrigation. Subdivision of the soil units is based on surface texture which reflects moisture supple, nutrient status and vulnerability to climate variability.

Ferrosols are deep to very deep strongly structured, highly permeable clay soils high in free iron developed mainly on basic geologies such as basalts. These highly productive deep to very deep highly permeable soils have moderate to high water holding capacity and nutrient levels, used extensively for cropping mainly in the south Burnett with smaller areas scattered throughout the Burnett and Mary Catchments.

Hydrosols are seasonally wet to permanently wet (wet for >3 months in the major parts of the profile) soils occurring mainly in the higher rainfall coastal/near coastal areas in lower landscape positions. These soils are not intensively developed, but where used for agriculture the land has been extensively drained and modified by levelling. Subdivision of the soil units is based on surface texture which reflects nutrient status, organic matter accumulation and vulnerability to climate variability.

Rudosols and Tenosols (loamy) are generally very shallow/rocky soils developed on upper slopes and crests of a diverse range of geologies. Due to their inherent low productivity, these soils are predominantly not developed, used mainly for extensive grazing, forestry and conservation.

Sodosols are texture contrast soils with a sandy to loamy surface abruptly changing to impermeable, dispersible sodic clay subsoil. Soils occur on a range of sedimentary, metamorphic and acid to intermediate igneous rocks with generally gently undulating to undulating topography. Due to their inherent chemical and physical disorders, these soils are no extensively developed for cultivation, used mainly for grazing and native forestry. Subdivision of the soil units is based on surface texture which reflects moisture supply, nutrient status and vulnerability to climate variability.

Tenosols/Rudosols/Podosols (sandy) include a broad group of soils with predominantly deep to very deep, highly permeable, nutrient deficient sandy textured profiles generally associated with sandy alluvium, coastal sand masses and some sandstone and granite geologies. The more fertile soils developed on alluvium are often developed for agriculture while the remainder are used mainly for extensive grazing, forestry and conservation.

Vertosols are moderately deep to very deep cracking clay soils developed on alluvium and clay forming geologies. Soils in the Burnett Mary region have moderate to high fertility with high water holding capacity often over impermeable sodic subsoil. These soils are extensively developed to cropping and grazing.

Figure X shows the distribution of the Soil Management Units in the Burnett and Mary Catchments.

Table xx lists the dominant land uses for each soil management unit. Overall, the more productive soils (Dermosols, Ferrosols and Vertosols) have a higher proportion (%) under cropping and sugar cane. The Land Use Groups are based on the 2009 Queensland Land Use Mapping completed by the Queensland Government and grouped based on similar land use management practices. For example the “Forestry” group includes plantation forestry and all lands designated as State Forests, while “grazing” includes all lands with introduced pastures and vegetation communities use for grazing of native pastures. “Cropping” includes cultivated lands for all crops and horticulture excluding sugar cane and plantation forests.

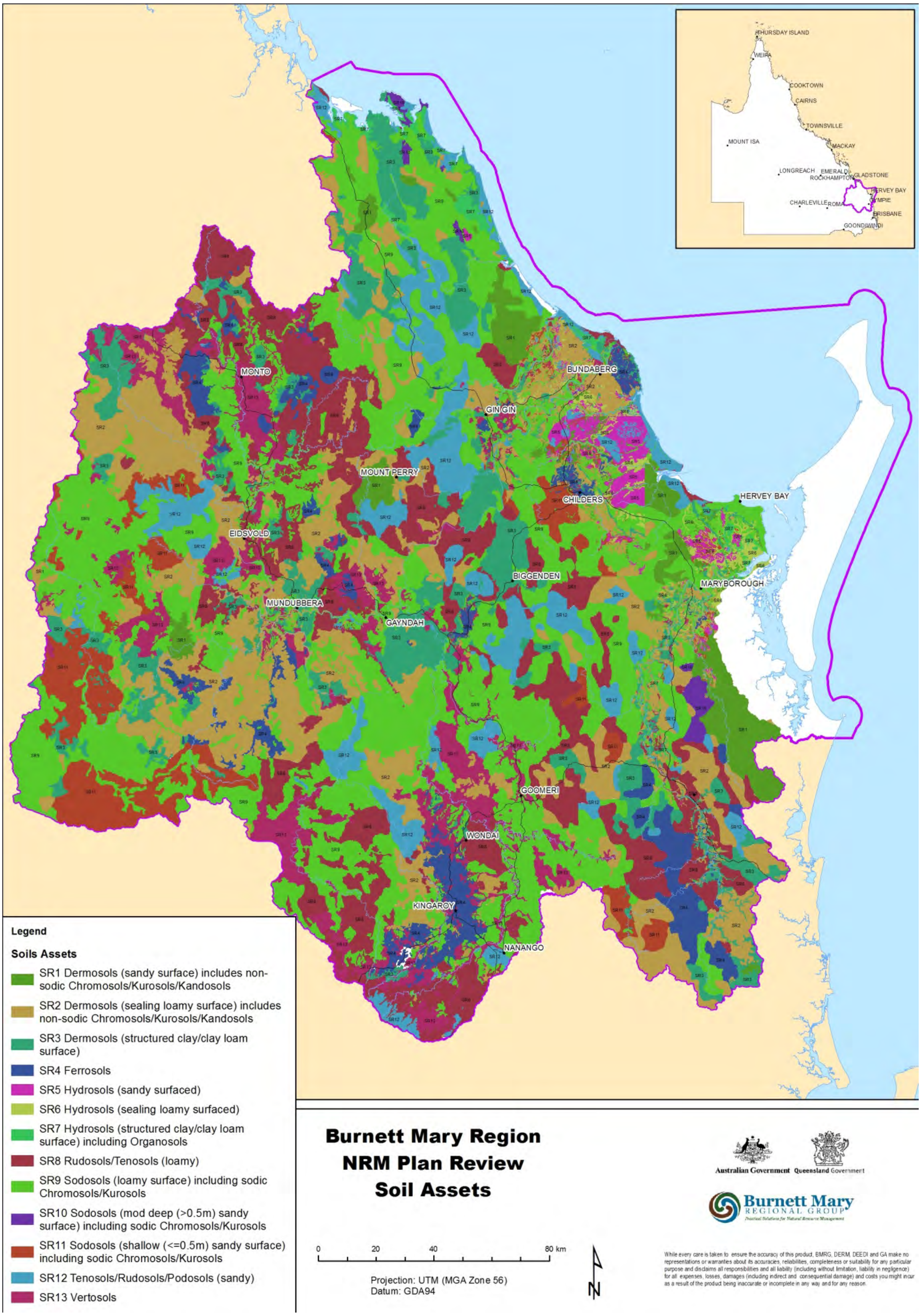


**Figure X.** Distribution of the Soil Management Unit in the Burnett Mary Region

**Table xx.** Dominant land uses for each Soil Management Unit

| Asset Code | Asset Description | Land Use Group | Land Use Area (Ha) | % of Total Asset |
|---|---|---|---|---|
| SR 1 | Dermosols (sandy surface) includes non-sodic Chromosols/Kurosols/Kandosols (Total area 200 180 ha) | Cropping | 573 | 0.3 |
| | | Forestry | 80134 | 40.0 |
| | | Grazing | 81140 | 40.5 |
| | | Sugar Cane | 6277 | 3.1 |
| SR 2 | Dermosols (sealing loamy surface) includes non-sodic Chromosols/Kurosols/Kandosols (Total area 915 700 ha) | Cropping | 11413 | 1.2 |
| | | Forestry | 128956 | 14.1 |
| | | Grazing | 616180 | 67.3 |
| | | Sugar Cane | 24854 | 2.7 |
| SR 3 | Dermosols (structured clay, loam surface) (Total area 75 350 ha) | Cropping | 5285 | 7.0 |
| | | Forestry | 23974 | 31.8 |
| | | Grazing | 23974 | 31.8 |
| | | Sugar Cane | 6983 | 9.3 |
| SR 4 | Ferrosols (Total area 224 740 ha) | Cropping | 33036 | 14.7 |
| | | Forestry | 59328 | 26.4 |
| | | Grazing | 96156 | 42.8 |
| | | Sugar Cane | 10208 | 4.5 |
| SR 5 | Hydrosols (sandy surfaced) (Total area 58 210 ha) | Cropping | 301 | 0.5 |
| | | Forestry | 7402 | 12.7 |
| | | Grazing | 11915 | 20.5 |
| | | Sugar Cane | 7434 | 12.8 |
| SR 6 | Hydrosols (sealing loamy surfaced) (Total area 39 660 ha) | Cropping | 355 | 0.9 |
| | | Forestry | 1616 | 4.1 |
| | | Grazing | 13154 | 33.2 |
| | | Sugar Cane | 5576 | 14.1 |
| SR 7 | Hydrosols (structured clay/clay loam surface) including Organosols (Total area 33 670ha) | Cropping | 19 | 0.1 |
| | | Forestry | 58 | 0.2 |
| | | Grazing | 13500 | 40.1 |
| | | Sugar Cane | 3531 | 10.5 |
| SR 8 | Rudosols/Tenosols (loamy) (Total area 712 110 ha) | Cropping | 2182 | 0.3 |
| | | Forestry | 70204 | 9.9 |
| | | Grazing | 519341 | 72.9 |
| | | Sugar Cane | 577 | 0.1 |
| SR 9 | Sodosols (loamy surface) including sodic Chromosols/Kurosols (Total area 1 618 910 ha) | Cropping | 14125 | 0.9 |
| | | Forestry | 256248 | 15.8 |
| | | Grazing | 1182854 | 73.1 |
| | | Sugar Cane | 11161 | 0.7 |
| SR 10 | Sodosols (mod deep (>0.5m) sandy surface) including sodic Chromosols/Kurosols (Total area 23 220 ha) | Cropping | 0 | 0 |
| | | Forestry | 11357 | 48.9 |
| | | Grazing | 3266 | 14.1 |
| | | Sugar Cane | 206 | 0.9 |
| SR 11 | Sodosols (shallow (<=0.5m) sandy surface) including sodic Chromosols/Kurosols (Total area 260 130 ha) | Cropping | 494 | 0.2 |
| | | Forestry | 251446 | 96.7 |
| | | Grazing | 221 | 0.1 |
| | | Sugar Cane | 1549 | 0.6 |
| SR 12 | Tenosols/Rudosols/Podosols (sandy) (Total area 352 710 ha) | Cropping | 609 | 0.2 |
| | | Forestry | 266040 | 75.4 |
| | | Grazing | 412 | 0.1 |
| | | Sugar Cane | 2695 | 0.8 |

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|---|---|---|---|---|
| SR 13 | Vertosols (Total area 381 330 ha) | Cropping | 59504 | 15.6 |
| | | Forestry | 6374 | 1.7 |
| | | Grazing | 299047 | 78.4 |
| | | Sugar Cane | 5188 | 1.4 |

### 5.5.3 Potential Climate Futures

The Soil Management Units of the region were assessed by an External Expert Panel (Refer relevant Technical Report for Expert Panel membership), to determine the vulnerabilities to climate change. The detailed results of the Assessment are contained within the Land and Soil Resources Technical Report (Volume x) however it was deemed that in general, Land and Soil Resources of the region were sensitive to the following climate change exposure indicators:

- Temperature Increases;
- Increasing lengths of dry periods;
- Spring rainfall decrease;
- More frequent and intense fires (measured as an increase of very high fire weather conditions (Forest Fire Danger Index FFDI), and,
- Increased frequency of intense rainfall events.

Under a Potential Future Climate at **2030 and 2090** for RCP 4.5, the following Land and Soil Resources would likely be vulnerable. For RCP 8.5 where emissions would continue to rise throughout the 21st century, the potential future for 2030 would be similar to the RCP 4.5. However, the potential futures under RCP 8.5 at 2090 would result in major to extreme effects on all soil and land resources resulting in major decrease in land productivity and economic sustainability, and threats to biodiversity and water quality.

| Climate Scenario | Potential Climate Future 2030 | Potential Climate Future 2090 |
|---|---|---|
| RCP 4.5 | Some increase in soil temperature reflecting atmospheric temperatures but productivity largely unaffected, Vertosols have significant linear increase due to inherent dark soil colours.<br>All soils with some to significant increase in drought periods affecting soil surface cover and productivity, organic matter and landscape hydrology particularly shallow soils, sandy surfaced soils and Hydrosols.<br>Some decrease in soil moisture reflecting spring rainfall decrease and reduced surface cover, Sodosols more affected.<br>Minor to some effects on the organic matter content, surface cover and erodibility due to more frequent and intensive fires with moderate effects on the Sodosols and high effect on the structured Hydrosols due to lower water table and loss on organic matter.<br>Some increase in soil erosion in all soils due to more intensive rainfall events, with a high increase on the erodible Sodosols due to reduced | Significant increase in soil temperature and reducing productivity.<br>All soils with significant to major increase in drought periods particularly soils with shallow rooting depths and Hydrosols, while Dermosols, Ferrosols and Vertosols least affected.<br>Significant to major decrease in soil moisture reflecting spring rainfall decrease, Sodosols more severely affected.<br>Some effects on the organic matter content, surface cover and erodibility in the more productive soils due to more frequent and intensive fires, with very high effects on the Sodosols and extreme effect on the structured Hydrosols due to lower water table and loss on organic matter.<br>Some to moderate increase in soil erosion in all soils due to more intensive rainfall events and reduced surface cover and loss of organic matter, with extreme increase |

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| | surface cover, loss of organic matter, increasing run-off and decreasing structural stability. | on the erodible Sodosols due to increasing run-off and decreasing structural stability. |

Increased soil temperatures will reflect atmospheric temperatures with minimal to some increase in expected effects on production, mainly through plant germination and establishment. The highly productive Vertosols with their inherent dark colour will be moderately affected. Adaptation may involve earlier/later planting dates, retention of crop residues to reduce surface temperatures and evaporation rates, and modified technology such as tolerant varieties.

Increased length of dry periods and droughts will affect all soil productivity and surface cover through reduced soil moisture availability. This will lead to reduced soil organic matter, structural stability and soil nutrition. Unless soils are carefully managed, the expected increase in the length of dry periods will result in a down-ward spiral of soil fertility, increased erosion and dramatic changes in landscape hydrology. Adaption has involved contraction of dryland cropping areas to the “better” soils, rapid destocking at the start of droughts, maintaining soil health (OM, pH, nutrition, structure), maintaining surface cover and residues to reduce erosion and retain soil moisture, and flexibility in management options. The soils with lower water holding capacity (shallow/rocky soils such as Rudosols/Tenosols, sandy textured soils, and soils with restricted rooting depth such as Sodosols) are most susceptible. Any changes in landscape hydrology will severely affect Hydrosols resulting in dramatic reduction in organic matter and probably changes in vegetation communities/biodiversity. The lowering of coastal water tables will result in the oxidation of sulfidic deposits in acid sulfate soils resulting in increased release of acid drainage and associated contaminates resulting in land and water acidification, loss of production, and aquatic/estuary/marine habitat loss. However, under RCP 8.5 where sea levels would rise significantly, much of the coastal acid sulfate soils would be inundated without significant actions to exclude the rising sea level. Under this scenario, the impacts of low lying acid sulfate soils would be reduced.

Decreased spring rain will reduce soil moisture supply for plant growth, having generally similar but less severe affects as increased length of dry periods as described above. As our spring rains are generally variable with “small” amounts relative to the main summer dominant rains, the effects of decreased spring rain is less pronounced than other areas in Australia where spring rains are essential for early planting of summer crops or to “finish–off” winter crops. The effects are reduced productivity and surface cover through reduced soil moisture availability. This will lead to reduced soil organic matter, structural stability and soil nutrition, increased erosion and some changes in landscape hydrology.

More frequent and intense fires are expected to occur on all landscapes especially when “good” seasons are followed by drought.  Fire results in the direct loss of surface cover, organic matter and associated soil health (pH, nutrition, structure), increased runoff and erosion and changed landscape hydrology. The soils at risk are generally the more fragile soils such as the shallow/rocky Rudosols/Tenosols, and Sodosols. Persistent burning will result in land degradation and changes in vegetation communities and biodiversity. The structured Hydrosols generally correspond to soils with very high surface organic matter, and under certain circumstances the formation of peats. Although peats do not occur in the Burnett and Mary Catchments, they do occur in the adjacent Fraser and Cooloola sand masses. Due to changes in coastal hydrology, these communities are prone to burning resulting in a dramatic and severe permanent loss of organic matter, habitat and biodiversity.

Increased frequency of intense rainfall events will affect productivity and soil health of all Soil Management Units to varying degrees. As described above, increased temperatures, decreased rainfall, increased drought and more frequent fires all influence the amount of surface cover, soil organic matter and other soil health (pH, nutrition, structure) all resulting in lower land productivity, increased run-off, changed landscape hydrology and reduced soil health. Therefore, any increase in the frequency of intense rainfall events will result in increased erosion and loss of sediment and nutrients to our waterways. This in turn reduces the capacity of our landscapes to support agricultural production, environmental services and healthy habitats. The soils at severe risk are generally the more fragile soils such as the shallow/rocky Rudosols/Tenosols, and Sodosols.

A benefit of a generally drier environment will be the reduction in the extent and severity of salinity as water tables will generally lower with the leaching of salts to lower in the soil profiles. However, as with the 2010-2013 “wet” seasons, the rapid rise in water tables in all landscapes resulted in extensive expressions of salinity, generally the most severe since the mid 1970’s. Management of salinity relies heavily on maintaining good vegetation growth (trees and pastures); however as described above, climate variability threatens the productivity and health of all landscapes particularly landscapes that have been cleared, under cultivation and irrigation.

Under all climate scenarios, any inundation of land from sea level rise would result in a significant increase in carbon sequestration in the soil. These changes are not mentioned here as they become part of the Marine Asset.

### 5.5.4 Land and Soil Resource Vision, Targets & Desired Outcomes

The visions and targets listed in the NRM Plan are non-statutory. They seek to achieve and align with long-term sustainability outcomes and principles referred to in the Wide Bay Burnett, Central Queensland and South East Queensland Regional Plan’s and other relevant State and Commonwealth Plans.

The Vision, 2020 Target and Desired Outcomes for the Land and Soil Resource Assets are summarised below.

| Asset | Vision 2035 | 2020 Targets | Desired Outcomes |
|---|---|---|---|
| Land and Soil Resource | Land condition will be maintained or improved. | Salinity extent and severity is maintained at the 2015 baseline. | Loss of agricultural productivity due to mobilisation of salts in the landscape, and increased sediment and nutrients from erosion impacting on adjacent vegetated communities and waterways are reduced or, at worst, maintained. |
| | | Soil acidification is maintained at the 2015 baseline for Cropping Land (i.e. cropping, horticulture, plantation forestry) | Soil pH in cropping land is managed to maintain or reduce agricultural productivity impacts. |
| | | Soil Organic Matter is maintained at the 2015 | The biological, chemical and physical properties of agricultural soils are not |

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|---|---|---|---|
| | | baseline for all Agricultural Land (i.e. cropping, horticulture, grazing and forestry). | compromised by loss of soil organic matter. |
| | | Sheet erosion risk, stream bank erosion risk and gully erosion extent and severity are reduced by 10% compared to the 2015 baselines. | Land productivity is maintained and damage to infrastructure is reduced. Nutrient and sediment loads in streams will be reduced by 20% to support the Reef Plan. |
| | | The extent of Acid Sulfate Soil disturbance is maintained at the 2015 baseline. | Disturbance of acid sulfate soils will be avoided or if disturbed the impacts of acid sulfate soil disturbance (acid drainage and pollutants in waterways, and infrastructure damage) will be managed. |
| | | Extent of Cropping Land (i.e. cropping, horticulture and plantation forestry) is maintained at the 2015 baseline. | The potential for agricultural production will not be compromised by alienation of cropping land. |
| | | Ground cover of grazing lands is maintained at the 2015 baseline. | The productivity of grazing land will be aided through good grazing land management. |

## Indicative 2020 Target - Salinity extent and severity is maintained at the 2015 baseline

**Salinity extent and severity**

Secondary salinity of our land resources is the accumulation of soluble salt in the soil or waters (surface and ground water) due to human activities. Salinity becomes an issue when the concentration of salt affects plant growth (crops, pastures or native vegetation), or degrades the soil or affects infrastructure. Secondary salinity becomes a water issue when the potential use of the water (including environmental needs) is limited by its salt content. Saline areas are also prone to erosion.

Measuring the expansion or contraction (extent in hectares) and intensity (salt concentration) of salt affected areas provides an effective tool for assessing changes in salinity status over time. It can also aid in determining risk of various landscapes (NLWRA, 2007).

Salinity extent and severity is linked with other soil health intermediate outcomes including improved soil fertility, reduced soil loss and improved water quality.

For the WBB the lack of available information on the current condition of salinity extent and severity requires the collection of baseline information. Until salinity extent and severity baseline data is available, 'salinity hazard' in combination with existing data on salinity sites and expert knowledge is used to identify priority assets (land, water and biodiversity) and investment strategies outlined in the NRM Plan. Salinity hazard is based on the ranking and addition of inherent land and soil properties which include regolith salt store, recharge potential and discharge potential as outlined in the DNRM Salinity Hazard Assessment in the Burnett Mary and Western Catchments of the South

East Queensland 2003. As salinity hazard does not change with changes in management or climate variability, it has no value as a monitoring tool. A map of salinity hazard is in Appendix …

**Conceptual understanding of the pressure and response relationships**

As salinity is the result of complex interactions between geophysical, climate and land use factors, land and water management aim to change the hydrologic equilibrium in sensitive areas. Excessively cleared landscapes naturally high in salts and under irrigation are at highest risk. Improved management activities seeks to manage the ground water through improved plant growth (crops, pastures and trees), improved irrigation methods (water application, water quality and water table monitoring), soil and land management, and engineering solutions (e.g. drainage, resistant infrastructure). Understanding landscape processes is essential to improve management decisions, but avoiding development in sensitive areas is the best management.

The conceptual understanding of how the salinity is expressed is illustrated below in Table X. The first row of the table describes the process of how human activities and natural events put pressure on systems causing physical and chemical changes to the environment, which can be measured by assessing indicator condition and trend. Row two describes the assumptions about the scientific understanding of secondary salinity processes while row three describes the data necessary to monitor condition and trend.

**Table X.** Tool for identifying salinity extent and severity indicator and information needs

| | ***Pressures*** | | ***Physical / chemical / attitudinal changes*** | ***Indicator*** |
|---|---|---|---|---|
| | **Human Activity** | **Natural Events** | | ***Condition & Trend*** |
| **Process/Function of secondary salinity** | Land use and land management influence the amount of deep drainage. | Climate and landscape hydrology influence the amount of deep drainage and landscape processes. | Watertable will rise as a result of increased deep drainage. In certain landscapes this rise can bring groundwater levels within 3m of the ground surface. | **Change in extent and severity of surface salinity.** |
| **Assumptions** | Land use is related to land management and land management is directly related to the amount of deep drainage in all landscapes. | Landscape pressures are known. Rainfall and evapo-transpiration are key factors that influence the amount of deep drainage. | Groundwater systems are known and behave similarly throughout the catchment. Watertables to the surface cause salinity. | **Assessment standards accurately reflect landscape processes. Surface salinity is an indicator of specified pressures and will reflect changes in pressures over time.** |

| | | | | |
|---|---|---|---|---|
| **Information needs (data)** | - Remnant vegetation<br>- BGI<br>- Land use mapping<br>- Industry programs (BMP)<br>- Incentive programs (BMP)<br>- Extension services (eg. GLM) | - Rainfall<br>- Evaporation | Depth and salinity of groundwater. | **Extent and severity of surface salinity.** |

## Indicative 2020 Target - Soil acidification is maintained at the 2015 baseline for Cropping Land (cropping, horticulture, plantation forestry)

### Soil acidification extent and severity

Soil acidity (as measured by pH) is a fundamental soil health indicator which is affecting significant areas of Australian cropping soils. Soil acidification is a natural process which is generally accelerated by the intensification of land management and use. Soil acidification is a major factor affecting many chemical and biological processes, and hence ecosystems processes. The process is responsible for reducing land utilisation options through reduced plant growth and productivity. Other onsite and offsite effects of soil acidification include:

1. Loss of soil biota involved in nitrification;
2. Accelerated leaching of Mn, Ca, Mg, K and anions;
3. Induced nutrient deficiency and toxicities;
4. Breakdown and subsequent loss of clay minerals from soil;
5. Soil erosion as a result of poor plant growth in acid soils;
6. Mobilisation of heavy metals into water resources and the food chain;
7. Acidification of waterways as a result of leaching of acidic ions; and
8. Increased siltation and eutrophication of streams and water bodies.

Measuring the expansion and contraction (extent in hectares) and intensity (how acid) of land affected by soil acidification provides an effective tool for assessing changes in soil acidification over time. Monitoring soil acidification will assist land managers, natural resource agencies and commercial organisations to understand the rate of soil acidification so that preventative and/or restorative measures can be implemented.

Soil acidification is linked with other soil health intermediate outcomes including improved soil fertility, reduced soil loss and improved water quality as listed above. A baseline map of soil acidification risk for the main cropping areas in the Burnett Mary Regions is in Appendix …

### Conceptual understanding of the pressure and response relationships

Soil acidification is the result of interactions between geology, climate and land use and management factors.

The major causes of soil acidification are:

1. Rainfall and leaching;
2. Organic matter decay (releasing of organic acids);

3. Harvest and removal of high yielding crops/pastures; and
4. Long term fertiliser application (particularly over fertilising).

The conceptual understanding of how soil acidity forms is illustrated below in Table X. The first row describes the process of how human activities and natural events put pressure on systems causing physical and chemical changes to the environment. These can be measured by assessing indicator condition and trend. Chemical composition/mineralogy of the parent material contributes various amounts of acidity/alkalinity to a soil and therefore the soils inherent buffering capacity. Row two describes the assumptions about the scientific understanding of soil acidification while row three describes the data necessary to monitor condition and trend.

**Table X.** Tool for identifying soil acidification indicator and information needs

| | Pressures | | Physical / chemical / attitudinal changes | Indicator |
|---|---|---|---|---|
| | **Human Activity** | **Natural Events** | | **Condition & Trend** |
| **Process/Function of soil acidity** | Land use and land management influence the amount of:<br>1. product removed from a site<br>2. excessive fertiliser use<br>3. Deep drainage. | 1. Climate (rainfall) and landscape hydrology Influence the amount of deep drainage.<br>2. Chemical composition/ mineralogy of soil parent material contribute various amounts of acidity and/or alkalinity | 1. Deep drainage from excessive rainfall or irrigation removes basic cations from the soil causing increased acidity<br>2. The weathering of soil parent material releases basic and or acid ions resulting in a change in soil acidity<br>3. Unutilised ammonium based fertilisers results in soil acidification by adding H+ ions<br>4.Continuous removal of vegetative material from a cropping/grazing system results in the loss of basic cations leading to soil acidity | **Change in extent and severity of soil acidification measured using soil pH** |
| **Assumptions** | Land use is related to land management and land management is directly related to product removal, fertiliser use and deep drainage in all landscapes. | Rainfall and mineralogy of soil parent material are natural factors that influence soil acidity. | Soil acidification processes behave similarly where all climate and soils are equal. | **Assessment standards accurately reflect landscape and land management processes. Soil acidification is an indicator of specified pressures and will reflect changes in pressures over time.** |

| Information needs (data) | - Land use mapping (past and present)<br>- Land management practices<br>- Soil type information including soil buffering capacity information<br>- Industry programs (BMP – Best Management Practice)<br>- IWUP (irrigation water use plan)<br>- Incentive programs (BMP)<br>- Extension services (e.g. GLM – Grazing Land Management) | - Rainfall<br>- Evaporation<br>- Lithology<br>- Soil biology | Measured soil pH across combinations of most common variables | **Extent and severity of soil acidity across common soil types and land uses.** |
|---|---|---|---|---|

**Indicative 2020 Target - Soil Organic Matter is maintained at the 2015 baseline for all Agricultural Land (i.e. cropping, horticulture, grazing and forestry).**

**Soil Organic Matter (Soil Organic Carbon)**

Soil organic matter (SOM) derived from decaying plants and animals plays an essential role in soil condition such as stable soil structure, effective nutrient supply, improved water availability, surface infiltration and profile permeability, healthy microbial and faunal activity and storage of carbon to buffer greenhouse gasses in the atmosphere.

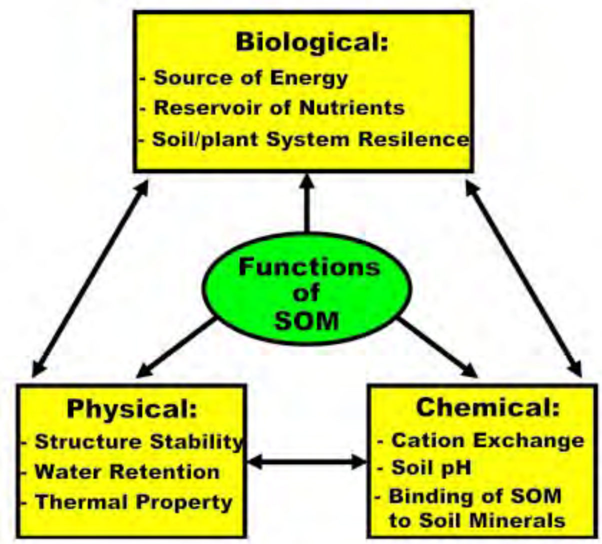


**Figure xx.** Functions of Soil Organic Matter and their interactions

Soil organic matter is generally concentrated within the upper soil horizons where organic inputs occur. A number of land use factors influence the accumulation (gains) and mineralisation (losses) of soil organic matter including organic inputs, cultural practice (cropping, grazing, ploughing etc.) and climate.

The majority of soil organic matter is soil organic carbon (SOC). SOC is relatively simple to measure and provides a convenient tool for measuring changes in soil organic matter, and therefore soil and land condition, over time. SOC is generally divided into three (3) groups or pools which describe how reactive it is in the soil and how long it could be expected to remain. The three groups in order of decreasing vulnerability are:

- The labile (or active) pool – living biomass, partly decomposed organic matter.
- The humus pool – humic and fulvic acids and humates.
- The recalcitrant pool – highly protected organic matter (mostly charcoal)

The relative proportion of each pool is an indicator of soil health. While the percentage of recalcitrant SOC remains generally steady, in degraded soils both the labile and humus pools will be significantly smaller. It is generally accepted that to adequately understand SOC all pools require measuring. However, it is more common to measure total SOC and labile SOC as these measurements are quick and relatively low cost, and the difference represents mainly the recalcitrant pool.

**Conceptual understanding of the pressure and response relationships**

Management actions will aim to maintain or improve the OM levels in our soils. Maintaining OM levels is not easy as disruption of normal plant growth will reduce the supply of OM to the soil. Cultivated soils are at most risk with most cropped soil having around 50% of the soil carbon than soils under original native vegetation. Management that supports the target includes minimum tillage, retention of plant/crop residues, maintenance of soil fertility (chemical and physical), low temperature burning at appropriate times, rehabilitation of degraded areas and reduced land degradation such as salinity, erosion and soil contamination. The effect of each of these factors is specific to each different soil type considered. A baseline map of risk of decline in soil organic matter for the main cropping areas in the WBB Regions is in Appendix …

The conceptual understanding of how OM changes in the landscape is illustrated below in Table X. The first row describes the process of how human activities and natural events put pressure on systems causing physical and chemical changes to the environment, which can be measured by assessing indicator condition and trend. Row two describes the assumptions about the scientific understanding of Soil Organic Matter while row three describes the data necessary to monitor condition and trend.

**Table X.** Tool for identifying soil organic matter indicator and information needs

| | Pressures | | Physical / chemical / attitudinal changes | Indicator Condition & Trend |
|---|---|---|---|---|
| | **Human Activity** | **Natural Events** | | |
| **Process/Function of SOM** | Land use and land management influence the amount of organic carbon cycling in the soil profile. | Climate, soil type, vegetation cover and vegetation type influence the amount of stored organic carbon. | Reduced soil OM levels result in soil health declines related to structure, moisture holding capacity, nutrient availability and erosion resistance. | **Changes in percentage of SOM as measured by SOC.** |

| | | | | |
|---|---|---|---|---|
| Assumptions | Land use is related to land management and land management is directly related to the amount of cycling organic carbon in all landscapes. | The amount of cycling organic carbon is related to climate (rainfall, evaporation and temperature), plant growth, topography, soil type (texture, pH, fertility & parent material) and how they interact with land management techniques. | Soil organic carbon levels behave in a uniform manner where all climate, soil, topographic and climate variables are equal. | **Soil organic carbon changes accurately reflect changes in land management practices over time.**<br><br>**Assessment sites represent modal land uses.** |
| Information needs (data) | - Land use statistics or mapping<br>- History of farming or land clearing<br>- Current vegetation mapping<br>- BGI (Bare Ground Index) | - Climate data (temperature, rainfall, evaporation)<br>- Vegetation coverage and type.<br>- Soil type (parent material, soil depth etc.).<br>- Topography (elevation, slope, rockiness)<br>- Land use.<br>- Geology | Measured concentrations of soil organic carbon across combinations of most common variables. | **Extent and variability of soil organic carbon levels under a range of common land uses.** |

**Indicative 2020 Target - Sheet erosion risk, stream bank erosion risk and gully erosion extent and severity are reduced by 10% compared to the 2015 baseline.**

**Erosion Risk**

***Sheet & Stream Bank Erosion***
Sheet erosion and stream bank erosion will be monitored by assessing Erosion Risk.

The risk of erosion is influenced by multiple pressures (natural and human) and as an indicator requires a variety of information inputs. Similarly, the effects of erosion spread across multiple spheres and directly and indirectly affect multiple natural resource assets (including *land resources*; *regional landscapes*; *coastal, estuarine and marine ecosystems*; and *terrestrial and freshwater ecosystems*). More specifically, soil loss through erosion has significant environmental, economic and social implications which often cannot be reversed. For example, loss of topsoil inhibits crop and plant growth, interferes with farming operations and may damage infrastructure, while sediment-laden runoff and sediment deposition negatively impact on terrestrial and aquatic ecosystems, with repercussions throughout the agricultural, fisheries, tourism and conservation sectors.

As an indicator, Erosion Risk:

- is capable of showing trends over time (e.g. alteration to management or cover will directly alter erosion risk)
- is sensitive to change and predictive (e.g. erosion risk is inherently predictive and alteration of any component causation factors will alter the level of risk).
- does enable assessment of cumulative impacts (e.g. soil loss, productivity, water quality, climate variability, etc)
- is relatively cost-effective (e.g. erosion risk associated with sheet erosion is primarily a spatial desktop exercise)
- is scientifically credible and statistically robust (i.e. application of the Revised Universal Soil Loss Equation (RUSLE) is widely accepted as a method for calculating sheet erosion risk, despite recognised limitations).

Measuring a change in the level of Erosion Risk provides a useful tool for assessing changes in soil retention (and therefore health), effectiveness of management practices and appropriateness of land use. Furthermore, as well as reducing soil loss, Erosion Risk is also linked to other intermediate outcomes, including improved fertility, increased adoption of best management practices (BMP) and improved water quality (for soil health) and viable rural production (for agricultural land). This is also fundamental to improving reef water quality under the Reef Plan which aims to reduce sediment loads by 20%. Baseline maps of sheet and bank erosion risk are in Appendix ….

**LINKS:** As well as reducing soil loss, monitoring sheet erosion risk is also linked to other assets, indicators and intermediate outcomes, including:

- SOM and improved fertility / increased SOC (Land Asset)
- Salinity and reduced extent and severity (Land Asset)
- Agricultural land and availability for viable production (Land Asset)
- Improved water quality (Water Resources and Coastal and Marine Assets)
- Minimised impacts on ecosystem health (multiple assets and indicators)
- Improved land use decision making (multiple assets and indicators)
- Increased adoption of BMP (multiple assets and indicators)
- Reduced impacts of infrastructure (multiple assets and indicators)

**LINKS:** As well as reducing soil loss, monitoring stream bank erosion is also linked to other assets, indicators and intermediate outcomes, including:

- Agricultural land and availability for viable production (Land Asset)
- ASS and reduced disturbance (Land Asset)
- Improved water quality (Water Resources and Coastal and Marine Assets)
- Minimised impacts on ecosystem health (multiple assets and indicators)
- Improved land use decision making (multiple assets and indicators)
- Increased adoption of BMP (multiple assets and indicators)
- Reduced impacts of infrastructure (multiple assets and indicators)

***Gully Erosion***

Gully erosion in the WBB will be monitored by assessing the extent and severity of digitally captured erosion gullies.

Erosion extent and severity is influenced by the same natural and artificial/human pressures as Erosion Risk, and requires similar information inputs. Similarly, measuring changes in gully extent and severity provides a useful tool for assessing changes in soil retention (and therefore health), effectiveness of management practices and appropriateness of land use. Furthermore gully extent will affect the availability of land for viable rural production; gully severity / activity will influence the need for increased adoption of best management practices (BMP) and improved fertility; and both extent and severity will have implications for improved water quality.

Measuring gully erosion extent and severity by means of traditional field methods is usually a time and resource intensive exercise, mainly used for a select number of sites. However, application of remote sensing methodologies provides a more efficient and cost-effective way of monitoring the extent and severity of gully erosion across the region. Using imagery to digitise the location of erosion gullies is a straightforward way of capturing extent, while using groundcover as a measure for assessing gully stability provides an effective process for monitoring changes in severity.

**LINKS:** In addition to a reduction in soil loss, monitoring gully extent and severity is also linked to other assets, indicators and intermediate outcomes, including:

- SOM and improved fertility and increased SOC (Land Asset)
- Salinity and reduced extent and severity (Land Asset)
- Agricultural land and availability for viable production (Land Asset)
- ASS and reduced disturbance (Land Asset)
- Improved water quality (Water Resources and Coastal and Marine Assets)
- Minimised impacts on ecosystem health (multiple assets and indicators)
- Improved land use decision making (multiple assets and indicators)
- Increased adoption of BMP (multiple assets and indicators)
- Reduced impacts of infrastructure (multiple assets and indicators)

**Conceptual understanding of the pressure and response relationships**

***Sheet & Stream Bank Erosion***

Erosion Risk is directly proportional to Soil Loss, which is influenced by:

- rainfall – e.g. the greater the frequency, intensity and duration of rain, the greater the risk of erosion).
- erodibility (ie. the soil's susceptibility to erosion based on inherent soil properties such as texture, structure, organic matter, dispersivity, etc.) – e.g. light textured / sandy, poorly structured dispersive soils with low organic matter are more likely to erode.
- slope length – e.g. the speed of runoff increases with slope length, increasing erosion risk.
- slope percent – e.g. the speed of runoff increases with gradient, increasing erosion risk
- cover – e.g. the less cover, the greater the risk of erosion.
- management practices – e.g. erosion risk increases with the level of soil disturbance.

Additional influences affecting stream bank Erosion Risk include:

- gully presence – e.g. stream bank erosion risk will be greater in areas where an erosion gully enters the stream; and
- stream curvature – i.e. flow velocity is greater on the outside of a steam bend, thus increasing the risk of erosion for this area of bank.

Figures x and x show the two types of erosion which will be monitored using Erosion Risk.

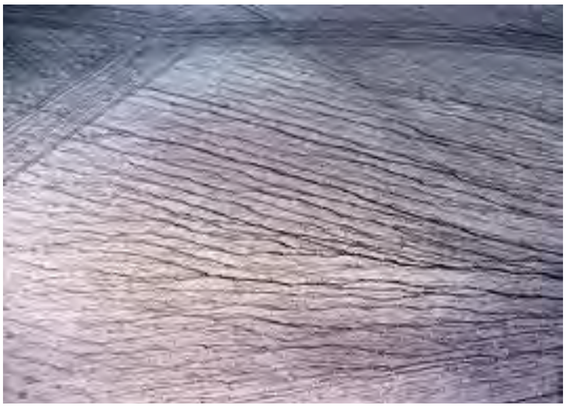

**Figure x.** Sheet Erosion (with rilling)

**Figure x.** Stream Bank Erosion

**Table XX.** Tool for identifying sheet and stream bank indicators and information needs

| | Pressures | | Physical / chemical / attitudinal changes | Indicator |
|---|---|---|---|---|
| | Human Activity | Natural Events | | Condition & Trend |
| Process/Function of sheet and stream bank erosion | Land use and land management influence the degree of soil disturbance, period of soil exposure and concentration of runoff. | Landscape hydrology - comprising climate (rainfall frequency & intensity), landscape attributes (slope gradient & length of slope), soil properties (susceptibility to erosion) and the level of groundcover – influence landscape pressures and the risk of erosion. | High levels of rainfall frequency and intensity; steep, long slopes; absence of ground cover; high erodibility; lengthy exposure; high levels of disturbance; and runoff concentration all increase the risk of erosion. | **Change in level of Erosion Risk.** |
| Assumptions | Land use is related to land management and land management is directly related to the amount of disturbance, period of exposure and concentration of runoff. | Landscape pressures are known. Rainfall, slope and cover influence runoff, which influences the risk of erosion in conjunction with soil erodibility. | High levels of rainfall frequency and intensity; steep, long slopes; absence of ground cover; high erodibility; lengthy exposure; high levels of disturbance; and runoff concentration all increase the risk of erosion | **Assessment standards accurately reflect levels of human activity, natural events and landscape and soil attributes.**<br>**RUSLE, which calculates Soil Loss, accurately reflects the level of Erosion Risk.** |

| Information needs (data) | • Management Practices<br>• Land Use (QLUMP)<br>• Cover (BGI)<br>• Projected Foliage Cover (PFC)<br>• Extension services (soil con advice)<br>• Industry BMPs<br>• Remnant Veg<br>• Disturbance (clearing permit areas)<br>• Soil Con Plans (state govt)<br>• Exposure periods | • Rainfall frequency<br>• Rainfall intensity<br>• Slope %<br>• Slope length<br>• DEM<br>• Cover (BGI)<br>• PFC<br>• Erodibility | • RUSLE factors<br>• Type of concentration (natural / artificial) | **Erosion Risk (categories).** |
|---|---|---|---|---|

***Gully Erosion***

Erosion gullies are influenced by the soil loss factors (i.e. rainfall, soil erosivity, slope length and gradient, cover and management) within their catchment area. In fact, it could be said that the presence of an erosion gully is a culmination of high levels of these factors, and as such, they can be directly taken into account by mapping gully extent.

All active erosion gullies will continue to grow until they reach a state of equilibrium, when they become inactive. Whether a gully is active (ie. gully activity) will be determined by how stable the gully is (ie. gully stability), which in turn is influenced by the same factors as soil loss. However, the level of groundcover will also be influenced by gully stability – i.e. no ground cover will be present within an extremely unstable gully. As such, gully severity can be determined by gully activity, which can be determined by the presence of groundcover within and immediately surrounding a gully.

Figure x show active gully erosion typically with a lack of groundcover.

**Figure x.** Active gully erosion

**Table XX.** Tool for identifying gully erosion extent and severity indicator and information needs

| | Pressures | | Physical / chemical / attitudinal changes | Indicator |
|---|---|---|---|---|
| | Human Activity | Natural Events | | Condition & Trend |
| Process/Function of gully erosion | Land use and land management influence the degree of soil disturbance, period of soil exposure and concentration of runoff in a gully catchment. | Landscape hydrology influences landscape pressures and gully extent and severity. | High levels of rainfall frequency and intensity; steep, long slopes; absence of ground cover; high erodibility; lengthy exposure; high levels of disturbance; and runoff concentration all increase gully extent and severity. | **Change in gully erosion extent and severity.** |
| Assumptions | Land use is related to land management and land management is directly related to the amount of disturbance, period of exposure and concentration of runoff. Gullies are affected by influences in their catchments. | Landscape pressures are known. Rainfall, slope and cover influence runoff, which, in conjunction with soil erodibility, influence gully erosion extent and severity. These factors influence presence of groundcover, which is proportional to and therefore a good surrogate for gully activity/stability (ie. severity). | High levels of rainfall frequency and intensity; steep, long slopes; absence of ground cover; high erodibility; lengthy exposure; high levels of disturbance; and runoff concentration all increase gully extent and severity. | **Assessment standards accurately reflect levels of human activity, natural events and landscape and soil attributes. Groundcover presence accurately reflects gully activity/stability (ie. severity).** |
| Information needs (data) | • Management Practices<br>• Land Use (QLUMP)<br>• Cover (BGI)<br>• Projected Foliage Cover (PFC)<br>• Extension services (soil con advice)<br>• Industry BMPs<br>• Remnant Veg<br>• Disturbance (clearing permit areas)<br>• Soil Con Plans (state govt)<br>• ESCPs (council)<br>• Irrigation Water Management Plans (IWMP)<br>• Exposure periods | • Rainfall frequency<br>• Rainfall intensity<br>• Slope %<br>• Slope length<br>• DEM<br>• Cover (BGI)<br>• PFC<br>• Erodibility<br>• Gully Extents | • Gully Severity | **Gully Extent & Severity** |

**Indicative 2020 Target - The extent of Acid Sulfate Soil disturbance is maintained at 2015 baseline**

**ASS Disturbance**

Acid sulfate soils (ASS) are soils containing iron sulfides, mainly formed under estuarine conditions in the last 10 000 years. In their natural state, ASS are commonly waterlogged, have neutral pH and are benign. In this state they are called potential acid sulfate soils (PASS). However when exposed to air, the sulfides oxidise to form sulfuric acid, acidifying soil and water, and releasing iron, aluminium and possible heavy metal contaminants. The resulting severely acidified soil can often have pH<4.0, when it is called actual acid sulfate soils (AASS). The acidification of soil, groundwater and surface caused by disturbance of ASS can reduce farm productivity, degrade infrastructure, have detrimental impacts upon terrestrial and aquatic habitats, and harm aquatic organisms.

Measuring the extent (hectares) and severity (pH) of acidified ASS provides an effective tool for assessing changes in ASS status over time. Monitoring will allow identification of areas requiring action, and assessment of mitigation measures. It can also be used to guide planning and aid in direction of future settlement patterns. A baseline map of the risk of disturbance of ASS is in Appendix ….

The extent and severity of acidified ASS is linked to other assets, indicators and intermediate outcomes, including:

- Erosion and reduced soil loss (Land Asset)
- SOM and improved fertility and increased SOC (Land Asset)
- Salinity and reduced extent and severity (Land Asset)
- Agricultural land and availability for viable production (Land Asset)
- Improved water quality (Water Resources and Coastal and Marine Assets)
- Minimisation of impacts upon ecosystem health within the coastal zone (Coastal and Marine Assets)
- Minimised impacts on ecosystem health (multiple assets and indicators)
- Improved land use decision making (multiple assets and indicators)
- Increased adoption of BMP (multiple assets and indicators)
- Reduced impacts of infrastructure (multiple assets and indicators)

Expected intermediate outcomes as the result of reduced disturbance of ASS are improved soil health, water quality, ecosystem functions, and agricultural production and reduced impacts upon urban infrastructure through improved management of ASS.

**Conceptual understanding of the pressure and response relationships**

Much of the Queensland population is located close to the coast, with land close to water in particular demand for development. As a result there are significant pressures on the low lying coastal areas where ASS are present. Activities such as sand extraction can also be located in these areas. Agricultural production from crops such as sugarcane is common in ASS areas, with drainage schemes often constructed in the past to attempt to improve production. These activities often disturb ASS and groundwater, which can result in acidification of soil, groundwater and surface water.

The natural concept of ASS is shown in Figure xx where acid events from oxidation of ASS are often of low frequency, low magnitude and have short duration (Sammut, J. 2000, *An introduction to acid sulfate soils*). Significant droughts can result in oxidation of ASS and subsequent acidification; however the impacts are likely to be much less than if disturbed by human activity.

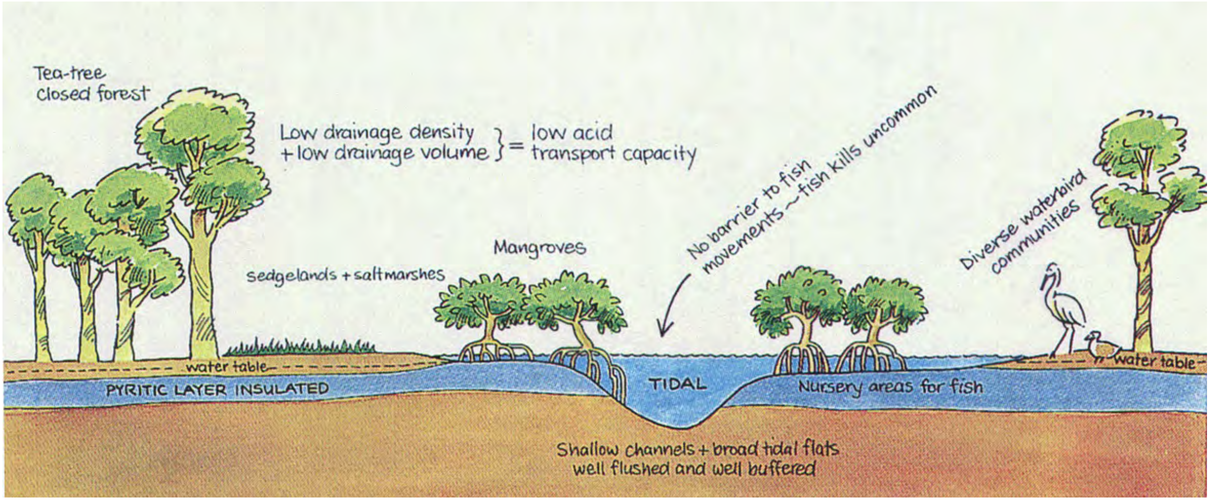


**Figure xx.** ASS in a natural setting (Sammut, J. 2000. *An introduction to acid sulfate soils*)

Figure xx shows ASS in a disturbed environment, where acid events from oxidation of ASS have a high frequency, high magnitude and can persist for more a much longer time.

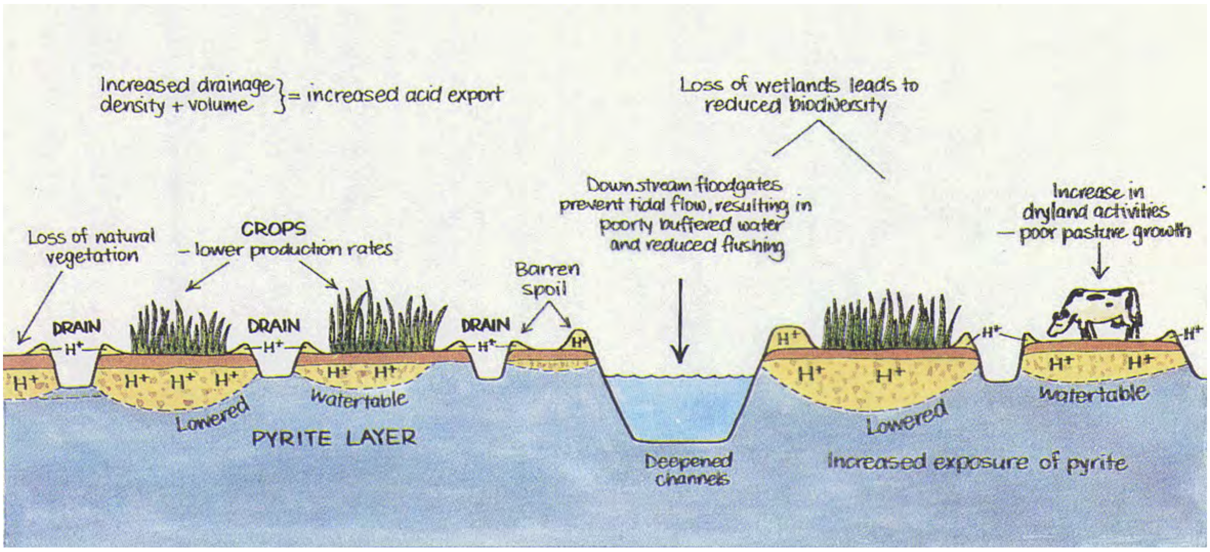


**Figure xx.** ASS in a disturbed setting

Avoiding disturbance of ASS is the best management option, as ASS is usually benign if left undisturbed. If disturbed, management strategies aim to limit the amount of sulfides exposed to the air and to neutralise the acid in the soil and water before the acid (and any contaminants) is released to receiving environments. Incorporation of ASS information into the WBB Regional Plan and Local Authority Planning Schemes is an effective tool to identify and implement appropriate development in high risk areas. The first row describes the process of how human activities and natural events put pressure on systems causing physical and chemical changes to the environment, which can be measured by assessing indicator condition and trend. Row two describes the assumptions about the scientific understanding of Acid Sulfate Soil processes while row three describes the data necessary to monitor condition and trend.

**Table 2 – Tool for identifying acid sulfate soil indicator and information needs**

| | Pressures | | Physical / chemical / attitudinal changes | Indicator |
|---|---|---|---|---|
| | **Human Activity** | **Natural Events** | | **Condition & Trend** |
| **Process/Function of ASS** | Land use and land Management disturbs soil and groundwater, exposing ASS to oxygen | Droughts can result in exposure of ASS to oxygen by lowering groundwater tables. | Exposure of ASS to oxygen results in generation of acid, acidifying soil groundwater and surface water. Detection of impacts should lead to improved management | **Change in extent and severity of acidification from acid sulfate soils.** |
| **Assumptions** | Intensive land use/land management will result in more exposure of ASS to oxygen than would occur in a natural setting.<br>Impacts will be Detectable.<br>Impacts upon human activities may be experienced are negative | Some exposure of ASS to oxygen will occur in a natural setting, but impacts are likely to be minor in comparison to a disturbed site.<br>Impacts will be Detectable.<br>Ecosystem will have enough resilience to handle natural events | Disturbing ASS will result in negative impacts. It should be possible to identify natural and human induced impacts upon ASS.<br>Improved management measures will be undertaken once impacts are identified.<br>Landowners will be willing to implement improved management | **ASS maps will accurately represent the baseline extent and severity of acidification from ASS.**<br><br>**Monitoring of changes in soil pH will reflect change in land management.** |
| **Information needs (data)** | - ASS maps<br>- LiDAR elevation data<br>- Remnant vegetation<br>- Land use mapping<br>- Land tenure DCDB (lot size) | - ASS maps<br>- soils mapping<br>- geology mapping<br>- aerial photography<br>- LiDAR elevation data<br>- contour data<br>- gamma radiometric survey data<br>- Remnant vegetation<br>- BGI (Bare Ground Index)<br>- Land use mapping<br>- Rainfall<br>- Evaporation | - Soil pH | **Extent and severity of acidification from acid sulfate soils.** |

**Indicative 2020 Target – Extent of Cropping Land (i.e. cropping, horticulture and plantation forestry) is maintained at the 2015 baseline.**

**Retained GQAL**

Good quality agricultural land (GQAL) is recognised as a finite state and national resource that must be conserved and managed for the benefit of future generations. This resource includes land which is capable of sustainable use for agriculture, with a reasonable level of inputs and without causing degradation of land or other natural resources. It is land used for crop or animal production, but excludes intensive animal uses such as feedlots, piggeries, poultry farms and plant nurseries based on either hydroponics or imported growth media. The state's best cropping land support economic growth for regional communities, is scarce resources, and is subject to competition from urban and mining interests. GQAL must be protected from permanent alienation.

Measuring the extent in hectares of GQAL and areas lost to permanent alienation provides an effective tool for assessing changes in retained GQAL status over time. It can also be used to guide planning and aid the direction of future settlement patterns. A baseline map of the extent of GQAL is in Appendix ….

**Conceptual understanding of the pressure and response relationships**

The productive capacity of agricultural land can be impacted by competition between and resultant changes in land use, fragmentation of the resource base, and from conflict due to incompatible adjacent land uses.

Globally, food security, scarcity of agricultural land and the intensifying demand for food, fibre and energy products from a growing population is putting pressure on GQAL. On a local scale, demand for land is increasing to cater for strong population growth, particularly in regional areas. Carbon sequestration forest agreements and nature conservation covenants are usually long term restricting agricultural production but are deemed to not alienate the resource from agricultural production as the land can be cleared if required. Energy related industries require access to specific natural resources (such as coal, gas, soil or water) and access to infrastructure. Due to the nature of these activities (e.g. open cut mining), these industries permanently impact on the availability and productive capacity of the land.

Urban encroachment onto agricultural land permanently alienates the resource, and is often associated with diminished productivity due to conflict that is associated with incompatible adjacent land uses (spray drift and noise impacting on residential areas). These impacts are often cumulative when the resource has been fragmented due to scattered residences locating within traditional farming areas. Agricultural cropping requires having access to fertile soils, water, transportation and communication infrastructure, service centres and markets. Those areas which meet these criteria are scarce.

The pressure on the finite resource of GQAL associated with the level of competition from urban, forestry, nature conservation and energy development is extreme. Agricultural industries that rely on processing and infrastructure (such as sugar mills, rail and irrigation infrastructure) are also at risk, due to the cumulative impacts of loss of the GQAL to support the industry. This supporting infrastructure needs to be maintained. The social and economic contributions of the agricultural sector to regional areas are significant and GQAL needs to be sufficiently protected against permanent alienation and diminished productivity.

The first row describes the human activities and natural events that put pressure on the resource base, causing changes to the area of retained GQAL. Row two describes the assumptions about the scientific understanding of the pressures on GQAL while row three describes the data necessary to monitor condition and trend.

**Table X.** Tool for identifying indicator and information needs

| | Pressures | | Physical / chemical / attitudinal changes | Indicator |
|---|---|---|---|---|
| | **Human Activity** | **Natural Events** | | **Condition & Trend** |
| **Process/Function of GQAL** | Demand for GQAL for urban expansion.<br><br>Demand for GQAL for mining and energy resources.<br><br>Revenue generated from urban development, forestry and mining | Climate change. Resource loss due to extreme weather – cyclones, flooding and drought | Changes in GQAL due to alienation.<br><br>Changes in GQAL due to diminished productivity from natural events. | **Extent of retained GQAL and SCL**<br><br>**Measurable changes in extent of retained GQAL due to alienation**<br><br>**Measurable changes in extent of retained GQAL over time due to diminished productivity** |
| **Assumptions** | Suitable alternative sites will be available to accommodate urban and mining sector expansion.<br><br>Competition between GQAL, mining, carbon sequestration forestry nature conservation and urban development will continue to put pressure on the resource base. | Minor areas of GQAL will be lost due to natural events. | The economic and social benefits of maintaining a strong agricultural base in the region are significant.<br><br>The infrastructure requirements for maintaining a strong agricultural base will be maintained. | **Planning processes are able to accurately reflect commitment to protect GQAL from alienation and diminished productivity.**<br><br>**Preferred settlement patterns are able to be directed away from areas with a strong agricultural base.** |
| **Information needs (data)** | - GQAL and SCL mapping<br>- land use mapping<br>- planning scheme maps & urban footprint<br>- area covered by mines, quarries and petroleum products<br>- Cadastral mapping<br>- Satellite imagery (orthophotos and aerial photos)<br>- Population trends | Flooding<br>Sea level rise | Depth and salinity of groundwater. | **Extent of retained GQAL** |

## Indicative 2020 Target - Ground cover of grazing lands is maintained at the 2015 baseline

**Grazing Land**

Land Condition within grazing systems is commonly assessed based on the Land Condition Framework (as promoted by the Grazing Land Management strategy) which takes into account factors such as: surface cover (i.e. plant material including litter, scalded/bare areas, erosion, salinity); weeds; abundance of desirable grass species (i.e. perennial, productive and palatable); and woody thickening. Land condition is important to maintain economic productivity and soil health. Percent surface cover is a convenient tool to monitor grazing land health for each of the Soil Management Units as it is monitored regularly throughout Queensland by the State Government. Each Soil Management Unit has inherent chemical (e.g. nutrient levels) and physical properties (e.g. plant available water capacity) resulting in a certain range of surface cover as influenced by local seasonal variation (e.g. rainfall). Due to seasonal fluctuations and rainfall variability over the Burnett Mary Region, comparison of pasture health at any one time is based on comparison with long term averages. Any decrease in surface over in the medium term can be attributed to land management. Climate variability will influence pasture cover in the long term.

Grazing land supports economic growth for regional communities, is a finite resource and is subject to competition from primary industries such as Mining and Forestry. Loss of pasture cover to land degradation (erosion, salinity) can also be monitored. Measuring pasture condition (surface cover) can only occur in areas with a tree foliage cover of <20%. Baseline maps of the long-term average ground cover for each pixel and for each soil group are in Appendix ….

**LINKS:**
The extent and condition of Grazing Land is linked to other assets, indicators, intermediate outcomes and associated issues, including:

- Agricultural Cropping Lands (Land Asset)
- Soil Health Indicators (Land Asset)
- Regional Connectivity (e.g. biodiversity corridors; agricultural land buffers; landscape and catchment fragmentation)
- Terrestrial & Freshwater Biodiversity Asset (e.g. managed/promoted ecological values)
- Air & Atmosphere Asset (e.g. spray drift, wind erosion and burning practices)
- Aboriginal Natural & Cultural Values Asset (e.g. Indigenous Pathways and accessibility)
- Community Asset (e.g. heritage and cultural conservation issues)
- Fire Management (bushfires and on farm practices)
- Improved water quality (Water Resources and Coastal & Marine Assets)
- Improved land use decision making (including development, forestry, mining and other primary industries)
- Increased adoption of Industry BMPs & good land management practices.

**Conceptual understanding of the pressure and response relationships**

Management actions will aim to maintain or improve the level of surface cover in our soils through improved grazing land management and improved soil health. Management that supports the target includes good grazing management, maintenance of soil fertility (chemical and physical), low temperature burning at appropriate times, rehabilitation of degraded areas and reduced land degradation such as salinity, erosion and soil contamination. The effect of each of these factors is individual to each different soil type considered.

The conceptual understanding of how surface cover changes in the landscape is illustrated below in Table X. The first row describes the process of how human activities and natural events put pressure on systems causing physical and chemical changes to the environment, which can be measured by assessing indicator condition and trend. Row two describes the assumptions about the scientific understanding of pressures and response to ground cover while row three describes the data necessary to monitor condition and trend.

**Table X.** Tool for identifying grazing land condition indicator and information needs

| | Pressures | | Physical / chemical / attitudinal changes | Indicator |
|---|---|---|---|---|
| | **Human Activity** | **Natural Events** | | Condition & Trend |
| **Process/Function of secondary salinity** | Land use and land management influence the amount of pasture growth and retention. | Climate, soil type, vegetation cover and pasture type influence the amount of surface cover. | Reduced surface cover result in reduced productivity, and soil health declines related to structure, moisture holding capacity, nutrient availability and erosion resistance. | **Changes in percentage of surface cover.** |
| **Assumptions** | Land management is directly related to the amount of surface cover in all landscapes. | The amount of pasture growth is related to climate (rainfall, evaporation and temperature), topography, soil type (texture, pH, fertility & parent material) and how they interact with land management techniques. | Surface cover levels behave in a uniform manner where all soil, topographic and climate variables are equal. | **Surface cover changes accurately reflect changes in land management practices over time.**<br><br>**Assessment sites represent modal land uses.** |
| **Information needs (data)** | - Land use statistics or mapping<br>- History of farming or land clearing<br>- Current vegetation mapping<br>- BGI (Bare Ground Index) | - Climate data (temperature, rainfall, evaporation)<br>- Vegetation coverage and type.<br>- Soil type (parent material, soil depth etc.).<br>- Topography (elevation, slope, rockiness)<br>- Land use.<br>- Geology | Measured levels of surface cover across all soils<br>. | **Extent and variability of surface cover levels under a range of common land management practices.** |

### 5.5.5 Future Investment

We need to take action to reduce risks and threats and improve biophysical condition. However, we also need to improve policy and planning, awareness and behaviour, adoption of improved management practices and improve the region's understanding and knowledge of natural systems and the interaction of human activities on those systems. All of these activities have one thing in common, which is the need for investment of resources - both people and funding.

The specific activities identified for the delivery of outcomes for Land and Soil Assets as identified through Community Consultation and Scientific Expert Panels are listed in Table xx. The activities were identified for addressing key issues for the Land and Soil Resource Assets and were subject to a prioritisation process examining:

- Cost
- Benefit
- Risk
- Barriers to Adoption
- Social Acceptability
- Carbon Sequestration Potential
- Maladaptation

Each target describes activities to achieve the desired outcomes. Each of the activities for Planning and Governance (includes industry), On-Ground, Community Capacity Building and Science are ranked from 1 to 3 (1 high, 2 moderate, 3 low). An overall ranking (**HIGH**, **MODERATE**, **LOW**) is applied to each target to indicate the relevant importance between targets in the Land and Soil Resources.

| **2020 Targets** | **Activity Category** | **Activity** | **Priority Ranking** | **Carbon Sequestration /Mitigation Co-Benefit** |
|---|---|---|---|---|
| Salinity extent and severity is maintained at 2015 baselines. **MODERATE** | Planning & Governance | - Incorporate baseline data into (town) planning decisions to avoid inappropriate development. | 1 | |
| | On-Ground | - Improve ground cover / vegetation and crop and irrigation management.<br>- Ensure infrastructure does not exacerbate salinity problems (eg channel / dam leakage). | 2 | Increased vegetative ground cover will result in increased carbon sequestration in both plants and soil, as well as reduced soil erosion.<br><br>(Increased veg cover → C seq. Reducing salinity reduces erosion) |
| | Community Capacity Building | - Ongoing education re salinity processes and management option.<br>- Provide / maintain extension services. | 1 | |
| | Science | - Complete baseline data – salinity extent and severity.<br>- Implement M & E. | 1 | |
| Soil acidification is maintained at 2015 baseline. **LOW** | Planning & Governance | - Incorporate baseline data into development of BMP for any crop production. | 2 | |
| | On-Ground | - Implement BMP. | 1 | Healthy cropping land soils retain greater levels of soil carbon than degraded soils.<br><br>(Maintain soil health to maintain soil carbon in cropping land.) |
| | Community Capacity Building | - Ongoing education re soil acidification processes and management options.<br>- Provide / maintain extension services. | 2 | |
| | Science | - Implement M&E. | 3 | |
| Sheet erosion risk, stream | Planning & Governance | - Incorporate baseline data into development of BMP for all land use. | 3 | |

| | | | | |
|---|---|---|---|---|
| bank erosion risk and gully erosion extent and severity are maintained at 2015 baselines. **HIGH** | On-Ground | - Implement BMP | 1 | Retained soils retain stored carbon in the landscape. (Maintaining soil carbon levels.) |
| | Community Capacity Building | - Ongoing education re soil erosion processes and management options. - Provide / maintain extension services. | 1 | |
| | Science | - Accumulate existing information into relevant format. - Implement M&E. | 2 | |
| The extent of Acid Sulfate Soil disturbance is maintained at 2015 baselines. **LOW** | Planning & Governance | - Incorporate baseline data into (town) planning decisions to avoid inappropriate development. | 1 | |
| | On-Ground | - Avoid development or implement BMP. - Ensure infrastructure does not exacerbate ASS problems (eg channel / dam construction). - Manage groundwater to avoid exposing potential ASS. | 2 | Areas of ASS inherently retain high levels of soil carbon, avoiding their disturbance ensures retention of that carbon. (By avoiding development on ASS area soil carbon is maintained / improved. ) |
| | Community Capacity Building | - Ongoing education re ASS processes and management option. - Provide / maintain extension services. | 2 | |
| | Science | - Complete baseline data – ASS disturbance extent. - Implement M & E. | 3 | |
| Extent of cropping lands is maintained at 2015 baselines. **HIGH** | Planning & Governance | - Incorporate baseline data into (town) planning decisions to avoid inappropriate development. | 2 | |
| | On-Ground | - Avoid inappropriate development | 1 | The capacity of cropping land to retain soil carbon is maintained if such areas are not subject to urban and industrial development. (By avoiding development on cropping land soil carbon is maintained / improved.) |
| | Community Capacity Building | - | | |
| | Science | - Complete baseline mapping. - Implement and M&E | 1 | |
| Ground cover of grazing lands is maintained at 2015 baselines. **HIGH** | Planning & Governance | - Incorporate baseline data into development of BMP for all land use. | 2 | |
| | On-Ground | - Implement BMP and appropriate fire management | 1 | Increased vegetative ground cover levels in grazing lands result in increased carbon storage. (Maintain / improve soil carbon through groundcover retention.) |
| | Community Capacity Building | - Ongoing education re BMP and management options - Provide / maintain extension services | 1 | |
| | Science | - Implement and M&E | 3 | |

The activities to maintain salinity extent and severity at the 2015 baseline aim to improve land management activities such as lower ground water levels through improved plant growth (crops, pastures and trees), improved irrigation methods (water application, water quality and water table monitoring), soil and land management, and engineering solutions (e.g. drainage, resistant infrastructure). Other activities include improved planning decisions by avoiding development on saline areas or if development can not be avoided, allow governments and industry to implement relevant codes to minimise damage to infrastructure and assets. In many cases, the knowledge of the landscape processes that drive salinity are well recognised by the science community, but public knowledge is poor. Therefore, community education and supply of extension services needs to be improved.

Soil acidification is a slow process mainly associated with plant product removal from a site and fertiliser use on acid sandy to loamy textured cropping soils. Management aims to implement best management practices such reducing fertiliser applications, liming and retaining crop residues. Other activities include the development of BMP by industry and community education.

Soil loss through erosion has significant environmental, economic and social implications which often cannot be reversed. For example, loss of topsoil inhibits crop and plant growth, interferes with farming operations and may damage infrastructure, while sediment-laden runoff and sediment deposition negatively impact on terrestrial and aquatic ecosystems, with repercussions throughout the agricultural, fisheries, tourism and conservation sectors. The various activities are a HIGH priority with the aim to reduce erosion through improved land management through community education and technical support to all land managers. All activities will support Reef Plan through the 20% reduction in sediment and nutrient loads to the reef waters.

The acidification of soil, groundwater and surface caused by disturbance of ASS can reduce farm productivity, degrade infrastructure, have detrimental impacts upon terrestrial and aquatic habitats, and harm aquatic organisms. As the disturbance of acid sulfate soils is regulated by existing government planning provisions, the overall target is a low priority. The activities aim to either avoid disturbance or if disturbed, manage the acidification to avoid damage to the environment, infrastructure and assets.

Good quality agricultural land (GQAL) is recognised as a finite state and national resource that must be conserved and managed for the benefit of future generations. The productive capacity of agricultural land can be impacted upon by competition between and resultant changes in land use, fragmentation of the resource base, and from conflict due to incompatible adjacent land uses. The activities aim to improve planning decisions to reduce urban encroachment onto agricultural land as any alienation permanently alienates the resource, and is often associated with diminished productivity due to conflict that is associated with incompatible adjacent land uses (spray drift and noise impacting on residential areas).

Grazing land supports economic growth for regional communities. Management actions will aim to maintain or improve the level of surface cover in our soils through improved grazing land management and improved soil health (as described above). Best management practices that supports the target includes good grazing management, maintenance of soil fertility (chemical and physical), low temperature burning at appropriate times, rehabilitation of degraded areas and reduced land degradation such as salinity, erosion and soil contamination. The effect of each of these factors is individual to each different soil type considered. On-going community education and technical support is a high priority.

### 5.5.6 Monitoring & Evaluation of the Land and Soil Resource Assets

The NRM Plan provides an opportunity to coordinate the region's effort towards monitoring the state of the environment and the health and condition of our natural resources. We need both monitoring systems and an evaluation process to get a true picture of how we are tracking.

Monitoring systems are about 'measurements' and aim to tell us something about the state or condition of an asset. Monitoring is generally about data collection, analysis and interpretation and uses indicators that tell us something about the important asset. The indicators are a particular aspect of an environmental asset we can measure over time. When we combine these measurements with a good understanding of how an environmental systems works we are able to assess the condition and identify any trends associated with an asset.

Evaluation tells us about the effectiveness of what we have been doing and if we have achieved the results and outcomes we are looking for from our activities. Evaluation is based on having a good understanding of the 'cause and effect' relationship between the actions we undertake and the variety of outcomes and changes we hope to see along the way to achieving our targets.

**Monitoring Framework**

The following outlines the process and methods proposed to monitor our progress towards the achievement of our targets. In many cases Baseline data does not exist and is the first action necessary to complete to establish an operable monitoring program.

***Salinity extent and severity***

**(i) Monitoring Process**

Monitoring the extent and severity of salinity is to be undertaken by following *the Land Salinity Matter for Target of the National Monitoring and Evaluation Framework – Areas threatened by shallow or rising water tables – location size and intensity of salt affected areas* (2007).

Eyre *et al.* (2011) has documented the methods and standards for assessing secondary salinity in South East Queensland. Any future monitoring will utilise similar methods.

In the WBB there is a lack of available information on the current condition of salinity extent and severity. The collection of baseline information is required for this indicator. Regular monitoring will need to occur to measure the change in salinity extent and severity.

**(ii) Existing / Available data**

No condition trend monitoring of salinity extent and severity data is available in the WBB and as a result this it has been identified as a data gap.

***Soil acidification extent and severity***

**(i) Monitoring Process**

To monitor the changes in soil pH across the WBB, baseline data is available for key cropping areas (see Appendix xx). This will require monitoring soil pH at standard depths across representative sites and land uses across the WBB region.

"High-risk" landscapes/soils have been identified and sites representing the most common land use categories of the WBB region have been selected. Preferably, and where applicable, representative areas to be monitored contains historical sites where laboratory assessed pH data is available.

**(ii) Existing / Available data**

Baseline data at an appropriate scale to assess soil acidity extent and severity across the WBB region baseline data is available for key cropping areas. Suitable permanent monitoring sites form the basis of long-term monitoring across WBB so that a soil pH can be benchmarked and soil pH change can be measured.

***Soil Organic Matter (SOC)***

**(i) Monitoring Process**

The methodology will follow National Land and Water Resource Audit protocols and recommendations from expert technical panels for monitoring soil condition.

Monitoring will focus on "high-risk" landscapes as a priority followed by sites representing the most common land use categories of the WBB region. To monitor the changes in SOC across the WBB, baseline data is available for key cropping areas (see Appendix xx).

**(ii) Existing / Available data**

Current soil carbon information for the WBB area is available for key cropping areas. Suitable permanent monitoring sites form the basis of long-term monitoring across WBB so that a SOC can be benchmarked and SOC change can be measured.

***Sheet erosion risk***

**(i) Monitoring Process**

The original Universal Soil Loss Equation (USLE) was developed in the United States of America in the late 1930s and published in the USDA Agricultural Handbook No. 537 (1965, revised 1978) and later superseded by the Revised Universal Soil Loss Equation (RUSLE), published in the USDA Agricultural Handbook No. 703 in 1997.

The RUSLE has become widely accepted as an effective approach for estimating Soil Loss, with a long history of field validation (as described in *Rosewell, 1993*). As such calculation of Soil Loss across large areas is essentially a desktop exercise using spatial analysis programs (eg. Geographic Information Systems) and does not require field effort.

A baseline is available for monitoring changes in Erosion Risk across the Wide Bay / Burnett (WBB) for grazing areas only (Appendix xx). Soil Loss has been categorised into Erosion Risk classes. (Note: actual values – i.e. the number of tonnes of soil loss per hectare - are not meaningful in this instance; rather classification into categories provides a more useful insight for comparison purposes).

Application of RULSE is documented by *Renard et al, 1997* and similar methods/standards has been used and/or adopted as appropriate/necessary to (i) initially establish an Erosion Risk baseline dataset for the WBB, and (ii) calculate Erosion Risk at five yearly intervals for monitoring purposes.

Calculation of Erosion Risk has been carried out as a spatial desktop exercise (e.g. using Geographic Information Systems) and involved the use of existing datasets (spatial layers) and the creation of new datasets (spatial layers).

**(ii) Existing / Available data**

Erosion Risk has been undertaken at a regional scale in the WBB.

***Stream bank erosion risk***

**(i) Monitoring Process**

Stream bank erosion is generally a result of scouring caused by internal stream flows; runoff down the bank (ie. sheet, rill or gully erosion); or bank slumping. Stream bank erosion is influenced by flood dynamics (mainly water velocity and duration), river geomorphology (channel curvature associated with mainly meander migration), soil stability, bank height and slope, and vegetation density and structure. Stream bank erosion risk will be monitored by measuring changes in *stream curvature* and vegetation cover (bare ground index, remnant vegetation/foliage cover).

Within a waterway, the area most susceptible to erosion is the section of bank on the outer side of a meander (the "external curve"), due to increased flow velocity – refer to figure x below. As the direction of a waterway alters from straight to meandering, the speed of the water increases on the outer side of a bend and decreases on the inside of a bend, enabling scouring of the bank on the outside of the bend and sediment deposition on the inside. This process also serves to alter bank steepness, whereby slope is increased along the external curve as soil is removed, and decreased along the inside curve as soil is deposited.

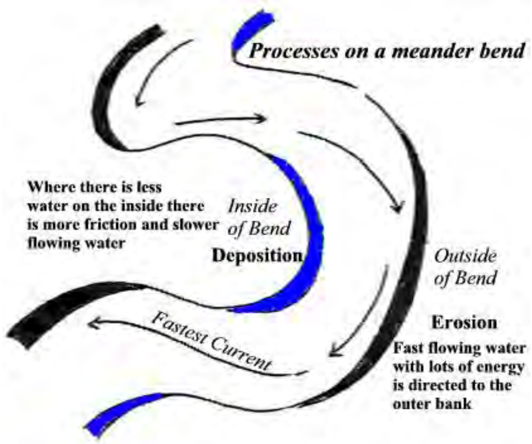


**Figure x.** Stream meander processes

**(ii) Existing / Available data**

Stream bank erosion risk has been established for the main channel of the Burnett River from Burnett Heads to Eidsvold, the lower section of the Kolan River. Stream bank erosion risk is not available for the Mary River.

***Gully erosion extent and severity***

**(i) Monitoring Process**

Erosion gully extent (ie. size and area) and severity (ie. stability/activity) is not currently available. It will be undertaken by means of remote sensing involving interrogation of imagery to digitise erosion gully extent within WBB and application of cover in and immediately surrounding mapped gullies as a surrogate for gully activity. Methodology used to establish a 2012 baseline will be repeated each five yearly monitoring effort.

Gully occurrence within 100 m grids over the WBB is currently available (Appendix xx) and will be used to initially identify areas to be assed for gully extent and severity.

**(ii) Existing / Available data**

To date neither detailed assessment nor monitoring of Gully Erosion has been undertaken at a regional scale in WBB. For baseline establishment in 2015, gully occurrence within 100 m grids over the WBB will be used to initially identify areas subject to gully erosion. Gully extent will be mapped using best available high resolution imagery while BGI and FPC data will be used as a surrogate for activity to apply as a severity rating (ie. activity category).

***ASS Disturbance***

**(i) Monitoring Process**

An ASS risk map identifying ASS extent and likelihood of disturbance (e.g. land use such as native forests – urban) has been developed for the WBB. Existing mapping of the depth to AASS/PASS, elevation, substrate type (unconsolidated materials/rock) and land use has been used where available. Monitoring will involve mapping the change in land use in areas containing or likely to contain ASS,

**(ii) Existing / Available data**

ASS maps which show depth to PASS/AASS and severity of acidification are not available over most of the WBB area. The ASS mapping in the WBB employed the standard mapping methodology to identify ASS in rural areas only. No ASS mapping is available for urban areas. An acid sulfate soil extent map was produced by DNRM in March 2011 as part of benchmarking for the WBB NRM plan. It collated existing ASS mapping, soils mapping, geology mapping, contour information and wetlands mapping together to identify areas likely to contain ASS.

The ASS risk map identifies the areas of ASS (ASS extent map) under various land uses and monitors the likelihood of disturbance (the change in land use). Areas subject to significant disturbance, such as urban areas, are identified as high risk. Areas under remnant native vegetation are low risk.

***Retained GQAL***

**(i) Monitoring Process**

Monitoring the extent of retained GQAL has been undertaken by analysing the existing GQAL information, land use, land tenure, mining tenements and examination of the preferred settlement patterns in the regional plan.

The methods and standards for assessing retained GQAL have been partially documented in the State of the Region Report 2008. This project will build upon this methodology. The baseline data for GQAL, land use, tenure, and planning schemes are available. Mineral resource and exploration tenement maps are available, but do not tend to reflect all future mining enterprises due to the nature of the industry.

At a simplistic level, Retained GQAL will be equivalent to Total GQAL areas greater than >5 ha minus areas alienated (urban footprint, conservation reserves and mining).

**(ii) Existing / Available data**

While the majority of baseline datasets are available (at some scale), there has been no monitoring or analysis of the data completed to date. This is identified as a data gap.

***Grazing Land***

**(i) Monitoring Process**

Measuring surface cover (green/living and non-living ground cover) in grazing lands (as defined and mapped by QLUMP) provides a useful way of tracking the health and productivity of the WBB grazing lands. Due to seasonal variability (eg. winter/summer) and variability in climatic (particularly rainfall) and pasture types across the region, the ground cover percent in September-November for each 30 m pixel over the whole region is averaged over the period of data availability, then averaged for each Soil Mapping Unit. The September to November period is seen as the driest period of the year and should indicate management over the previous season. Monitoring will involve the assessment of medium to long term changes in surface cover for each pixel (30 X 30 M) and comparison to the long term average for the Soil Management Unit. As satellite imagery of bare ground and surface cover can not occur where trees have a foliage cover >20%, these areas are excluded from the monitoring.

Each Soil Management Unit has inherent chemical (eg. nutrient levels) and physical (eg. plant available water capacity) which will influence the pasture type and production.

Changes in surface cover in the long term will reflect management options and possible climate variability, and land degradation such as erosion and salinity.

**(ii) Existing / Available data**

Existing bare ground and surface cover exists for the whole region.

**Evaluation Framework**

Catchment NRM activities and policies have been implemented throughout the WBB by community bodies, government and industry to improve NRM outcomes. However, very little information is available on how effective these polices and activities have been for delivering improved NRM outcomes.

The evaluation framework involves the determination of how effective the various activities and policies are in changing the condition of the Land and Soil Asset indicators. The requirement for additional monitoring or research to adequately complete the evaluation process will be highlighted during the evaluation. It is anticipated that the results from this process will influence policy makers and regional investors to make policy and financial decisions to achieve improved NRM outcomes.

The two over-arching evaluation questions underpinning the land asset and addressing the targets are:

1. To what extent is the suite of soil health programs, initiatives, policies and government instruments delivering on improved soil health for the WBB? and
2. To what extent are policies and government instruments protecting agricultural land from alienation in the WBB?

Additional 'supporting questions', often indicator-specific, may be required to assist in answering the key question for relevant indicators. The seven tables below provide an outline of the evaluation questions and a brief overview of their significance for each of the Land Asset indicators.

The data needed to answer each of supporting evaluation questions ranges from biophysical data to social/anthropogenic data. Much of this data is not available in a ready to use form and will require significant research investment to obtain, while some data is ready and easily accessible.

Each of the evaluation questions aims to assess what causes change in the indicator. This will involve investigating and understanding the natural and human pressures being imparted on the indicator so that a clear determination can be made as to which is predominantly responsible for any change. For example, indicator 'x' decreased by 'y' amount due to 'z' changes in programs/activities or natural processes.

Due to the size of the WBB region it may be necessary to target the evaluation to a sub-catchment or representative localities to explain why a change has occurred in the indicator.

***Salinity extent and severity***

**Table xx.** Salinity key evaluation questions

| Salinity |
|---|
| **Key evaluation question** |
| **To what extent is the suite of soil health programs and initiatives delivering a reduction in secondary salinity expression and severity for the WBB?** |

| Supporting evaluation question | Why this question |
|---|---|
| 1. To what extent are land management practices meeting preferred industry standards in WBB to decrease salinity extent and severity?<br>o in rural and rural residential lands<br>o in urban areas | This questions deals with the "level" of land management being implemented and whether the "level" is having an effect on salinity. |
| 2. To what extent is the adoption of BMP's resulting in a decrease in salinity extent and severity? | This questions tests the assumption that change is dependent on the understanding of salinity or other NRM incentives/activities i.e. the importance of BMPs for decreasing salinity extent and severity |

***Erosion Risk***

**Table xx.** Erosion risk key evaluation questions

| Erosion | |
|---|---|
| **Key evaluation question** | |
| **To what extent is the suite of soil health programs and initiatives delivering on improved or maintenance of soil health for WBB?** | |
| **Supporting evaluation question** | **Why this question** |
| 1. To what extent are land management practices meeting preferred industry standards in WBB to decrease:<br>• Sheet Erosion Risk<br>• Gully Erosion Extent & Severity<br>• Stream Bank Erosion Risk in<br>• rural and rural residential lands<br>• urban areas | This questions deals with the "level" of land management being implemented and whether the "level" is having an effect on erosion levels. |
| 2. To what extent is adoption of industry BMP's resulting in an improvement in a decrease in:<br>• Sheet Erosion Risk<br>• Gully Erosion Extent & Severity<br>• Stream Bank Erosion Risk. | This questions tests the assumption that change is dependent on the understanding of erosion or other NRM incentives/activities (i.e. the importance of BMPs for decreasing erosion). |
| 3. To what extent are Government Instruments resulting in a decrease of<br>• Sheet Erosion Risk<br>• Gully Erosion Extent & Severity<br>• Stream Bank Erosion Risk<br>for<br>• soil conservation plans<br>• clearing permits<br>• ESCPs | This question tests the assumption that implementation of Government-enforced Instruments is effective in reducing Erosion Risk. May also address effectiveness of implementation. |
| 4. To what extent is soil conservation extension resulting in decreased erosion levels? | This question deals with the "level" of extension services being provided and whether that "level" is having an effect on Erosion Risk. |

***Quantity of organic matter***

**Table xx.** Quantity of organic matter key evaluation questions

| Organic matter | |
|---|---|
| **Key evaluation question** | |
| **To what extent is the suite of soil health programs and initiatives delivering on improvements in, or maintenance of, Soil Organic Matter (SOC) for WBB?** | |
| **Supporting evaluation question** | **Why this question** |
| 1. To what extent are land management practices meeting preferred industry standards in WBB to increase SOC in rural cropping lands? | This questions deals with the "level" of land management being implemented and whether the "level" is having an effect on SOC. |
| 2. To what extent is the adoption of BMP's resulting in an increase in SOC? | This questions tests the assumption that change is dependent on the importance of BMPs for improving organic matter |
| 3. To what extent is knowledge of SOC resulting in an improvement in or maintenance of SOC levels? | This questions tests the assumption that change is dependent on the understanding of SOM or other NRM incentives/activities |

***Soil Acidification extent and severity***

**Table xx.** Soil acidification extent and severity key evaluation questions

| Soil acidification | |
|---|---|
| **Key evaluation question** | |
| **To what extent is the suite of soil health programs and initiatives delivering a reduction in soil acidification for the WBB?** | |
| **Supporting evaluation question** | **Why this question** |
| 1. To what extent are land management practices meeting preferred industry standards to decreasing soil acidification extent and severity?<br>• in rural cropping lands | This questions deals with the "level" of land management being implemented and whether the "level" is having an effect on soil acidification. |
| 2. To what extent is the adoption of BMP's resulting in a decrease in soil acidification extent and severity? | This questions tests the assumption that change is dependent on the understanding of salinity or other NRM incentives/activities i.e. the importance of BMPs for decreasing soil acidification extent and severity |

***ASS extent and severity***

**Table xx.** Acid sulfate soil extent and severity key evaluation questions

| Acid sulfate soil | |
|---|---|
| **Key evaluation question** | |
| **To what extent is the suite of programs and initiatives delivering a reduction in the extent and severity of acidification caused by disturbance of ASS in the WBB?** | |
| Supporting evaluation question | **Why this question** |
| 1. To what extent has development impacted on ASS?<br>• Has effective management of ASS been implemented in disturbed areas? | These questions determine whether current ASS strategies and policies have been effective in minimising |

| | |
|---|---|
| • Have proposed developments been altered to avoid areas of ASS? | impacts from ASS disturbance |
| 2. To what extent are land management practices meeting preferred industry standards (e.g. cane growing code of practice) in relation to ASS in the WBB? | This questions deals with the "level" of ASS land management being implemented and whether the "level" having an effect on ASS |
| **3.** To what extent is adoption of BMP's / other resulting in a decrease in the extent of acidification caused by disturbance of ASS in the WBB? | This questions tests the assumption that change is dependent on the understanding of ASS or other NRM incentives/activities i.e. the importance of BMP's for decreasing the extent and severity of acidification caused by disturbance of ASS |

***Agricultural land protection evaluation***

**Table xx.** Agricultural land protection key evaluation questions

| Agricultural land | |
|---|---|
| **Key evaluation question** | |
| **To what extent are policies and government instruments protecting agricultural land in WBB.** | |
| **Supporting evaluation question** | **Why this question** |
| 1. To what extent is the suite of programs and initiatives protecting agricultural land in WBB?<br>* in the WBB Regional Plan<br>* in local government planning schemes<br>* In development assessment | This question deals with fragmentation and alienation issues and the role of land planning decisions. |
| 2. Under what circumstances was agricultural land alienated? | This question deals with fragmentation and alienation issues and the role of land planning decisions. |
| 3. To what extent have the capacity building activities lead to the commitment of decision makers in WBB? | This question tests the assumption that available planning tools and instruments are being actively applied to the fullest extent. |

***Grazing land evaluation***

**Table xx.** Grazing land key evaluation questions

| Agricultural land | |
|---|---|
| **Key evaluation question** | |
| **To what extent is the suite of programs and initiatives delivering on improved or maintenance of soil health for WBB?.** | |
| **Supporting evaluation question** | **Why this question** |
| 1. To what extent are land management practices meeting preferred industry standards for increasing groundcover in grazing lands? | This questions deals with the "level" of land management being implemented and whether the "level" is having an effect on groundcover. |

| | |
|---|---|
| 2. To what extent is the adoption of BMPs resulting in an increase in groundcover in grazing lands? | This questions tests the assumption that implementation of BMPs increases groundcover in a grazing context. |

## Appendix xx

**Map xx**. Salinity hazard in the WBB

**Map xx**. Soil acidification risk (2015) in cropping lands in the WBB

**Map xx**. Soil organic carbon risk (2015) in cropping lands in the WBB

**Map xx**. Sheet erosion risk (2015) in the WBB

**Map xx**. Stream bank erosion risk (2015) in the WBB

**Map xx**. Erosion extent (2015) for 100m cells in the WBB

**Map xx**. ASS risk (2015) of disturbance in the WBB

**Map xx**. GQAL extent (2015) in the WBB

**Map xx**. (a) Long term average ground cover (2015) for each Soil Management Unit in WBB
(b) Long term average ground cover (2015) for each 30 m pixel in WBB